With Compliments
(K.V. Peter)

RECENT ADVANCES
IN
TROPICAL VEGETABLE PRODUCTION

[Compendium of Lectures]

29-7-91 to 7-8-91

DEPARTMENT OF OLERICULTURE
COLLEGE OF HORTICULTURE
KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA, THRISSUR

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C O N T E N T S

FOREWORD

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Kerala Agricultural University in the forefront of research and development in tropical vegetables

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Vice-Chancellor

I am extremely happy to welcome you to this beautiful campus at a time when Kerala awaits the celebration of Onam, a festival of happiness and prosperity. On this occasion, I intend to share a few of my thoughts with my learned colleagues to generate some thinking on prospects and problems of vegetable production in India and Kerala in particular. The Kerala Agricultural University intends strongly to be a part of the national endeavour to make India self sufficient in vegetable production.

The state of Kerala is bestowed with a variety of tropical vegetables. The unique warm humid tropical climate provides an ideal set up for cultivation of about 12 major vegetables namely, brinjal, bittergourd, snakegourd, pumpkin, chilli, tomato, cowpea, bhindi, amaranths, cucumber, beans and ashgourd.

Chairman's address delivered on 29th July, 1991 on the occasion of inauguration of Summer Institute on "Recent advances in tropical vegetable production" at College of Horticulture, Vellanikkara.

About 23 minor vegetables such as lablab bean, drumstick, winged bean, cluster bean, clove bean, cauliflower, cabbage, radish, carrot and water leaf are also cultivated. Vegetarianism has been largely prevalent in the state. Surprisingly during the post independance period the consumption of vegetables has gone down due to many fold reasons. The per capita consumption is as low as 30 g/day as compared to the national average of about 110 g.

Based on consumption of seasonal vegetables in Kerala, the current availability of vegetables is only 3.18 lakh t. Based on current area under vegetables, the internal production is only 1.5 lakh t. This indicates that 50% of the total vegetables consumed in Kerala comes from outside, thus lossing Rs.90 crores/year or more. This is an area for employment potential and income generation in the state.

The demand for vegetables in Kerala varies with seasons and local festivals. One estimate assumes that 30% of the total vegetable consumption occurs during one week prior to Onam. Though the agro-climatic conditions in the state are very favourable for the cultivation of a variety of vegetables, the situation is not properly exploited at present. Marketing of tropical vegetables is an area demanding much attention. A recent study on vegetable marketing shows that farmers are mostly selling their produce at the farms to pre-harvest contractors at Malappuram in Kerala State. Farmers received only 50-54% of the retail price of vegetables which they produced. Marketing cost incurred by the intermediaries ranged from 8.59 to 9.4% of the retail price and net margins of intermediaries ranged from 37 to 41%. Inefficiency of the marketing system results in lower returns to the farmer or higher prices to the consumer or both. By increasing marketing efficiency, it is possible to improve the economic well being of farmers and consumers.

The economic sustainability of modern agriculture and especially vegetable cultivation conceptualises increased productivity, reduced cost of production, minimising risks, enhancing returns and generates resource mobility in the feasibility of adoption of newer technology and better consumable market quality. Increased productivity helps both the producers and consumers since the share of vegetables in total private consumption expenditure is higher among low income groups. An array of tropical parasitic and non parasitic diseases was limiting vegetable production. The diseases such as bacterial wilt in tomato, chilli and brinjal, viral diseases such as mosaic in bhindi, pumpkin and cucumber, devastating insect pests such as fruitfly in bittergourd and snakegourd; fruit and shoot borer in brinjal and bhindi are some of the major biotic constraints standing in the way of high productivity in vegetables.

The main constraint in tropical vegetable production has been non-availability of quality seeds. The current availability of vegetabls seeds is only 15-20 t/year while the requirement is 75 t/year. During 2000 AD, the vegetable seed requirement is 1555 tonnes. Kerala has no separate set up to cater to the requirement of vegetable seeds.

The Kerala Agricultural University has the mandate to execute research on vegetables and allied sciences to boost farmers income. Vegetable research in Kerala started much earlier than the establishment of KAU in 1972. The research programme has since been streamlined. A separate co-ordination group in vegetables, plans, executes, evaluates and monitors research on the crops. The University taking into consideration the genetic diversity on vegetables has currently 10 projects on vegetables involving breeding for pests and disease resistance, crop improvement, standardisation of agro-techniques, management of biotic stresses, pests and disease management and processing and storage of vegetable seeds.

The University operates one centre under the All India Coordinated Vegetable Improvement Project of ICAR. This is in addition to the three ICAR ad-hoc schemes now in operation. The ICAR ad-hoc scheme "Breeding for resistance to bacterial wilt in chilli and brinjal" was recently concluded and I may quote the comments of the scientific panel on this project as - "The final report submitted by KAU is an excellent one. The panel appreciated the efforts of the University in implementing the scheme and achieving some very useful results. The implementation of the scheme and compilation of the report may serve as a model for others." The bacterial wilt resistant lines in chilli and brinjal are now being further evaluated for the ultimate use of the farmers.

The University has an ambitious programme on vegetable seeds. The Ministry of Agriculture, Government of India, funds a plan scheme to produce breeder and foundation seeds of selected tropical vegetables. During 1990-91 alone 8.5 qtls. of vegetable seeds were supplied to farmers. The recently sanctioned ICAR ad hoc scheme on "Development of F_1 hybrids in pumpkin, bitter gourd and snakes gourd" aims to identify heterotic F_1 hybrids in the above crops which excel in production and quality. Development of F_1 hybrids and formulation of a production technology is a priority item of research.

The University interacts very intimately with the department of Agriculture, Government of Kerala and other agencies such as Kerala Horticultural Produce Development Corporation and the Kerala State Cooperative Bank to spread the knowledge and materials on scientific vegetable cultivation.

Alternative agriculture which may include a spectrum of farming systems, seeks innovative practices to integrate and take advantage of naturally occurring beneficial interactions, in order to sustain and enhance biological interations on which production agriculture depends. The aim is also to reduce the use of harmful off-farm inputs which may have deleterious effects on the environment, the farmer and the consumer. The world over, this awareness is gaining momentum. A blend of organic farming with integrated pest management (IPM), use of biocides, a better understanding of pest-predator relationship for biological control, enhancing natural processes through nitrogen fixation rather than chemically intensive methods are part of the innovative approach to production agriculture. There is an urgent need for research in this direction for developing long term sustainability of production levels and for the development of package of practices in the present context - to be useful for our homestead farmers, and small and marginal vegetable cultivators. I understand that His Grace Most Rev. Mar Gregorios, Arch Bishop of Thiruvananthapuram has a full paper in this theme for presentation here.

Vegetables are highly perishable and the bulk of the production should reach the markets, fresh. We are lagging here. The collection, storage and distribution system are grossly inadequate. Some of the chemical treatments given by farmers for enhancing appearance of freshness of vegetables could lead to health hazards. We do not have prescribed standards for enhancing post-harvest keeping qualities. There is need for evolving a cold chain system. Pre-harvest treatment of vegetables to prolong storage life and quality without residual contaminants, all need our immediate attention. Today, India exports vegetables and in this context, development of value added products, improved methods of preservation including IQF and attractive packaging are a must.

I am sure, this Summer Institute will look at all these areas, connected with tropical vegetable production. I also look forwarfor the Training Programme to enrich our participants in practical aspects of vegetable production.

Thank you.

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भारतीय कृषि अनुसंधान परिषद्
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Foreword

Since 1967, the Indian Council of Agricultural Research is the sponsoring organisation of Summer Institutes/Short Courses in different disciplines of Agriculture, Animal and allied Sciences. The whole purpose is to bring about qualitative improvement and update the teachers, researchers and extension specialists in the latest knowledge and techniques in the field of their specialisation. The participants are exposed to new knowledge and refresh their concept of basic sciences which are relevant to understand recent scientific knowledge earned in their subjects. An opportunity is provided for discussion and exchange of ideas to scientists/teachers in the same field to increase contact and to develop understanding of each other's achievements and problems. The participants are exposed to specialised techniques of teaching or research. Inter Institution Co-operative research is like-wise fostered. The proceedings of such well run short courses make excellent reservoirs of knowledge subsequently.

The ICAR, realising the importance of tropical vegetables in India's economy and more vitally in the nutritious diet of its people has now organised a short course on "Recent advances in tropical vegetable production". The short course consists of lectures delivered by eminent authorities in the field, supported by visits to vegetable research plots, laboratories and farmer's fields. The subject matter covered includes recent information on crop improvement, crop management - package of practices, diseases, pests and their management, seed production techniques and economics and marketing of tropical vegetables.

Through concerted efforts, adequate expertises are now available in tropical vegetable culture under field conditions, development of F_1 hybrids in tropical vegetables, vegetable germplasm preservation and maintenance, disease and pest resistance breeding programme, use of growth regulators, seed production techniques and useful basic studies on cytogenetics of tropical vegetables and their systematics. There has been significant research achievements in vegetable crop improvement. These include,

1. 95 improved varieties in 15 vegetable crops are recommended for release by AICVIP and 25 have been released through CVRC.

2. In resistance breeding programme varieties of brinjal, tomato and Okra are developed.

3. Six F_1 hybrids are entered for commercial productions, 4 of which are recommended by CVRC.

4. Agro techniques for optimum spacing/ fertiliser requirements, irrigation and weed control are standardised for several crops.

5. Breeder seed production is organised to supply seeds to various seed agencies for multiplication.

In spite of the above achievements, there are still many gaps which need to be bridged. The specific **areas are:**

1. Vegetable forcing technology, hydroponics, aeroponics, plastic culture of vegetables, polyhouses, polytunnels etc.
2. Genetic Engineering aspect of biotechnology - transgenosis, like induction or nodulation in tomato etc.
3. Refined technologies to produce colourless Oleoresins, processing of vegetables and low cost technology for package etc.
4. Technologies for genetic manipulation through cell fusion of otherwise unrelated species to induce desirable characteristics in vegetables.
5. Development of labour saving tools and implements as used by Japanese vegetable growers.
6. Use of environment neutral chemicals (bioinsecticides and biofertilisers)

Our country is endowed with a vide range of agroclimatic situations which enable the production of several vegetables througnout the year in one or the other part of the country thus maintaining a continuous supply of fresh vegetables. The short term (1990-95) target for vegetable production is 75 million tons with an enhanced productivity of 12.5 tons/ha. The long term target (2000 A.D.) is 120 million tons of vegetables and enhancing productivity to 15 tons/ha from the present 10 tons/ha. This is a gigantic task which demands Co-ordinated and integrated effort involving scientists, farmers, and administrators. The present compilation of information provided by eminent vegetable scientists, seed scientists and progressive farmers would serve this cause to a larger extent.

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18.7.1991.

RECENT ADVANCES IN VEGETABLE RESEARCH IN INDIA

By

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1. INTRODUCTION

1. India is a large country and is bestowed with varied agro-climatic conditions. This makes it possible to grow a wide variety of vegetable crops all the year round in one part of the country or the other.

2. Nearly 60 vegetables are grown in one or the other part of India. However, major vegetables grown in the country are;

Solanaceous Crops	:	brinjal, tomato, chillies, sweet papper (Capsicum).
Cole Crops	:	cabbage, cauliflower, knol khol
Okra	:	Okra
Bulbous vegetables	:	onion, garlic
Cucurbits	:	longmelon, muskmelon, snapmelon, watermelon, cucumber, pumpkin, summer squash, bitter gourd, bottle gourd, pointed gourd (parwal), ridge gourd, round gourd, snake gourd, sponge gourd, waxgourd (ashgourd).
Root vegetables	:	carrot, radish, turnip
Leguminous vegetables	:	broad bean, cluster bean, cowpea, dolichos bean, french bean, peas.
Leafy vegetables	:	amaranthus, beet leaf(Palak),fenugreek,spinach.
Salad vegetables	:	Lettuce.

Inaugural Address at the "Summer Institute on Recent Advances in Tropical Vegetable Production" held at Kerala Agricultural University, Vellanikhara, Trichur, from July 29-August 12, 1991.

3. India is the second largest producer of vegetables in the world next only to China with an estimated production of about 48.53 million tonnes from an area of 4.5 million hectares. It however, produces the largest number of vegetables in the world. However, the per capita consumption in India is only about 130 gm which is far below the minimum dietry requirements of 280 g/day/person.

4. In the independent India, systematic efforts have been made to upgrade vegetable production technology. However, such efforts were quite inadequate due to priority given to food grain production programmes so far. Inspite of this vegetable production in India has steadily increased from about 28 m. tonnes during 1969-71 to its present level. The demand of vegetables has been increasing fast in the urban areas with a gradual rise in standard of living coupled with development of communication and transport facilities. It, therefore, calls for a major research and development effort to achieve our target for the supply of 200 gms of vegetables per capita per day to an estimated population of 1 billion by 2000 A.D. through suitable research programmes.

2. RESEARCH INFRASTRUCTURE

2.1 Institutions/Programmes:

5. Research on vegetable crops in India, was initiated by the Indian Council of Agricultural Research(ICAR) during 1947-48 soon after independence with the sanctioning of a nucleus Plant Introduction Scheme at the Indian Agricultural Research Institute(IARI), New Delhi. Simultaneously, the ICAR started ad-hoc schemes in different states like Himachal Pradesh, Jummu and Kashmir, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal. The Govt. of India also established a Vegetable Breeding Station at Katrain in Kulu Valley, Himachal Pradesh, during 1949. This station which was subsequently transferred to the Indian Agricultural Research Institute during 1955, has been primarily carrying out intensive research on temperate vegetables and their seed production

6. Systematic research on vegetables was organised with the creation of Division of Horticulture at the Indian Agricultural Research Institute, during 1956-57. However, it received a real boost with the establishment of the Indian Institute of Horticultural Research with a full fledged Division of Vegetable Crops at Bangalore in 1968. A separate Division of Vegetable Crops and Floriculture was also started at IARI, New Delhi in 1970. In 1982, the Floriculture work was separated from the Division of Vegetable Crops which was assigned research work exclusively on Vegetable Crops. Besides IARI, IIHR and their Regional Stations at Katrain, Ranchi and Codhara, the Central Institute of Horticulture for Northern Plains at Lucknow has also been given the mandate to work on Vegetable Crops of the region. Further, Vivekanand Parvatiya Krishi Anusandhan Shala, Almora, Central Agricutural Research Institue, Port Blair and ICAR Research Complex for NEH Region Shillong are also carrying out some research work on Vegetable Crops to meet regional needs. Establishment of 26 Agricultural Universities in 17 States from 1960 onwards, gave further fillip to Vegetable Research which is being carried by their Deptts. of Horticulture and in 9 cases by separate Departments of Vegetable Crops.

7. An All India Coordinated Vegetable Impvorement Project was also started by the ICAR in 1970-71 (Fourth Plan) to provide a national grid for testing of technologies develped by various research institutes and agricultural universities through inter-disciplinary multi-location research approach. The project was started with 7 main and ten sub-centres. Three centres were added to it during the fifth, two in the sixth and two in the seventh plan. At present there are 23 centres working under this project. This project was upgraded as a Project Directorate of Vegetable Research during the VII Plan in 1987 and is undertaking multidisciplinary, multilocation research at 23 regular centres besides 42 voluntary centres. The project at present headquartered in Delhi is proposed to be shifted near Varanasi(U.P.).

8. In addition to this, a number of short term time bound and result oriented ad-hoc schemes on area specific problems of selected vegetable crops are also being supported by the ICAR at various Central Institutes and State Agricultural Universities. There is also one foreign aided project on Post-harvest Technology of some Fruits and Vegetables. A project on Protected Cultivation and Green Houses has been decided to be implemented with USAID support. The details of Infrastructure available for vegetable research vis-a-vis other horticultural crops & field crops is given in Table-1.

Table-1: EXISTING FACILITIES OF RESEARCH ON VEGETABLE CROPS

Field Crops	Institute & NRC	Project Directorate	AICRP	SAU
Cereal Crops	7	3	8	26
Commercial Crops	5	-	5	26
Oilseeds	5	1	7	26
Horticulture Crops				
Fruits	6	-	3	26
Vegetables	4	1	-	26
Potato & Tuber Crops	2	-	2	20
Floriculture & Medicinal Plants	3	-	2	16
Plantation Crops and Cashew	3	-	2	11

9. By and large vegetable research has been carried out in India by Public Institutions. However, in recent years there has been an effort to start R & D activities by some private companies with foreign collaboration. Some private companies conducting research include M/s Indo-American Hybrid Seed Co. Bangalore; M/s Mahyco, Jalna, Maharashtra; Nath Seeds, Aurangabad, Maharashtra; Suttons & Sons, Calcutta, West Bengal; Bejo Sheetal Hybrid Seeds, alna, Maharashtra; Biogene; Bangalore, Karnataka & Unicorn Group in Hyderabad, Andhra Pradesh.

2.2 Investment in Research

10. An idea of Budget allocation to different groups of horticultural and other important food crops is given in Table-2.

TABLE-2: BUDGET FOR RESEARCH ON VEGETABLES VIS-A-VIS OTHER CROPS.

Rs. in Millions

Crops	Expenditure in VII Plan (1985-90)	Suggested Allocation for VIII Plan (1990-95)
Cereal Crops	1457.31	3311.68
Commercial Crops	497.42	1040.72
Oilseeds	154.16	511.79
Total	2108.89	4861.19
Horticulture Crops		
Fruit	168.74	594.20
Vegetables	78.03	269.81
Potato & Tuber Crops	201.33	499.69
Floriculture & Medicinal Plants	29.30	127.77
Plantation Crops	196.27	549.59
Spices	39.25	138.40
Post-harvest Technology (Fruits & Vegetables)	43.06	69.60
Total Horticulture	755.98	2249.26

The amount represents allocations only to ICAR programmes and is by no way exhaustive as expenditure on vegetable research by other Institutes/ Agricultural Universities has not been included. The data in the table will show that by and large investment in vegetable research is insignificant compared to cereals and is the fourth highest amongst horticultural crops next to fruit, tuber-crops and plantation crops and higher only to floriculture and spices.

2.3 Manpower:

11. The total manpower deployed for research on different horticultural crops is given in Table-3.

TABLE-3: EXISTING MANPOWER FOR RESEARCH ON VEGETABLE CROPS VIS-A-VIS OTHER CROPS

(AS ON 1.4.1990)

Field Crop	Total	Scientific
Food Crops		
Cereal Crops	9139	2213
Cmmercial Crops	2919	688
Oilseeds	1122	419
Total	13180	3320
Horticulture Crops		
Fruits	1076	306
Vegetables	505	163
Potato & Tuber Crops	1295	347
Floriculture & Medicinal Plants	173	88
Plantation Crops	1201	232
Post-harvest Technology (Fruits & Vegetables)	212	71
Total	4462	1207

It will be seen that a total of 505 persons are engaged in vegetable research of which 163 are scientists the remaining being technical, administrative and supporting staff. Against this 1076 persons with 306 scientists are emplyed for research on fruits, 1295 with 347 scientists for potato and other tuber crops and 9139 with a component of 2213 scientists for cereal crops during the VII Plan.

3. RESEARCH ON VEGETABLES:

12. The major objectives of research on vegetables in India is improving production per unit area by solving chronic problems of production through breeding high yielding, disease & pest

resistant varieties, developing F_1 hybrids, standardisation of agro-techniques for different agro-ecological situations, disease and insect pest management and post-harvest studies with a view to reduce post-harvest losses. Twenty three vegetable. namely, amaranthus, bitter gourd, bottle gourd, brinjal, cabbage, carrot, cauliflower, chillies, cowpea, cucumber, Dolichos, frenchbean,garlic, Luffa, muskmelon, okra, onion, peas, pointed gourd, pumpkin, sweet pepper, tomato and watermelon have been included in the national research programme on vegetable crops. The salient research achievements in vegetable research are given below.

3.1 Crop Improvement:

i) New Varieties Released:

13. The evaluation of indigenous and exotic germplasm introductions, and their hybridization resulted in the selection of over 30 superior varieties of different vegetables during fiftees. Of these, varieties 'Pusa Sawani' of okra, 'Pusa Ruby' and 'Pusa Early Dwarf' of tomato, 'Pusa Purple Long' of brinjal and 'Bonneville' of garden peas still continue to be the main vegetable varieties due to their high yield potential and consumer's preference. As a result of multi-disciplinary, multi-location testing of new research materials during the last two decades, 119 improved varieties in 16 major vegetable crops have been identified and recommended for cultivation in various agro-climatic regions of the country (Table-4). These include 20 varieties of

tomato, 22 of brinjal, 13 each of onion and cauliflower, 12 of garden pea, 9 of chillies, 8 of muskmelon 4 each of water melon, pumpkin & okra, 3 of frenchbean (bush type) 2 of garlic and 1 each of Dolichos bean, cabbage, carrot, cowpea and capsicum.

TABLE-4: LIST OF VARIETIES RELEASED AT NATIONAL LEVEL UPTO 1990.

Crop	Varieties released through Central Variety Release Committee	Others
	A. SOLANACEOUS CROPS	
1. Brinjal:		
a) Long	Pusa Anupma, Pant Samart, PH-4, Pusa Kranti, Pusa Purple Cluster.	ARU-1C, ARU-2C, Azad Kranti, H-7, K-202-9, NDB-25, Pusa Perpal long.
b) Round	Jamuni Gole Baingan, Pant Rituraj.	Arka Navneet, BB-7, BWR-12, H-8, Pusa Hybrid-6, T-3.
c) Small Round	Aruna	
d) Green	-	Arka Kusumkar
2. Peppers		
a) Capsicum	-	Kt-I
b) Chillies	Andhra Jyoti, J-218, K-2, Musalwadi, Pusa Jwala, X-235	Bhagyalakshmi, LCA-206, Sel-I.
3. Tomato		
a) Determinate	HS-101, Pusa Early Dwarf, Pusa Gaurav, S-12.	BT-1, CO-3, KS-2, La-Bonita, Punjab Chhauhhara, Punjab Kesri, Sel-7.
b) Indeterminate	Arka Vikas, Pant Bahar Pant T-3.	Arka Saurabh, Pant T-2, Pusa Ruby, Sel-120, Sioux.
	B. COLE CROPS	
1. Cabbage	Pusa Mukta	-
2. Cauliflower		
a) Early	Early Kunwari, Pusa Deepali,	Pusa Early Synthetic, 235-S.
b) Mid Season	Pusa Synthetic, Pant Shubhra	Improved Japanese, Pusa Shubra.
c) Late	Pusa Snowball-1, Pusa Snowball-2 Pusa Snowball-K-1.	Snowball-16
	C. LUGUMINOUS CROPS	
1. Cowpea	-	Pusa Komal
2. Dolichos	-	Deepaliwal
3. French Bean	VL-Boni, Arka Komal Pant Anupma.	-

4.	Pea		
	a) Early	Arkel	Jawahar Matar-4, Early December, PM-2.
	b) Mid Season	Jawahar Matar-I, VL-3.	Bonneville, JP-4, Lincoln, P-88, PRS-4, Pant Uphar.

D. CUCURBITACEOUS CROPS

1.	Muskmelon	Hara Madhu, Punjab Hybrid, Pusa Sharbati	Arka Jeet, Arka Rajhans, Durgapura Madhu, Hybrid M-3, Pusa Madhuras.
2.	Pumpkin	Arka Chandan, Ambali, Pusa Vishwas	Arka Suryamukhi
3.	Watermelon	Arka Manik, Sugar Baby.	Arka Jyoti, Durgapura Meetha.

E. BULB CROPS

1.	Garlic	Jamuna Safed, Agri-Found White	-
2.	Onion		
	a) Red	Agrifound Dark Red, Arka Niketan, Pusa Madhvi	Arka Kalyan, N-2-4-1, N-257-9-1 Punjab Selection, Pusa Ratnar, Pusa Red, VL-3.
	b) White	-	Pusa White Flat, Pusa White Round, S-48.

F. ROOT CROPS

Carrot	Pusa Yamdagni	

G. OTHER CROPS

Orka	-	P-7, Parbhani Kranti, Sel-2, Sel-10(IIHR)

14. It is interesting to note that out of 119 varieties recommended by All India Coordinated vegetable Improvement Project, 52 varieties/hybrids have been released through Central Variety Release Committee for commercial cultivation in different zones of India. Moreover, the foundation and certified seeds of these varieties are being produced by the National Seeds Corporation Government of India. Besides, 74 varieties of different vegetables have been released by different states and their list is given in Table 5.

TABLE-5: LIST OF VEGETABLE VARIETIES RELEASED BY STATE VARIETY RELEASE COMMITTEE, (NOT INCLUDED IN THE NATIONAL LIST)

Crops	Variety
Solanaceous Crops	
a) Brinjal	Annamalai, Azad B-1, Co-1, Gujarat Brinjal-6 Junagadh Oblong, Kalianpur Type-3, MDU-1
b) Tomato	Azad T-2, Kalianpur Angoorlata, Kalianpur-1 NTDR-1, PKM-1, Punjab Tropic.
peppers	
Chillies	Chanchal, Co-1, CO-2, DH-76-6, Gujarat Chillies, K-1,MDU-1, Pant C-1, Sindhur
Bulb Crops	
Onion	CO-4, MDU-1, VL-Piaze-67, CO-1, CO-3, Kalianpur Red Round, Punjab-48.
Root Crops	
Radish	CO-1, Kalianpur No.1, Punjab Safed, Co- 1
Leafy Vegetables	
Methi	Co-1

Leguminous Crops

a) Cowpea	Birsa Sweta
b) French Bean	Birsa Priya (Pole), Watex (Bush)
c) Dolichos bean	Co-8 (bush), Co-9(bush), CO-10 (bush) Kalianpur T-2(Pole), Rajni (Pole).
d) Cluster bean	Durga bahar
e) Garden peas	Azad P-1, Hara Bona, JM-2, JM-3, JM-5 Madhu,Punjab-87.

Cucurbitaceous Crops

a) Ashgourd	CO-2,
b) Bitter gourd	Kalianpur Baramasi, MDU-1 & Priya, CO-1.
c) Bottle gourd	Co-1, Kalianpur Long Green
d) Cucumber	Kalianpur Green
e) Muskmelon	Gujarat Muskmelon-1, Gujarat Muskmelon-2
f) Ridge goud	CO-1, CO-2, PKM-1, Punjab Sadabahar.
g) Summer Squash	Punjab Chappan Kaddu-1
h) Snakegourd	PKM-1, CO-1
i) Sponge gourd	Kalianpur Hari Chikni
j) Tinda	S-48
k) Watermelon	Durgapura Kesar

ii) F1 Hybrids Developed:

In India , even though the first report of hybrid vigour in chillies came in 1933 from Indian Agricultural Research Institute, the first F_1 hybrid of tomato and capsicum was available for commercial cultivation only in 1973. Since then, there has been an increasing interest in growing hybrids in vegetable crops among the Indian farmers.

16. Heterosis breeding in vegetable crops in India has received serious attention only in recent years. As a result the progress in developing and popularising hybrid varieties has been very slow. The first F1 hybrid of tomato (Karnataka Hybrid) and capsicum (Bharat) were released for commercial cultivation in 1973 by a private seed company, M/s Indo-American Hybrid Seeds followed by 19 other Hybrids in 9 vegetable crops. Of the 21 F1 hybrids in 9 vegetable crops . developed so far by public research institutions, nine hybrids listed below have been recommended for commercial cultivation.

Brinjal	:	Arka Navneet, Azad Hybrid and Pusa Hybrid-6.
Bottle gourd	:	Pusa Meghdoot and Pusa Manjari
Capsicum	:	KT-1
Muskmelon	:	Punjab hybrid and M-3 Hybrid.
Watermelon	:	Arka Jyoti

17. Besides-, hybrids Pusa sanyog of cucumber, Pusa Alankar of summer squash, Pant Hybrid-1, Pant Hybrid-2, Hybrid-10 and Hybrid-11 of tomato have also been identified and recommended for commercial cultivation. In addition to F1 hybrids, two synthetic cauliflower varieties, namely, 'Pusa Synthetic' in mid.season and 'Pusa Early Synthetic' have also been recommended for release.

18. The F hybrids developed have not been fully exploited so far due to inadequate facilities for their seed production. At present there is an urgent need to simplify the technique of hybrid seed production. Various genetic mechanisms like male sterility, self-incompatibility and gynoecious sex forms need special attention to exploit :
them as female parents of the hybrids. Pioneer research work has been carried out in the Division of Vegetable Crops, IARI,

New Delhi and some female parents like self -incompatible lines in cauliflower and cabbage and gynoecious sex forms in muskmelon and cucumber have been developed and are being utilized in heterosis breeding.

19. In general, there is acute dearth of good hybrid seeds in cauliflower, cabbage, tomato and onion and taking up heterosis breeding in these crops is an immediate need.

20. Several private seedsmen have also been marketing hybrid vegetable varieties, either directly imported and relabelled or developed by crossing exotic parents and hybrid seeds produced indigenously. Some of these F_1 hybrids are in tomato "Rupali", "Vaishali", and "Naveen" from Bangalore, "Hybrid S-15", "Hybrid S-16" and "Samirudhi" from Jalna and SG-12" and SG-9" from Calcutta; in capsicum "Bharat" from Bangalore; 'Early Bounty' and Suttons Gen Gant from Calcutta: in watermelon "Madhu and Milan" from Bangalore; in cabbage "Ganesh Gole", "No. 8" and "Harirani" from Jalna; in cucumber "Priya" from Bangalore. There are many more being offered by other seedsmen as well but their adoption is comparatively slow.

iii) Disease and Pest Resistant Varieties

21. Research on breeding for disease/pest resistance has resulted in the release of twenty four varieties. 'Pusa Sawani' variety of okra developed as resistant to yellow-vein-mosaic virus is the first example of successful disease resistance breeding in vegetable crops in India. A list of resistant varieties of different crops released so far is given in Table-6.

TABLE-6: VEGETABLE VARIETIES RESISTANT TO DISEASES AND INSECT PESTS

Crop	Variety	Disease/Insect Pest	Source
Brinjal	BWR-12	Bacterial Wilt (*Pseudomonas solanacearum*)	IIHR-Bangalore
	Pant Rituraj	-do-	GBPUAT-Pantnagar
	Pant Samrat	Bacterial Wilt (*P.solanacearum*) Phomopsis Blight (*Phomopsis vexans*) Shoot & Fruit Borer & Jassids	GBPUAT-Pantnagar
	Pusa Purple Cluster	Bacterial Wilt (*P.solanacearum*)	IARI-New Delhi
	BB-7	-do-	OUAT,Bhubaneswar
	Pusa Bhairav	Phomopsis Blight (*P.vexans*)	-do-
Cabbage	SEL-8	Black Rot (*Xanthomonas campestris*)	IARI-Katrain

Cauliflower	Pusa Shubhra	Black Rot	IARI-New Delhi
	Pusa Snowball K-1	Black Rot	IARI-Katrain
Chilli	Pusa Jawala	Leaf Curl (CMV &PVY)	IARI-New Delhi
Cowpea	Pusa Koml	Bacterial Blight (Xanthomonas vignicola)	IARI-New Delhi
Muskmelon	Arka Rajhans	Powery Mildew (Sphaerothica fubginea)	IIHR-Bangalore
Okra	Sel-10	Y.V.M.Virus	IIHR-Bangalore
	Sel-2	Y.V.M Virus	NBPGR-New Delhi
	P-7	Y.V.M.Virus	PAU-Ludhiana
	Parbhani Kranti	Y.V.M.Virus	MAU-Parbhani
Pea	PRS-4	Powdery Mildew	GBPUAT-Pantnagar
	PM-2	Powdery Mildew	GBPUAT-Pantnagar
	JP-4	Powdery Mildew & Rust (Uromycess pisi)	JNKVV-Jabalpur
Tomato	BT-1	Bacterial Wilt	OUAT-Bhubaneswar
	Pant Bahar	Varticilium Wilt (Verticicum sps) & Fusarium Wilt (Fusarium Oxysporum)	GBPUAT-Pantnagar
	SEL-120	Root Knot Nematode (M.incognita M.arneria & M. javanica	IARI-New Delhi
Watermelon	Arka Manik	Anthracnose (Colletorichum lagenarium) Powdery Mildew (Sphaerotheca fuligenea) Downy Mildew (Pseudoperonospora cubensis)	IIHR-Bangalore

3.2 Agrotechniques:

22. Besides the development of a number of high yielding varieties, efforts have been made to develop package of practices for getting maximum economic returns. A large number of agronomical practices have also been developed to grow almost all vegetable crops under varied agro-climatic conditions. Similarly several control measures for protecting these crops from the attack of various diseases and insect pests have been found out. Under the All India Coordinated Research Project alone 34 agronomical recommendations relating to spacing, nutritional requirements, irrigation and weed control in 11 vegetable crops, namely brinjal, cabbage, cauliflower, chillies, muskmelon, okra, onion, peas, radish, tomato, and watermelon have been made. For chemical control of major diseases and insect-pests recommendations have been made in 11 vegetable crops namely; bottle gourd, brinjal, cauliflower chillies, muskmelon, okra, onion, peas, tomato, turnip and watermelon. Thus 55 measures against major diseases and insect-ests have been standardised. Recommendations have also been made for increasing yield of tomato and brinjal by application of chemical growth regulators like mixatalol and 2,4-D respectively.

23. Technology has been developed and perfected for the production of vegetable seeds in general and that for temperate vegetables in the hilly region of the country in particular. Techniques for post-harvest management are also being developed.

3.3 Breeder Seed Production:

24. Since availability of superior quality seeds is the most important single input for production of vegetable crops tremendous attention is required to be paid on strengthening of research on seed production technology of these crops. Therefore, the efforts for research and production of Breeder's Seed of these crops are being intensified. Accordingly, production of Breeder's Seed of

vegetables has been included in the National Seeds Project during the Seventh Plan which is operating at eleven centres, namely; IARI Karnal (Haryana), IARI Katrain (H.P.), IIHR Bangalore (Karnataka), PAU Ludhiana (Punjab); CSAUAT, Kanpur (U.P.), BCKVV Pedong (W.B.), MPKV Rahuri (M.S.), YSPUHF Solan (H.P.), JNKVV Jabalpur (M.P.), APAU Lam (A.P.), and TNAU Coimbatore (T.N.). About 100 tonnes of breeders seed is being produced annually against an average requirement of 36 tonnes which forms the basis of multiplication of superior quality foundation and certified seed. Even this limited quantity of breeders seed is not being utilized properly. The largest beneficiary of the breeder seed viz. N.S.C. is presently producing only about 650 tonnes of certified seed whereas private seed industry contributes about 2000 tonnes besides contribution of other certified state seed agencies amount to 500-1000 tonnes. Thus present quality of breeder seed could have fulfilled certified seed requirement to the extent of 30%, it is doing so only to the extent of 13-15% . Recently the Govt. of India has launched a scheme on intensification of vegetable producutuion through which funds have been put at the disposal of central institutes and the state agricultural universities to intensify production of breeders foundation and certified seed to overcome the wide gap in seed requirement. The result of these efforts are yet to be known. The new seed policy of the Govt. of India affords enough opportunity of introducing new useful genes through the import of improved vegetable varieties and F_1 hybrid seeds. This may pave the way for utilizing these promising genes for developing new high yielding, disease and insect-pest resistant varieties and F_1 hybrids possessing tolerance to abiotic factors.

4. IMPACT OF VEGETABLE RESEARCH & MANAGEMENT

25. Development of a large number of improved varieties and wider adaptability and standardisation of their production technologies for various agro-climatic conditions has made it possible to produce vegetables in wider areas and has improved the prospects of their supply tremendously as follows.

i) **Garden pea:** variety **'Arkel'** has revolutionised the production of early peas in all pea growing areas.

ii) **Cauliflower:** variety **'Pusa Early Synthetic'** has adapted to warm climtic conditions of Tamil Nadu and has made it possible to grow cauliflower commercially in this non-traditional area.

iii) **Watermelon:** variety **'Sugar Baby'** has spread fast in entire Northern and Eastern India and has benefitted both the growers with better remuneration and the consumers with superior quality. Another variety **'Arka Manik'** has made a dent in the Southern and South-Western parts of the country.

iv) **Okra:** variaty **'Pusa Sawani'** bred for resistance to yellow vein mosaic virus prone areas/seasons replaced all other local varieties from cultivation all over the country.

v) **Tomato:**variety Pusa **'Sel-120'**has made it possible to achieve high yields of quality produce in root-knot nematode infested soils.

vi) **Radish:** with appropriate choice of suitable varieties for spicific seasons now we can grow **radish** round the year.

vii) **Tomato:** With the released of cold tolerant variety **'Pusa Sheetal'**, we can now grow **tomatoes** all the year round.

viii) **Onion:**Until 1978, Kharif onion cultivation was only common in Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu. However, identification of variety **N-35** and development of technology for kharif onion has enabled to get two crops of onion annually in Northern India where it used to be only a winter/spring crop.

ix) F_1 Hybrids: There has been an alround appreciation of growing of F_1 hybrids in vegetable crops. Sizeable area of 20,000 ha. is estimated to be covered under tomato hybrids in Karntaka, Maharashtra & Southern Gujarat. Similarly the area under F_1 hybrid of cabbage is estimated at about 8,000 ha.

5. GAPS AND CONSTRAINTS:

26. Despite a large number of varieties and hybrids developed, the productivity of vegetable crops has not improved. Varieties with longer shelf life and suitable for processing are very few. Multiple disease resistant varieties are yet to be developed. Although a lot of work on heterosis breeding in vegetable crops has been done in the country, yet there is acute dearth of real good hybrids

in crops like tomato, cabbage, cauliflower, onion etc. Vegetable based cropping systems have not been developed so far, which puts these crops at a disadvantage for fitting them in crop rotations. Excessive use of pesticides has created problems of pesticide residues and hence there is a need for integrated pest and disease control.

Briefly, these gaps are identified as follows:-

i) Insufficient germplasm in different vegetable crops and the need to augment indigenous and exotic-collections.

ii) Lack of new high yielding vegetable varieties/hybrids, carrying high degree of resistance to diseases, pests, environmental stresses etc.

iii) Absence of basic/fundamental research programmes to accelerate the work on applied aspects.

iv) Lack of competent scientific manpower to manage the research programmes.

v) Lack of infrastructure and fund availability for research on vegetables.

6. FUTURE RESEARCH PRIORITIES:

27. While significant progress has already been made there are still several problems to be tackled. For this, the following research priorities have been identified for the VIII Plan.

1) Breeding for resistance to abiotic factors viz diseases and insect-pests such as:-

Tomato	:	leaf curl virus, TMV bacterial wilt, phytopthora blight, fruit borer.
Brinjal	:	fruit and shoot borer, bacterial wilt, little leaf.
Okra	:	yellow vein mosaic and pod borer.
Chillies/ capsicum	:	virus and pest complex
Onion	:	purple blotch, stemphylium (moth and thrips).

Cucurbits : downy mildew, powdery mildew, CMV, fruit fly.

Cole crops : Sclerotinia, Alternaria and soft rot.

Peas : Powdery mildew

Beans : Septoria, mosaic virus and bruchus

2) Breeding for resistance to abiotic stresses e.g. salinity, alkalinity, salt tolerance and stress environment e.g., hot set and cold set tomatoes.

3) Heterosis breeding in onion, tomato, cabbage, cauliflower, cucurbits brinjal, and capsicum.

4) Breeding for nutritional and processing qualities in vegetables like tomato, onion, peas and garlic (dehydration).

5) Use of biotechnology for incorporation of resistance to disease/pests/abiotic stresses.

6) Intensification of research on seed production of temperate, tropical and sub-tropical vegetables and intensification of breeders seed production programme.

7) Export oriented research on vegetables like onion, chillies, okra, peas, tomato, brinjal, cucumber, cauliflower and cabbage.

8) Developing efficient cropping systems.

9) Research on growing vegetables in protected environments.

10) Research on off-season vegetable production and under exploited vegetables.

11) Studies on insecticidal residues.

SUMMARY

28. Our country has achieved self sufficiency and a good degree of stability of food production. This has created an urgent need for providing health security to our one population by supplying nutrition through balanced diet. Vegetables from the most important component of a balanced diet. We can grow a wide variety of vegetables (about 60) all the year round. The country is the world's second largest producer of vegetables next only to China. However our per capita consumption is quite low.

29. In the post partition period a good infrastructure for vegetable research has been created. At present vegetable research is being carried out at four central institutes, one National Research Centre and 26 State Agricultural Universities. The All India Coordinated Research Programme of the Project Directorate of Vegetable Research provides facilities for multidisciplinary, area specific research on 23 vegetable crops and provides a national grid for multilocation testing of technologies developed by various institutions. As a result research on various aspects of major vegetable crops is being undertaken in order to improve existing varieties and standardise production techniques. The investment in vegetable research is insignificant compared to cereals so is the manpower deployment.

30. Through intensive research efforts 119 improved varieties in 16 vegetable crops have been released. Of these, nine are F_1 hybrids, two are synthetic cauliflower varieties and 24 varieties are resistant to different diseases and insect pests. Some of these varieties have already made significant impact/confribution in revolutionising the production of vegetables in the country. Besides developing new varieties several agro-techniques and plant protection measures against diseases and insect pests have been standardised and recommended. Systematic efforts are also on to achieve self sufficiency in seed production, though the goal is quite far.

31. Several biotic constraints pertaining to non availability and erosion of germplasm and its evaluation, diseases and insect pests, manpower, abiotic factors such as limited availability of funds, physical environmental and soil factors and seasonal problems, socio-economic factors and limitations of infrastructure are limiting vegetable research in India.

32. The priorities of research in years to come have been identified as breeding for resistance to biotic and abiotic stresses, heterosis breeding, breeding for improvement of nutritional quality and processing, seed technology research, development of technlogy for growing vegetables in protected environment, use of biotechnology, insecticidal residues and off season vegetable production etc.

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An overview of research and development in tropical vegetables

Kirthi Singh* and K.V. Peter**

Vegetable research in India got momentum in the 50's, with the sanctioning of a nucleus plant introduction scheme at IARI, New Delhi. The late Dr. Harbhajan Singh who headed the division of plant introduction, deserves acclaim for his well foresighted and acumen mind, which has given varieties like Pusa Sawani in bhindi, Pusa Purple Long, Pusa Purple Round and Pusa Purple Cluster in brinjal still held in esteem by the Indian Vegetable growers. The Indian Council of Agricultural Research organised an exclusive co-ordinated research project in 23 centres spread over 8 different agroclimatic zones of India for improvement of vegetables. The project is now elevated into the status of a Project Directorate. The mandate of the Project Directorate is to solve problems, facing vegetable growers of the country and thereby boosting the national income. In India, vegetables are grown over an area of 4 million ha. with a production of 40-45 million tonnes. The present productivity is only 10 t/ha. The short term objective (1990-1995) is to increase the area to 6 million ha and production to 75 million tonnes and increasing productivity to 12.5 t/ha. The long term goal (2000 A.D.) is to further increase the area to 8 million ha. and production to 120 million tonnes. The productivity is to be raised to 15 t/ha.

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The present scenario

A large number of tropical vegetables with considerable nutritive value are grown in India (Table 1). Chillies have the highest average nutritive value of 27.92 and watermelon the lowest (0.90). The poor man's spinach', Amaranth has a fair value of ANV (11.32). In a country like India with problems of vitamin A deficiency and mineral undernutrition, the emphasis on Amaranth needs to be stressed. Vegetables are grown throughout India, the state of Orissa occupying the highest area followed by Uttar Pradesh and Bihar (Table 2). The prospect for further enhancing the area may be limited and the option is to increase productivity per unit of land per unit of time.

Conservation of tropical vegetable germplasm is a high priority item of research to boost up productivity and sustain its maintenance. India is a primary centre of origin for brinjal, a few cucurbits and a few leaf vegetables. There is an international network maintaining and supplying valuable genetic materials in tropical vegetables (Table 3). The National Bureaux of Plant Genetic Resources, New Delhi is the nodal agency for services dealing with vegetable germplasm.

Being a vast country with considerable variations in ecology, weather and climate, a recent agroclimatic approach is suggested for the development of vegetable programmes in the country. (Table 4). The formerly suggested eight zones are elaborated into 15 agro-climatic zones.

Organizations, sources of funding and their mandates

Considering the importance of tropical vegetables in human nutrition, many organisations have programmes to fund research projects (Table (5). The Indian Council of Agricultural Research

Table 1. Nutritive value of important tropical vegetables (per 100g of edible portion)

Sl. No.	Name of Vegetables	Energy K Cal.	Fibre g.	Protein mg.	Calcium mg.	Iron mg	Vitamine A mg	Thiamine mg.	Riboflavin mg	Vitamin C mg	Average nutritive value
1	2	3	4	5	6	7	8	9	10	11	12
1.	Tomato	20	0.7	1.2	7	0.6	0.5	0.6	0.04	23	2.39
2.	Brinjal	26	1.0	1.6	22	0.9	124.0	0.8	0.07	6	2.14
3.	Chillies	116	15.0	6.3	86	3.6	6.6	0.37	0.051	96	27.92
4.	Lady's finger	31	0.9	0.8	90	1.0	0.1	0.07	0.08	18	3.21
5.	Cucumber	12	0.5	0.6	21	0.4	0.1	0.03	0.04	11	1.69
6.	Pumpkin	27	0.8	0.7	24	0.7	0.8	0.03	0.04	14	2.68
7.	Watermelon	21	0.1	0.6	8	0.2	0.1	0.03	0.03	6	0.90
8.	Ashgourd	10	0.8	0.4	30	0.8	-	0.06	0.10	1	-
9.	Snakegourd	18	0.8	0.5	50	1.1	160 IU	0.04	0.06	0	-
10.	Bittergourd	19	1.0	0.8	26	2.3	0.1	0.06	0.04	57	4.10
11.	Bottle gourd	12	0.6	0.2	20	0.7	0	0.03	0.01	6	-
12.	Cowpea	51	2.0	4.3	80	2.5	941 IU	0.07	0.09	13	-
13.	Winged bean	-	2.6	2.9	330	1.7	0.54	0.06	0.12	37	-
14.	Dolichos bean	48	1.8	3.8	210	1.7	312 IU	0.10	0.06	9	-
15.	Amaranth	26	1.3	3.6	154	2.9	6.5	0.04	0.22	23	11.32

(contd.)

Table contd.

1	2	3	4	5	6	7	8	9	10	11	12
16.	Tapioca	159	0.6	0.7	50	0.9	-	0.50	0.10	25	-
17.	Colocasia	97	1.0	3.0	40	1.7	40 IU	0.06	0.03	63	-
~~18.~~	~~Amorphophallus~~	~~79~~	~~0.8~~	~~1.2~~	~~50~~	~~0.6~~	~~434 IU~~	~~0.06~~	~~0.07~~	~~-~~	~~-~~
19.	Sweet Potato	120	0.8	1.2	20	2.8	10 IU	0.08	0.04	24	-
20.	Drumstick	26	4.8	2.5	30	5.3	110 IU	0.05	0.07	120	-
21.	Chekkurmanis	103	1.4	6.8	570	28.0	5706 ug	0.48	1.32	247	-
22.	Agathi	93	212	8.4	1130	3.9	5400 ug	0.21	0.09	1.2	-

Source - Indian Council of Medical Research, Hyderabad, India 1980 and
Kerala Agricultural University, Vellanikkara, Trichur, Kerala 1982.

Table- 2 : Area under vegetable crops in India (82-83) in various states.

State/Union territory	Area (000 ha)	
Andhra Pradesh	84	
Assam	120	
Bihar	313	III
Gujarat	79	
Haryana	36	
Himachal Pradesh	21	
Jammu & Kashmir	15	
Karnataka	108	
Kerala	291	
Madhya Pradesh	123	
Maharashtra	137	
Manipur	2	
Meghalaya	27	
Nagaland	9	
Orissa	593	I
Punjab	63	
Rajasthan	44	
Sikkim	3	
Tamil Nadu	110	
Tripura	18	
Uttar Pradesh	465	II
West Bengal	304	
A&N Islands	1	
Arunachal Pradesh	6	
Delhi	5	
Pondicherry	1	
All India	2980	

Source : Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India.

Table 3. Directory of tropical vegetables

Vegetables	Country of deposit	Institute
Abelmoschus	Brazil	Departmento de fitotechnica Universidade federal de vicosa. 36.570, vicosa, MG.
	Ghana	Plant introduction & exploration crop Research Institute Box 7, Bunso
	India	NBPGR, IARI Campus, New Delhi 110012.
	Iraq	Plant Genetic Resources Unit, Agricultural Research Centre, Abughraih.
	Ivory Cost	Laboratoire de genetique, office de la recherche scientifique et technique d outermer (ORSTOM) centred' Adiopodoume BP V-51 Abidjan
	Mali	Station de RECHERCH AGRONOMICUS - sotuba BP 438. Bamako.
	Nigeria	National horticultural research institute (NIHORT) Idi-ischin PMP 5432 Ibedan.
	Pakistan	Plant genetic Resources Laboratory, Agricultural Research Council (ARC) PO Box - 1031 Islamabad.
	Papua New Guinea	Lowlands Agricultural Experiment Station. Department of Primary Industry Keravat.
		Department of Agriculture
		University of Papua New Guinea PO Box 4820, Port Moresby
	Philippines	Institute of Plant Breeding (IPB) University of the Philippines at Los Banos, Laguna 3720.

Vegetables	Country of deposit	Institute
	Turkey	Aegen Regional Agricultural Research Institute (ARARI) Menemen Izmir
	United States of America	National Seed Storage Laboratory (NSSL) U.S. Department of Agriculture (USDA) Colorado State University Fort Collins, Colorado 80523 Southern Regional Plant Introduction Station (S-9) USDA Experiment, Georgia 30212.
	Upper Volta	Station de Recherche Kamboinse, Institute Voltaique de Recherche Agronomique et Zootechnique (IVRAZ) B.P. 7192 Ouagadougou
Amaranths	Bolivia	Estacion Experimental de Patacamaya Instituto Boliviano de Technologia Agropecuaria (IBTA) Patacamaya
	China	Asian Vegetable Research and Development Centre (AVRDC) P.O. Box 42 Shanhua Tainan Taiwan
	Germany-Democratic Republic	Zentralinstitut fur Genetik and kulturpflanzenforschung Corrensstrassee 3 4325 Gatersleben
	India	National Bureau of plant Genetic Resources (NBPGR) Indian Agricultural Research Institute (IARI) Campus, New Delhi 110012.

Vegetables	Country of deposit	Institute
		Regional Station, NBPGR Phalgi Simla 171 004 Faculty of Horticulture TNAU Coimbatore 641 003.
	Indonesia	National Biological Institute P.O. Box 110 Bogor
	Nigeria	National Horticultural Research Institute (NIHORT), Idi-Ishin PMB 5432. Ibadan
	Peru	Estacion Experimental de Camacani Universidad Nacional Tecnica del Altiplano Puno Centro de investigacion de cultivos Andinos, Universidad Nacional del cusco, Avenida de la inflancia 440 Huanchac Cusco
	Thailand	Fang Horticultural Experimental Station, Department of Agriculture Fang, Chiang Mai
	United Kingdom	Royal Botanic Gardens, kew wakehurst Place, Ardingly Haywards Heath, Sussex RH 17 6 TN
	United States of America	Organic Gardening & Farming Research Centre (OGFRC) P.O. Box 323 Kutztown, Pennsylvania 19530 National Seed Storage Laboratory (NSSL), USDA, Colorado State University, Fort Collins, Colorado 80523.
	Zambia	Crop Science Department School of Agricultural Sciences University of Zambia P.O. Box 2379, Lusaka

Vegetables	Country of deposit	Institute
Capsicum	Australia	Department of Primary Industries Common wealth Scientific and Industrial Research Organization (CSIRO) Horticultural Research Station, P.O. Box 538, Bowen, Queensland 4805
	Austria	Institute fur pharmakognosie der universitat Wien Waheinger strasse 25, 1090 Vienna
	Brazil	Departmento de Fintotecnica Universidade Federal de Vicosa 36. 570 - Vicosa - M.G.
	Bulgaria	Institute of Plant Introduction and Genetic Resources, 4122 Sadovo.
		Maritsa Institute for Vegetable Crops ul. Brexovsko shosse 32 4003 plovliv.
		Institute of Genetics and Plant Breeding. Bulgarian Academy of Sciences. Sofia 1113.
	Colombia	Centro Experimental Palmira Instituto Colombiano Agropecuario (ICA) AA 233. Palmira Valle
	Costa Rico	Unidad-de. Recursos Geneticos Centro Agronomico Tropical de Investigacion. y, Ensenanxa (CATIE) Apartado 74, Turrialba
	Czechoslovakia	Dept. of genetic Resources Division of Genetics and Plant Breeding Methods Research Institute of Plant Production Ruzyne 507

Vegetables	Country of deposit	Institute
	El. Salvador	Centro Nacional de Tecnologia Agropecuaria (CENTA) km 33-1/2 carretere a santa Ana San Andres, La Libertad
	Ethiopia	Plant Genetic Resources Centre (PGRC) P.O. Box 30726. Addis Ababa
	France	Station d' Amelioration des plantes Maraicheres, Institute National de la Recherche Agronomique (INRA) Domain Saint - Maurice 84140 Montfavet - Avignon
	Germany	Zentralinstitut fur Genetik and kulturpflanzen forschung corrensstrasse 3, 4325 Getersleben
	Greece	Greek Gene Bank, Cereals Institute North Greece Agricultural Research Centre Thessaloniki
	Hungary	Research Station Butateteny Vegetable Crops Research Institute pf. 108, park u.2, 1775 Budapest
		Research Centre for Agrobotany National Institute for Agricultural variety Testing (NIAVT) 2766 Tapioszek.
	India	National Bureau of Plant Genetic Resources (NBPGR) IARI campus, New Delhi 110 012
		Regional Agrl. Research Station Andhra Pradesh Agrl. University, Lam, Guntur 522 034, A.P.

Vegetables	Country of deposit	Institute
	Italy	Instituto del Germoplasma via G. Amendola 165/A 70126 Bari
		Instituto di Miglio ramento genetico eproduxione delli sementi Universita degli Studi, Via Pietro Giuria, 15, 10126 Torino
	Japan	Seed Storage Laboratory Division of Genetics, Department of Physiology and Genetics, National Institute of Agrl. Sciences (NIAS) Tsukuba, Ibaraki 305.
		Plant Germplasm Institute Faculty of Agriculture, Kyote University, Nakafol, Mozume, Mukoshi Kyoto 617.
	Mexico	Unidad de Recursos Geneticos Centro de Investigaciones Agricolas de El Bajio (CIAB)
		Instituto Nacional de investigacions Agricolas (INIA), AP 112, Celaya Guanajuato
	Netherlands	Institute for Horticultural Plant Breeding (IVT), P.O. Box 16, 6700 AA Wageningen.
	Nigeria	National Horticultural Research Institute (NIHORT) Idi-Ishin PMB 5432 Ibadan
	Peru	Programa de investigacion in Hortalixas, Universidad National Agraria, A.P. 456, La Mobra, Lima
	Phillippines	Institute of Plant Breeding (IPB) University of the Philippines at Los Banos, Laguna 3720.

Vegetables	Country of deposit	Institute
	South Africa	Division of Plant and Seed Control pvt. Bag x 179, Pretoria 0001.
	Spain	Centro Regional de Investigacion Y Desarollo Agrario (CRIDA 3), Institute Nacional de Investigaciones Agrarias (INIA) A.P. 202 Carretera de Montanana 177 Laragaza 16
	Thailand	Division of Horticulture, Dept. of Agriculture, Bangken, Bangkok 9
	Tunisia	Insttitut National de la Rechuche Agronomique de Tunisie Avenue de l' Independance Ariana
	Turkey	Aegean Regional Agrl. Research Institute (ARARI) P O Box 9 Menemen, IzMir
	USSR	N.I. Vavilov All-Union Institute of Plant Industry (VIR) Herzen Street 44, 190000 Leningrad
	UK	Dept. of Plant Biology University of Birmingham P.O. Box 363 Birmingham B 15 2TT
		Dept. of Agrl. Botany University of Reading Whiteknights Readings RG6 2AS
	USA	National Seed Storage Laboratory (NSSL) USDA, Colorado State University Fort Collins, Colorado 80523

Vegetables	Country of deposit	Institute
		Southern Regional Plant Introduction Station (S-9) USDA Experiment Station, Georgia 30212
		North East Regional Plant Introduction Station (NE-9), USDA, New York State Agrl. Experiment Station Geneva, Noew York 14456.
		Dept. of Vegetable Crops, University of California Davis, California 95616.
		Dept. of Botany Miami University Oxford, Ohio 45056
Cucurbitaceae	Argentina	Estacion Experimental Regional Agropecuaria de pergamino Institute Nacional de Tecnologia Agropecuaria (INTA) CC 31, Pergamine Buenos Aires.
		Estacion Experimental Agropecuaria Sanpedro, Institute Nacional de Technologia Agropecuaria (INTA) CC 43, 2930 San Pedro, Buenos Aires.
	Brazil	Departmento de Fitotechica Universidade Federal de Vicosa 36. 570 - Vicosa - M.G.
		Centro Nacional de pesquisa de Hortalicas (CNPH) Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) C.P. 11.13.16 70.000 - Brasilia - D.F.

Vegetables	Country of deposit	Institute
	Bulgaria	Institute of Plant Introduction and Genetic Resources, 4122 Sadovo.
		Maritsa Institute for Vegetable Crops ul. Brezovsko Shosse 32, 4003 plovdiv
	Colombia	Centro Experimental Palmira Institute Colomiano Agropecuario (ICA) A.A. 233, Palmira Valle
	Costa Rica	Unidad de Recursos Geneticos Centro Agronomico Tropical de Investigacion of Ensenanza (CATIE) Apartado 74, Turrialba
	Czechoslovakia	Dept. of Genetic Resources, Division of Genetics and Plant Breeding Methods, Research Institute of Plant Introduct-ion Ruxyne 507, 16106 Prague 6
	Ethiopia	Plant Genetic Resources Center (PGRC) P.O. Box 30726 Addis Ababa
	France	Station de Amelioration des plantes Maraicheres, Institut National de la Rechercha Agronomique (INRA) Domaine Saint-Maurice 84140 - Montfavet -Avignon
	Germany-DR	Zentralinstitut furgenetik and kulturpflanz enforschung Corresnstrassez 4325 Gatersleben
	Hungary	Research Centre for Agrobotany National Institute for Agrl. Botany National Institute for Agrl. variety Testing (NIAVT) 2766 Tapioszele.
		Research Station Budateteny Vegetable Crops Research Institute pf 108, park 42, 1775 Budapest

Vegetables	Country of deposit	Institute
	India	Regional Station, NBPGR, Phalgi Simla 171004
		Regional Station, NBPGR, Vellanikkara PO Trichur, Kerala
		Dept. of Olericulture, College of Horticulture, KAU, P.O. Vellanikkara, 680 654, Trichur, Kerala
		Vivekananda Parvatiya krishi Anusandhan Shala, Almora, UP
	Iraq	Plant genetic Resource Unit Agrl. Research Centre, Abu Ghraib
	Italy	Institute del Germoplasma, via G. Amendola, 165/A, 70126 Bari.
	Japan	Seed storage Laboratory Division of Genetics, Dept. of Physiology and Genetics, NIAS, Tsukuba, Ibaraki 305
	Mexico	Unidad de Recursos Geneticos Centro de Investigaciones Agricolas de El Bajio (CIAB) Institute Nacional de Investigacions Agricolas (INIA), AP 112, Celaya Guanajuato.
	Netherlands	Institute of Horticultural Plant Breeding (IVT), P.O. Box 16, 6700 AA Wageningen
	Nigeria	NIHORT, Idi-Ishin, PMB 5432, Ibadan
	Pakistan	Plant Genetic Resources Laboratory Agrl. Research Council (ARC) P.O. Box 1031 Islamabad
	Peru	Programa de Investigacion en Hortalizas, Universidad Nacional Agraria AP 456 Lamolina, Lima

Vegetables	Country of deposit	Institute
	Philippines	Institute of Plant Breeding (IPB) University of the Philippines at Los Banos, Laguna 3720.
	Poland	Dept. of National Plant Resources Plant Breeding and Acclimatization Institute (IHAR), Radzikow K. Warwy 05-870 Blonie
	South Africa	Division of Plant and seed control Pvt. Bag x 179, Pretoria 0001
	Spain	Instituto Nacionalde Investigaciones Agrarias (INIA) Jose Abascal 56, Madrid
	Thailand	Dept. of Horticulture Faculty of Agriculture Kasetsart University, Bangkhen Bangkik 9
	Turkey	Aegean Regional Agrl. Research Institute (ARARI), P.O. Box 9, Menemen, Izmir
	USSR	N.I. Vavilov All Union Institute of Plant Industry (VIR) Herzen street 44, 190 000 Leningrad.
	USA	NSSL, USDA, Colerado State University, Fort Collins, Colorado 80523
		North Central Regional Plant Introduction Station (NC-7) USDA, Lowa State University Ames, Lowa 50010.
		Southern Regional Plant Introduction Station (S-9) USDA Experiment, Georgia 30212

Vegetables	Country of deposit	Institute
		Northeast Regional Plant Introduction Station (NE-9), USDA, Newe York State Agrl. Experiment Station Geneva, New York 14456
		Dept. of Plant Science, University of Arizona, Tucson, Arizona 85721
		Imperial Valley conservation Research Centre 4151, Highway 86, Brawley California 92227.
Lycopersicon	Argentina	Estacion Experimental Regional Agropecuaria Alto Valle de Rio Negro Instituto Nacional de Tecnologia Agropecuaria (INTA) CC. 52 8332 General Roca, Rio Negro.
	Australia	Dept. of Primary Industries Commonwealth Scientific and Industrial Research Organisation (CSIRO) Horticultural Research Station P.O. Box 538. Bowen, Queensland 4805
	Brazil	UEPAE de cascata Empresa Brasileira de pesquisa Agropecuaria (EMBRAPA) C.P. 403. 96. 100-pelotus - R.S.
		Departmento de Fitotecnica Universidade Federal de Vicosa 36-570-Vicosa - M9
	Bulgaria	Institute of Plant Introduction and genetic Resources 4122 Sadovo
		Maritsa Institute for Vegetable Crops ul. Brezovsko shosse 32. 4003 Plovdiv.
	Canada	Central Office for the Plant gene Resources of Canad (PGR) Research Station, Agriculture Canada Building 75, Ottawa, Ontario KIA oc6

Vegetables	Country of deposit	Institute
	China.	AVRDC, P.O. Box 42, Shanhua, Tainan, Taiwan.
	Colombia	Centro Experimental Palmira Institute Colombiano Agropecuario (ICA) A.A. 233 Palmira Valle
	Costa Rica	Unidad de Recursos Geneticos Centro Agronomico Tropical de Investigacion Y Ensenanza (CATIE) Apartado 74, Turrialba
	Cuba	Instituto de Investigaciones Fundamentales en Agriculturea Tropical (INIFAT), "Alezandro de Humbolt" Calle 1ª esq 2ª Santiago de las Vegas Cindad Habana
	Czechoslovakia	Dept. of Genetic Resources Division of Genetics and Plant Breeding Methods Research Institute of Plant Production Ruzyne 507, 161 06 Prague 6
	Ecuador	Instituto de ciencias Natuarales Universidad Central de quito Casilla 633 Quito
	Elsalvador	Centro Nacional de Tecnologia Agropecuaria (CENTA) km 33-1/2 Carretera a santa Ana San Andres, La Libertad.
	France	Station d' Amelioration des Plantes Maraicheress, Institut National de la Rechercha Agronomique (INRA) Domaine Saint Maurice - 84140 Mont favet - Avignon

Vegetables	Country of deposit	Institute
	Germany DR	Zentralinstitut flu Genetik and Kulturpflanzenforschung Corrensstrasse 3, 4325, Gatersleben
	Ghana	Horticultural section Crops Research Institute, P.O. Box 3785 Kwadaso, Kumasi
	Hungery	Research Centre for Agrobotany, NIAVT 2766. Tapioszele
	India	NBPGR, IARI Campus, New Delhi 110012.
	Iraq	Plant Genetic Resources Unit Agrl. Research Centre, Abu Gharaib
	Italy	Instituto del germoplasma Via. G. Amendola, 165/A, 70126 Bari
	Japan	Seed Storage Laboratory Division of Genetics Dept. of Physiology and Genetics NIAS, Tsukuba, Ibaraki 305
	Netherlands	Institute for Horticultural Plant Breeding (IVT), P.O. Box 16 6700 AA Wageningen
	Newzealand	Crop Research Division Dept. of Scientific and Industrial Research, Private Bag, Christchurch
	Nigeria	NIHORT, Idi-Ishin, PMB 5432 Ibadan
	Peru	Programma de Investigacion en Hortalizas, Universidad Nacional Agrarka, A.P. 456, La Molina, Peru.
	Philippines	IPB, University of the Philippines at Los Banos, Laguna 3720

Vegetables	Country of deposit	Institute
	Poland	Dept. of National Plant Resources IHAR, Radzikow K. Warszawy 05-870 Blonie
	South Africa	Division of Plant and seed control pvt. Bag x 179 Precatoria 0001
	Thailand	Division of Horticulture Dept. of Agriculture Bangken, Bangkik 9
		Faculty of Agriculture Chiang Mai University, Chiang Mai
	Turkey	Aegean Regional Agrl. Research Institute P.O. Box 9, Menemen, Izmir
	USSR	Nivavilor All-Union Institute of plant Industry, Herzen Street 44, 190000 Leningrad
	USA	NSSL, USDA Colorado State University Fort Collins, Colorado 80523
		North Central Regional Plant Introduction Station (NC-7) USDA, Lowa State University Ames, Lowa 50010.
		Northeast Regional Plant Introduction Station (NE-9), USDA, New York State Agrl. Experiment Station, Geneva, New York 14456.
		Dept. of Seed and Vegetable Sciences New York State Agrl. Experiment Station Geneva, New York 14456.
		Campbell Institute for Agrl. Research Campbell soup Company Campbell Place, Cam den, New Jersey 08101

Vegetables	Country of deposit	Institute
		Tomato Genetic Stock Centre (TGSC) Dept. of Vegetable Crops University of California, Davis, California 95616.
Solanum	Costa Rica	Unidad de Recursos Geneticos Centro Agronomico Tropical de Investigation Y Ensenanza (CATIE) Apartado 74, Turrialba.
	Czechoslovakia	Dept. of Genetic Resourses Division of Genetics and Plant Breeding Methods Research Institute of Plant Production Ruzyne 507, 161 06 Prague 6
	El Salvador	Centro Nacional de Tecnologia Agropecuaria (CENTA) Km 33-1/2 carretera a santa Ana San Andres, La Libertad
	France	Station d' Anelioration desplantes Maraicheres Institut National de la Recherche Agronomique (INRA) Domaine Saint-Maurice 84140 Mont favet - Avignon
	Germany DR	Zentralinstitut fur genetik and Kulturpflunzenfor schung Corrensstrasse 3, 4325 Gatersleben
	Ghana	Plant Introduction and exploration Crops Research Institute Box 7, Bunso
	India	Division of Vegetable Crops & Floriculture, IARI, New Delhi 110 012. NBPGR, IARI Campus, New Delhi 110 012.

Vegetables	Country of deposit	Institute
	Iraq	Plant Genetic Resources Unit Agrl. Research Centre Abu Ghraib
	Italy	Instituto del germplasma Via G. Amendola, 165/A 70126 Bari
	Ivory coast	Centre Neerlandais Office de la Recherche Scientifique et Technique d' outre Mer (ORSTOM) Centre d' Adiopodoume B.P. V-51, Abidjan
	Japan	Seed Storage Laboratory Division of Genetics Dept. of Physiology & Genetics NIAS, Tsukuba Ibaraki 305.
	Netherlands	IVT, P.O. Box 16, 6700 A A Wageningen
	Nigeria	NIHORT, Idi-Ishin, PMB 5432 Ibadan
	Philippines	Institute of Plant Breeding University of the Philippines at Los Banos, Laguna 3720
	South Africa	Division of Plant and Seed Control Pvt. Bag x 179 Pretoria 00001
	Turkey	ARARI P.O. BOX 9 Menmen, Izmir
	USSR	N.I. Vavilov All Union Institute of Plant Industry (VIR) Herzen Street 44 190000 Leningrad

Vegetables	Country of deposit	Institute
	UK	Dept. of Plant Biology University of Birmingham P.O. Box 363, Birmingham B 15 2TT
	USA	NSSL, USDA Colorado State University Fort Collins, Colorado 80523.
		Southern Regional Plant Introduction Station (S-9) U.S.D.A. Experiment Georgia 30212
		Northeast Regional Plant Introduction Station (NE-9) USDA, New York State Agrl Experiment Station, Geneva, New York 14456

*Source : IBPGR (1982). Directory of Germplasm collections, IBPGR, Rome 187 p.

through its 8 major programmes is the major funding agency. Five main organisations deal with vegetable research (Table 6). Six Central Institutes, 26 Agricultural Universities and many vegetable farms are also involved in this task (Table 7). The major research projects operating under the Project Directorate of Vegetables deal with survey and collection of germplasm, varietal trials, heterosis breeding, resistance breeding and more vitally the transfer of technology (Table 8).

Marketing of vegetables has been a constraint reducing returns to the growers. Many organisations are now in the fray to organize

Table : 4. **Agro climatic approach**

1. Western Himalayan Zone (J and K, HP, UP Hills)
2. Eastern-Himalayan Zone (Sikkim, Darjiling Hills, Arunachal Pradesh, Meghalaya, Nagaland, Assam, Tripura, Mizoram).
3. Lower Gangetic plains (West Bengal)
4. Middle Gangetic plains (UP, Bihar)
5. Upper Gangetic Plains (U.P.)
6. Trans-Gangetic Plains (Punjab, Haryana, Delhi, Rajastan)
7. Eastern Plateaux and Hills (MP, Orissa)
8. Central Plateaux and Hills (MP, UP, Rajastan)
9. Western Plateaux and Hills (Maharashtra, MP, Rajastan)
10. Southern Plateaux and Hills (AP, Karnataka, TN)
11. East coast plains and Hills (Orissa, AP, TN)
12. West coast plains and Hills (TN, Kerala, Karnataka, Goa, Maharashtra)
13. Gujarat Plains and Hills (Gujarat)
14. Western Dry Region (Rajastan)
15. Islands Zone (Andaman, Nicobar, Lakshadweep).

vegetable production and marketing (Table 9). Post harvest handling of vegetables is another area which has recently attracted attention. An All India Co-ordinated Research Project on post harvest technology of Horticultural crops is in operation and it deals with 10 main areas of research (Table 10). The above information indicate the awareness and the quantum of resources mobilised to boost vegetable production in the country.

Table 5. Organisations funding research on Vegetables in India

SlNo.	Organisations	Area of inspect
1	Indian Council of Agricultural Research New Delhi	All India
	a. All India Co-ordinated Vegetable Improvement Project (AICVIP)	
	b. AP Cess fund ad-hoc research schemes	
	c. USIF research projects	
	d. National Agricultural Research projects (World Bank funded)	
	e. Scheme on Professors of eminence and national fellows	
	f. Scheme on Emeritus scientists	
	g. Summer institutes	
	h. Publications on vegetables	
2	Council of scientific and Industrial Research (CSIR)	All India
3	Department of Biotechnology (DBT)	All India
4	Department of Environment (DOEN)	All India
5	Department of Electronics (DOE)	All India
6	Defence Research Development organisation (DRD)	All India
7	Department of Science and Technology (DST)	All India
8	Indian Council of Medical Research (ICMR)	All India
9	University Grants Commission (UGC)	All India
10	State Councils and departments of Science and Technology	States

Achievements in research on tropical vegetables

Productivity of vegetables has been the lowest in India (Table 11). It was only 9.15 t/ha in tomato, while the world average is 20.99 t/ha. A large number of vegetable varieties

Table 6. Organisations involved in vegetable research in India

Sl No.	Organisations	Area
1	All India Co-ordinated Vegetable Improvement Project (ICAR) -7 maincentres, 16 sub centres and 21 voluntary centres	All India
2	IIHR, IARI, CPRI, BARC, AADF, CTCRI	All India
3	National Research Centres	All India
4	State Agricultural Universities (26 Nos)	States
5	Private organisations (Indo American Hybrid seeds, Mahy Co., Pioneer, PHI BIOGENE LTD., etc.	All India

are developed at IARI, New Delhi and at IIHR, Bangalore which are high yielding and suited to different agroclimatic zones (Table 12). A large number of vegetable varieties are now evolved at diffe-fent Agricultural Universities and research institutes. These are now evaluated under the Project Directorate of vegetables (Table 13). Based on continuous trials for three seasons at different locations, vegetable varieties are identified for specific zones (Table 14). Hybrids yield more than the varieties, there has been stress on developing hybrids in India (Table 15). The hybrids like Arka Jyothi in watermelon and Pusa Hybrid 5 in brinjal are very popular.

Table 7. Research institutes in India working on vegetables

1. Central Institutes

   1. Indian Agric. Res. Institute, New Delhi.
   2. Indian Institute of Horticultural Research, Bangalore.
   3. Central Potato Research Institute, Simla.
   4. Central Tuber Crops Research Institute, Trivandrum
   5. All India Co-ordinated Vegetable Improvement Project with its 23 centres spread throughout the country.
   6. All India Co-ordinated Potato Improvement Project.

2. State Institutes

   1. 25 State Agricultural Universities and Departments of Horticulture/Vegetable Crops.
   2. Dr. Y.S. Parmar University of Horticulture and Forestry at Solan.
   3. Vegetable farms of the State Departments of Agriculture/Horticulture

Incidence of diseases and pests is yet another constraint limiting productivity of vegetables. Breeding for varieties resistant to major diseases and pests resulted in the identification of a large number of varieties. This is a positive achievement of vegetable research in India (Table 16). Chemical control of diseases and pests are yet another area where substantial progress are made both under All India Co-ordinated Vegetable Improvement Project and also through projects run at State Agricultural Universities (17, 18, 19, 20). Importance of better management like fertilizer application, spacings,

Table 8. Current research projects operating in India on vegetables*

1. Survey, collection and maintenance of vegetables
2. Varietal trials to identify high-yielding and adaptable varieties.
3. Heterosis breeding
4. Resistance breeding
5. Agronomy of vegetables including weed control
6. Chemical control of vegetable diseases
7. Insect and nematode control
8. Physiology and biochemistry
9. Vegetable seed production
10. Transfer of technology.

The above projects are in operation in 23 centres spread throughout India.

*Source : ICAR 1987 Proceedings of the IX th Workshop of AICVIP held at Faizabad.

irrigation and mulching etc. are realised. There are now specific agromical practises formulated (Table 21). There are specific fertiliser recommendations (NPK) for different vegetables in different States (Table 22). This is a major achievement brought about by efforts by a large number of scientists. Being tropical vegetables competing with tropical weeds, there has always problems of noxious weeds in vegetable plots. The incidence of weeds

Table 9. Organisations involved in vegetable production and marketing in India

SlNo.	Organisations	Area
1	National Horticultural Board	All India
2	National Diary Development Board and Mother Diary	New Delhi
3	State farming corporation of India	States
4	National Seed Corporation	All India
5	Bangalore Horticulture produce Marketing and Processing Society Ltd., Lalbagh, Bangalore	Karnataka
6	Nilgris Co-operative marketing Society, Uthagamandalam, Tamil Nadu	Tamil Nadu
7	Nilgris vegetable Growers Co-operative Marketing Society, Udhagamandalam, Tamil Nadu	Tamil Nadu
8	State departments of Agriculture/ Horticulture	States
9	Fruits and Vegetables production and Marketing Co-operative Societies	Regional
10	National Agricultural Co-operative Marketing Federation (NAFED)	National
11	Private seed companies	All India

reduces crop productivity in addition to enhancement in cost of cultivation. There has been a few recommendations on weed control in tropical vegetables (Table 23).

Table 10. Current Research Projects operating in India on post-harvest technology of vegetables*

1. Handling, grading and packaging of fruits and vegetables.
2. Storage of fresh fruits and vegetables
3. Transportation and marketing of fruits and vegetables
4. Preservation of fruits and vegetables.
5. Waste utilization
6. Pre-harvest factors and harvesting techniques of fruits and vegetables.
7. Handling, Pre-cooling, packaging and transportations of fruits and vegetables.
8. Post harvest storage of fruits and vegetables
9. Processing of fruits and vegetables.
10. Utilisation of commercially unacceptable fruits and vegetables and processing of wastes

*Source : I.C.A.R. 1985-86 - Annual report of all India Co-ordinated Research Project on post harvest technology of Horticultural Crops. ICAR, New Delhi.

Recently the innovation in biotechnology have benefitted tropical vegetables. Two tomato varieties 'Mansanto 1987' and 'Dupont 1988' are evolved through genetic manipulation (Table 24). Techniques are now standardised to transfer defined genes from

Table 11. Average yield (t/ha) of Vegetables

Vegetables	Developed countries	Developing countries	World	INDIA		
				Local variety	Improved variety	Hybrids
Beans	6.86	5.79	6.30	2.10	10-12	-
Cabbage	25.17	17.28	21.34	6.03	30-35	50-70
Cauliflower	16.90	10.15	13.29	7.33	10-15	25-30
Peas	6.24	3.17	5.25	2.90	8-10	-
Onion	17.24	9.94	12.27	7.50	30-40	-
Tomato	27.46	15.61	20.99	9.15	25.45	75.80

ecologically different organisms to tropical vegetables (Table 25). The genetic engineering on tropical vegetables is yet to take root in India.

Development of seed programmes

Availability of tropical vegetable seeds remains yet another constraint. There is a wide gap between total requirement of certified seeds and the seeds now available with NSC., organised seed companies and fairly reliable private sources (Table 26). Statistics are available on cropwise requirement of certified seeds for targeted production of different vegetables (Table 27). This necessitates production of breeder and foundation seeds through a systematic production programme (Table 28).

Table 12. Improved tropical vegetable varieties developed at Indian Agricultural Research Institute, New Delhi.

Vegetables	Varieties	Characteristics
Amaranth	Pusa Chauli	Suitable for summer planting
Bhindi	1.Pusa Sawani	Heavy yielder and tolerant to mosaic virus
	2.Pusa Makhmali	Early, fruits long, five edged, susceptible to yellow vein mosaic virus.
	3.Perkins Long Green	Bright green long fruits with 8 edges
Bittergourd	1.Pusa Do Mausami	Medium long, continuous ridged fruit, heavy yielder.
	2.Pusa Visesh	Fruit medium thick, dark green, early (55-60 days), yields 15t/ha.
Bottlegourd	1.Pusa Manjeri (F_1 hybrid)	A hybrid between PSPR x Seln. 11, early, round fruited, suitable for year round planting
	2.Pusa Meghdoot (F_1 hybrid)	A hybrid between PSPL x Seln 2. Early long and tender fruits suitable for year round planting.
	3.Pusa Naveen	Medium sized, cylindrical fruits (30-40 cm) heavy yielder.
	4.Pusa Summer Prolific long	Fruits green, 40-45 cm long.
	5.Pusa Summer Prolific Round	Round fruits, suitable for year round planting
Brinjal	1.Pusa Purple Long	Extra early, fruits glossy purple, 20-25cm long, average yield 30t/ha.
	2.Pusa Kranti	Early (55 days), oval fruited, glossy deep purple fruits

...contd.

Vegetables	Varieties	Characteristics
	3. Pusa Purple cluster	Non spiny fruits, 4-9 fruits/ cluster, moderately resistant to bacterial wilt.
	4. Pusa Anupam (KT-4)	Fruits in clusters of 3-5, cylindrical fruits with purple colour, resistant to bacterial wilt.
	5. Pusa Anmol (F_1 hybrid)	Hybrid of PPL x Hyderpur. Maturity 55-60 days. Heavy fruiting.
	6. Pusa Bhairav	An early variety resistant to phomopsis fruit rot
	7. Pusa Hybrid 6	Attractive purple colour, average fruit weight 200gm. early maturity.
Cowpea	1. Pusa Phalguni	Bushy, duration 60 days, dark green pods.
	2. Pusa Barsati	Climbing habit, pods light green, ready in 45 days.
	3. Pusa Do Fasli	Photo insensitive, bushy, pods 15 to 18cm long, ready in 55-60 days.
	4. Pusa Komal (K-1552)	A bacterial blight resistant variety, Early (45-50 days), Synchronised pod bearing, pods 20-22cm long, average yield 10 t/ha.
Cucumber	1. Japanese Long Green	Extra early, yellowish green fruits, 30-45cm long.
	2. Straight - 8	Fruits 20-25cm long, with white spines.
	3. Pusa Sanyog (F_1 hybrid)	Very early, fruits 28-30cm long cylindrical, very heavy cropper.
Luffa gourd	1. Pusa Nasdhar	Ridge gourd, flowering in 60 days, 15-20 fruits/Vine, fruits ridged and light green.

(contd..)

Vegetables	Varieties	Characteristics
	2. Pusa Chikni	Smooth gourd, early prolific bearer, fruits smooth and green.
Muskmelon	1. Pusa Madhuras	Salmond Orange Flesh, very sweet (T.S.S. 12-14%), fruit weight - 1 kg, maturity 90-95 days.
	2. Pusa Sharbati	Bright Orange flesh, seed cavity narrow, sweet, good keeping qualities.
	3. M3. hybrid	Very early (75-80 days), T.S.S.- 11%, fruit weight - 0.8 to 1 kg. yield 15-20 t/ha.
Pumpkin	1. Pusa Vishwas	Light brown, spherical fruits, fruit weight 5 kg. Maturity in 120 days yield 23 t/ha.
Summer Squash	1. Australian Green	Very early, bush type, dark green fruits.
	2. Pusa Alankar	F_1 hybrid, fruits dark green, 20-25 cm long.
Tomato	1. Pusa Ruby	Indeterminate. Well adapted throughout India
	2. Pusa Early Dwarf	Determinate. Fruits medium sized. Uniform red, slightly furrowed. does well in spring-summer.
	3. Sioux	Early, indeterminate, round fruited, prolific bearer
	4. Pusa 120	Semi determinate, round to flattish round fruits, resistant to nematodes.
	5. Marglobe	Indeterminate, mid season variety
	6. Best of All	Indeterminate, smooth fruited, juicy fruits, heavy yielder
	7. Roma	Semi determinate, fruits in clusters of 4-5, pear shaped fruits, very good for ketchup and long distance transport.

(contd.)

Vegetable	Varieties	Characteristics
	8. Pusa Sheetal	Fruits set even at 8°C and suitable for early spring season. Yields 35 t/ha.
	9. Pusa Gaurav	Determinate suitable for long distance transportation and processing.
Watermelon	1. Sugar Baby	Fruits 3-5 kg, with attractive dark green rind, T.S.S. 12% maturity 90-95 days.
	2. Asahi Yamato	Fruits 6-7 kg, round, T.S.S. 9-11%, maturity 100 days.
	3. Pusa Bedana	A seedless triploid (3x) derived from Tetra 2 (4x) x Pusa Rasal (2x), T.S.S. - 12-13%.
		Fruits 5-6 kg, 3-6 fruits/vine, very good keeping quality.

*Source : Gill, H.S. and Singh, Narendra (1991), Contributions of division, Vegetable Crops, IARI, New Delhi 110 012, 15 p.

Government of India has recently liberalised the import of vegetable seeds. The salient features of new seed policy, though debatable are quoted.

Table 12. List of tropical vegetables developed at IIHR, Bangalore

Vegetables	Varieties	Characteristics
Bittergourd	Arka Harit	Improvement over local collection IIHR-4 from Rajastan. Fruits Spindle-shaped, yields 13t/ha in 120 days.
Bottlegourd	Arka Bahar	Improvement over a local collection from Karnataka, fruit straight devoid of crook neck, fruits weigh 1 kg, yields 40-45 t/ha in 120 days.
Brinjal	1. Arka Kusumakar	An improvement over IIHR 193, small fruited, born in clusters, green fruited, yields 49t/ha in 110 days.
	2. Arka Navneet	F_1 hybrid (IIHR 22.1 x Supreme), fruits oval, seeds a few, yields 65-70 t/ha in 120 days.
	3. Arka Sheel	A pure line from IIHR 192, deep purple, yields 48t/ha in 120 days.
	4. Arka Shirish	Improvement over IIHR 193, fruits extra long, green, yields 47t/ha in 175 days.
Longmelon	Arka Sheetal	An improvement over a local collection, fruits straight, medium sized, lush green, free from bitter principles, yields 35t/ha in 90-100 days.
Muskmelon	1. Arka Jeet	An improvement over IIHR - 103, fruits small, 300-500g/fruit, TSS 15-17%, Juicy, rich in Vit. C, early maturing, yields 15t/ha in 90 days.
	2. Arka Rajhans	An improved selection from IIHR 107, round fruited, fruit weighs 1.25 to 2 kg; T.S.S. 11 to 17%,

Vegetables	varieties	Characteristics
		good keeping quality, resistant to powdery mildew.
Pumpkin	1. Arka Suryamukhi	Improvement over IIHR 79, small fruited, deep orange colour, each fruit weighs 1-1.5 kg, resistant to fruit fly, yields 36 t/ha in 100 days.
	2. Arka Chandan	Improvement over IIHR 105, medium sized (2-3 kg), T.S.S. 8-10%, rich in carotene (3331 IU/100g of flesh), pleasant aroma, yields 32.5t/ha in 120 days.
Round melon	1. Arka Tinda	Selection from a cross between T-3-4 and T-8-2, fruits round, light green, tolerant to fruit fly, yields 10t/ha in 90-100 days.
Squash	1. Patty Pan	An introduction from USA, fruits disc shaped, early, yields 72t/ha in 75 to 85 days.
Tomato	1. Arka Saurabh	A selection from V-685, semideterminate, fruits medium large (70g), resist to fruit cracking, good transport quality and shelf life.
	2. Arka Vikas	A selection from Tip Top, semi determinate, fruits medium large (80-90g) suitable for fresh markets. Yields 35-40 t/ha in 105-110 days, tolerant to moisture stress,
Watermelon	1. Arka Manik	Selection from a cross between IIHR-21 and Crimson Sweet. Round to oval fruits with green rind. Average weight 6 kg, T.S.S. - 12-16%.
	2. Arka Jyothi (F_1 hybrid	Cross between IIHR-20 with Crimson Sweet.

Source : IIHR (1985). IIHR, New Varieties.
IIHR, Hissarghatte, Bangalore pp 7-19.

Salient features of new seed policy

The new seed policy, which came into effect from October 1988, has liberalised the import of seeds and planting materials of oil seeds, pulses, coarse grains, vegetables, fruits and flowers. It has slashed the import duty on seeds to 15 percent from the previous range of 90 to 105 per cent. It also envisages reduction in import duty on machines/equipment for seed production and processing, not manufactured in the country or for which technological upgradation is necessary.

The procedures for importing seeds have been simplified and the time-consuming clearance processes minimised. Special care has been taken to prevent repetitive bulk import of seeds and it has been stipulated that the companies which have technical and financial collaboration with foreign seed manufacturers should secure the parent line of seeds from the overseas firm within two years from the date of import of the first commercial consignment after clearance from the Government.

Import of seeds and planting materials of vegetables, flowers and ornamental plants will be allowed under OGL through identified categories of importers such as the departments of agriculture and horticulture in the States, State Agricultural Universities, Seed producing companies, seed corporations, food processing industrial units and individual growers of vegetables and flowers.

The Government claims that the new policy will open up opportunities for the farmers to get the best seeds at affordable cost. While the seed industry has hailed the new policy, farm scientists and plant breeders in the various agricultural research institutes have opposed the new seed policy.

Table 13. List of vegetable varieties entered in the All India Co-ordinated Vegetable Improvement Project during 1990-1991.

Vegetables	Varieties	Source
Brinjal (Long)	1. BL-1	Ludhiana
	2. K -316	Kalianpur
	3. K-314	Kalianpur
	4. Sel-4	Hyderabad
	5. PB Barsati	Ludhiana
	6. BB-9	Bhubaneswar
	7. H-9	Hissar
	8. BB-26	Bhubaneswar
	9. Sab, Annapurna	Sabour
	10. JC	Jorhat
	11. HOE-404	HOECHST
	12. H-7 (chect)	Hissar
Brinjal	1. BR-11	Ludhiana
	2. JC-2	Jorhat
	3. DBR-8	IARI
	4. DBR-31	IARI
	5. KS-224	Kalianpur
	6. KS-233	Kalianpur
	7. Sel-1	Hyderabad
	8. Pant Rituraj	Pant nagar
	9. H-8	Hissar
Brinjal (Small round)	1. RAH-51	Rahuri
	2. RAH-58	Rahuri
	3. PLR-1	Coimbatore
	4. PBS-12	Ludhiana
	5. DBSR-44	IARI
	6. Manjarigota	Rahuri
Bittergourd	1. Priya	Vellanikkara
	2. Pusa Visesh	IARI
	3. Arka Harit	IIHR

Vegetables	Varieties	Source
	4. BG-14	Ludhiana
	5. MC-84	Vellanikkara
	6. NDBT-1	Faizabad
	7. ARU-41	DARL
	8. Kalianpur Sona	Kalianpur
	9. Pusa Hybrid	IARI
	10. Phule BG-6	Rahuri
	11. Pusa Domousmi	IARI
Bottlegourd	1. Arka Bahar	IIHR
	2. Pusa Naveen	IARI
	3. 78-2	Sabour
	4. ARU-25	DARL
	5. KBA-13	Kalianpur
	6. NDBG-1	Faizabad
	7. Pusa Hybrid	IARI
	8. Pb. Komal	Ludhiana
	9. ARBGH-5 (F1)	Ankur seeds
	10. NDBG-10	Faizabad
	11. Phule BTG-1	Rahuri
	12. HOE-505	HOECHST
	13. PSPL	IARI
Chillies	1. TC-2	BARC
	2. KCS-1	Kalianpur
	3. Phule-5	Rahuri
	4. DPLC-1	Dapoli
	5. LCA-248	Lam
	6. BC-21-2	Bhubaneswar
	7. PKM-1	Coimbatore
	8. JCA 283	Jabalpur
	9. CA-219	Vellanikkara
	10. Sel-1	IIHR
	11. LCA-206 B	Lam
	12. Pusa Jwala	NSC
Cowpea (Green podded)	1. Sel - 61-B	IIHR

Vegetables	Varieties	Source
	2. Sel-263	Ludhiana
	3. Sel-2-1	Faizabad
	4. VS-389	Vellanikkara
	5. Pusa Komal	IARI, Karnal
Cucumber	1. 72-5	Sabour
	2. ARC-1	Ankur seeds
	3. 75-2-1	Rahuri
	4. Sheetal	Dapoli
	5. Khira-75	Solan
	6. Khira-90	Solan
	7. DCH-1	IARI
	8. DCH-2	IARI
	9. Poinsettee	NSC
	10. Pusa Sanyog	Katrain
Dolichos bean (Pole type)	1. KBD - 403	Kalianpur
	2. KBD-405	Kalianpur
	3. Rajini	Kalianpur
	4. Deepaliwal	Akola
Dolichos bean (Bush)	1. Sel-1	IIHR
	2. Sel-3	IIHR
	3. DPLD	Dapoli
	4. DDB-1	IARI
	5. DDB-2	IARI
Muskmelon	1. NDM-1	Faizabad
	2. NDM-2	Faizabad
	3. MH-5	Hissar
	4. MH-13	Hissar
	5. RM-43	Durgapura
	6. MR-12	Ludhiana
	7. Sunehari	Ludhiana
Tomato (Determinate)	1. Sel-18	Hissar
	2. NDT -120	Faizabad
	3. Kalyani Eunuish	Kalyani
	4. TC-1	Kalianpur
	5. Pusa Sel-4	IARI

Vegetables	Varieties	Source
	6. Pusa Sel-8	IARI
	7. BT-2	Bhubaneswar
	8. BT-3	Bhubaneswar
	9. Sel-32	Hissar
	10. KS-7	Kalyanpur
	11. Sel-1-6-1-4	Ludhiana
	12. Phule-16	Rahuri
	13. KS-2	Kaliapur
	14. Sel-7	Hissar
Tomato (Indeterminate)	1. Sel-30	IIHR
	2. DT-10	IARI
	3. BT-12	Bhubaneswar
	4. Arka Vikas	IIHR
	5. AC-238	Pant nagar

*Source : ICAR (1990). Proceedings of the 11th Vegetable Workshop held at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, H.P. Project Directorate on Vegetables, New Delhi -12. 174 p.

Future programmes of research

Diseases and insect pests are the natural enemies of tropical vegetables. There is need to work out control measures against major diseases and major pests through resistance breeding programmes as well as through non polluting measures (Tables 29,30). Development of processed items and value added products alone would boost up farmer's income. Considering the perishability of tropical vegetables, the biochemical and processing aspects on vegetables which require immediate attention are indicated (Table 31).

There is alround awareness on increasing availability of tropical vegetables. The present tempo activity and development need to be sustained.

Table 14. New Varieties identified by All India Coordinated Vegetable improvement Project

Crop-Variety Source/year of identification	No. of testing centres	Suitable Zones*	Average increased yield over control (%)	Varietal characteristics
1	2	3	4	5
Brinjal Long				
1. Pusa Purple Long, IARI Delhi (1975)	12	IV, VI, VII, VIII	34.71	Plants dwarf (40-50 cm), semi-erect, leaves light green with 1-3 spines occasionally on the midrib and without edges. Fruits long (20-25 cm), purple, glossy, tender, drooping and touching the ground. Ratooning is possible if plants are pruned in January. Suitable for summer and autumn crops. Does extremely well in North.
2. Pusa Purple Cluster IARI, Delhi (1975)	8	I, V, VI, VII	37.58	A medium early variety. Plants tall, erect, compact, Sturdy with purple pigmentation on stem. Leaves purple, non-spiny; Fruits borne in clusters of 4-9

*Zone I ... Humid Western Himalayan Region
II ... Humid Bengal-Assam Basin
III ... Humid Eastern Himalayan Zone and Bay islands
IV ... Sub-humid Sutlej - Gange Alluvial Plains
V ... Sub-humid to Humid Eastern and South-Eastern uplands
VI ... Arid Western Plains
VII ... Semi-arid Lava Plateaux and Central High Lands
VIII ... Humid to semi-arid Western Ghats and Karnataka Plateaux.

Table contd.

1	2	3	4	5
				fruits, 10-12 cms long and deep purple in colour. Suitable for Southern and Northen hills, moderately resistant to bacterial wilt.
3. PH-4 Ludhiana (1975)	8	IV,VI	35.32	A derivative of the cross Hyderpur x PPL. Plant growth habit bushy, stem is pigmented. Fruits long to medium and thin, dark purple in colour, flesh of light-green colour.
4. Pusa Kranti IARI, Delhi (1975)	12	IV	24.35	Plants medium tall, upright, erect growth habit with purple pigmentation on young leaves and branches. Leaves are dark-green and non-spiny, Fruits, uniform, thick, oblong, 15-20 cm long, dark purple with shining green calyx and less seeded. Fruits do not touch the ground. Suitable for growing in spring and autumn.
5. Pant Samrat, Pantnagar (1981)	17	IV, V, VI	-	A selection from local collection. Plant height 80-120 cm, robust leaves broad and purple green. Fruits of attractive purple colour with soft texture. Resistant to phomopsis blight and bacterial wilt under field conditions. Less infestation of shoot borers, fruit borers and jassids. Good for rainy season in both plains and hills.

(contd.)

1	2	3	4	5
6. Azad Kranti Kallianpur (1983)	17	I, IV	9.2	Young leaves dark green and non-spiny, fruits uniform, thick oblong 15-20 cm long, dark purple with shining green calyx and less seeded. Fruit do not touch the ground.
7. **Aruna** (1989)		-		-
Brinjal (Round)				
1. Arka Navneet (F_1) IIHR, BANGALORE (1981)	22	IV, VI VII, VIII	18.68	Fruit oval and free from bitterness, skin attractive deep purple, flesh soft, white and few seeds. Yield 650-700 qtls fruit per/ha. Maturity in 120 days after transplanting.
2. Pant Rituraj (PBR-91-2) Pantnagar (1985)	21	IV, VI VII, VIII	18.26	A derivative of T_3 x PPC. Plant height 60-70 cm and semi-erect growth habit. Foliage purple green with occasionally light purple colour on leaves. Fruit almost round attractive in purple colour, soft in texture, less seeded with good flavour and keeping quality and good consumer preference. Duration of picking is spread over 3 months in rainy season and 2 months in summer season. Posesses field resistance to bacterial wilt.
3. T-3, Kalianpur (1975)	17	IV, VI VIII	79.82	Plant height 65-70 cm. semi spreading. Stem green leaves small and narrow. Fruits round, light purple with whitish green colour at stigmatic end.

1	2	3	4	5
				Moderately resistant to little leaf and bacterial blight under field conditions.
4. Jamuni Gole Baingan (S-16) Ludhiana (1975)	17	V,VI	59.13	Plant medium in height, spreading thornless, fruits are round with shining purple colour and plump. Average yield 153 q/ha. Early maturity first harvesting 65 days after transplanting.
Brinjal Green				
1. Arka Kusumkar Bangalore (IIHR) (1981)	13	IV,VI VIII	7.8	Fruits small, bone in clusters of 5 to 7, good texture and cooking qualities. Skin light green. Yield 490 q/ha in 110 days after transplanting. Suitable for Southern India.
Cowpea				
1. Pusa Komal (L-1552) IARI, Karnal (1981)	13	II,IV,V, VI,VII, VIII	170.39	The plants are bushy, indeterminate less vegetative. Flowers in 45-50 days and synchronous in pod bearing. The pods are 20-22 cm, non fiberous, cylindrical and light green in colour. Highly resistant to bacterial blight.
Chillies				
1. Andhra Jyothi (G-5) Lam (1975)	19	I,IV,V, VI,VII, VIII	50.75	Released by Central Sub-Committee on Release of Varieties in 1977 for all chillies growing regions in the country with dry stout fruit with high seed content. Fruits short, pungent with thick, glossy red pericarp.

1	2	3	4	5
2. Bhagyalakshmi (G-4) Lam (1975)	19	I	164.17	Av. plant height 52.9 cm, leaf lamina-dark green. Fruit length 8.2 cm and width 0.7 cm. Crop duration 180 days. High yield ie. 16q/ha and 45 q/ha under rainfed and irrigated conditions respectively.
3. K-2, Kovilpatti (1985)	22	I,V,VI	22.54	Plant height 90 to 95 cm, tall and bushy. Fruits pendent, fruit length 6.1 cm and 4 cm girth. Days to flowering 95 days. Fruit elongated samba type, bright scarlet red on maturity. Tolerant to thrips. Seed yield 7.50 q/ha.
4. Jawahar mirch 218 (1989)		-		-
Muskmelon				
1. Hara Madhu Ludhiana (1975)	8	IV,VII	-	Vines 3-4 meters long and vigourous. Fruits large, round, slightly tapering at stalk end, skin light yellow with ten prominent green sutures. Average fruit weight 1 kg. Fleshgreen, crisp, very sweet 2-3 cm. thdck with small seed cavity.
2. Pusa Sharbati IARI (1975)	8	IV	11.70	Vines moderately spreading, leaves 5 lobed, green with light pubescence and medium in size, round to oval, netted with green stripes on outer skin. 3-4 fruits per vine. Flesh thick orange with

1	2	3	4	5
				cantaloupe flavour, less juicy with small seed cavity. Average yield 100-130 q/ha. Suitable for riverbed conditions and other field conditions in North India.
3. Pusa Madhuras (Sel-445) IARI (1975)	8	IV, VI, VII, VIII	10.77	Vigorous vines, leaves entire green pubescent with large petioles. Fruits flattened found with green stripes, yellowish, skin smooth. Flesh salmon orange juicy and rich in flavour very sweet (12-14% T.S.S.). Fruit weight 1.0kg. Average yield 120-160 q/ha. Suitable for growing in northern India.
4. Arka Raj Hans Hesserghatta (1975)	8	VIII	81.60	Fruit medium large, round to slightly oval, creamy white with fine netting, weighing about 1.25 -2.0kg. Flesh thick, white, firm texture and sweet. Moderately resistant to powdery mildew. Keeping quality excellent.
Pb. hybrid Ludhiana (1985)	8	IV, VIII	27.40	Vines long (2-2.5 meters), Vigorous, luxuriant growth. Fruits are light yellow with light green sutures, rind is netted. Flesh is organge in colour, juicy sweet and flavoured, fruits being netted can be stored for 2 days after harvesting at full ripe stage under room temperature. Suitable for distant transportation. Moderately resistant to powdery mildew.

1	2	3	4	5
6. Arkajeet Hesserghatta (1975)	8	VI,VIII		Relatively dwarf growth habit. Fruits small and flat in shape, round, attractive, orange yellow, weighing about 300-350gm. Flesh white, very sweet, medium soft texture, excellent flavour and high Vitamin C Content.
7. Durgapura Madhu Durgapura (1975)	8	IV,VI VII, VIII	27.88	Fruits of medium size, oblong, light green with green stripes, weighing about 500-700 gm. Flesh light green, juicy, very sweet.
Okra				
Selection-2 NBPGR (1985)	12	IV,V	71.10	Suitable for summer and kharif both. Average plant height 110 cm with occasional, branching tendency, flowers having purple petal base colour. Fruits green, long, 5 edged and tender. Resistant to yellow vein mosaic.
Tomato				
1. Pusa Ruby IARI (1975)	17	II,IV, VI,VII, VIII	68.00	Plant height 80-85 cm, indeterminate growth habit, spreading, less branched, and hardy. Fruits flat, round, small to medium, uniform deep red, slightly lobed (4-5 locules), slightly acidic. 25-30 fruits per plant. Early variety maturity 60-65 days. Suitable for autumn, winter and spring-summer seasons in

1	2	3	4	5
				plains. Good for juice and ketchup. It is an old variety derived from the cross Improved Meeruti x Sioux.
2. H.S. - 101 Hisser (1975)	17	I,II,IV, VI, VIII	75.03	Plant height 50 cm, dwarf multi branched, sturdy and determinate in growth habit. Fruits borne in cluster of 2-3, round small to medium in size, 3-4 locules. Fruit ripe uniformly, 40-50 fruits per plant. Suitable for winter season.
3. S-12 Ludhiana (1975)	17	I,II, IV,VII, VIII	27.22	Plants are dwarf, bushy, vigorous, fruits are medium sized, compressed round. Uniformly coloured red at maturity, juicy, highly acidic. Average yield 175-230 q/ha. Suitable for marketing, fresh for the table.
4. Sel-120 IARI (1975)	17	I,IV, VI,VII, VIII	42.76	Semi-indeterminate, spreading type, foliage dark green, good coverage, fruits attractive, round to flatish round, medium to large in size, smooth, uniform, red in colour, less acidic and less seeded. Resistant to nematodes. Suitable for summer and winter.
5. T-1 Pantnagar (1975)	17	I, II IV,VII VIII	2.9	Plant height 100-120 cm. tall erect and indeterminate in growth habit foliage green in colour. Fruit round, slightly pointed at the stigmatic end, 4-5 locules, 4-5 fruits per truss, non-cracking, red on ripening. Susceptible to TMV.

1	2	3	4	5
6. Sweet-72 Gwalior (1975)	17	I, IV, VII		Plants determinate type, fruit flatish round, green stem end, slightly furrowed. Uniform maturity. Heavy yielder.
7. Pusa Early Dwarf NBPGR (1975)	17	I, IV, VIII	-	Plant typical dwarf 50-55 cm. in height with determinate growth habit. Fruit set closely roundish,. slightly flatish, medium large, uniform red, ribbed, Obscure furrow, 5-6 locules, 30-40 fruits per plant. Maturity in 55 to 60 days after transplanting. Suitable for rainy season in plains and March in hills.
8. Sioux IARI, Delhi (1977)	17	II, IV, VI, VII	-	Plants with indeterminate growth habit, fruits round, smooth, medium to large attractive red on ripening, less seeded. Maturity 60-70 days after transplanting. Suitable for summer and spring. Suitable for plains and hills both.
9. Pusa Gaurav (Sel-152) IARI (1983)	.24	I, II, IV, VI, VII, VIII	-	Determinate growth habit, cut leaves with light green foliage, fruit yellow, smooth, oblong, two locules, uniform ripening. Maturity 80-85 days after sowing. Excellent for processing and suitable for long transportation.

1	2	3	4	5
10. Pb. Chhuhara Ludhiana (1981)	24	I, II, IV, VI, VII, VIII	26.50	Plants dwarf, bushy and determinate growth habit with dense and luxuriant foliage. Fruits are medium sized, pear shaped, firm, fleshy, usually bilocular, less seedy less sour, thick walled, uniformly coloured, red at maturity, retain marketable quality for a week after harvesting under ordinary condition during summer. Most suitable for long transportation. Average yield 300-320 q/ha.
11. KS-2 Kalianpur (1985)	23	I, II, IV, VI	18.87	Plants determinate, foliage light green. Fruits flatish round, slightly furrowed. Moderate yield. Stem end and leaves are slightly rolly, No. of locules 4-5.
12. Pant Bahar (AC-238) Pant nagar (1985)	23	I, II, IV, V	49.93	Plant height 93 cm., bushy indeterminate in growth habit and branched. Light green foliage, stem relatively thin, leaflets small in size. Days to first ripening-78 days. Fruits flatish round, medium in size 5-6 locules, slightly ridged, red on maturity. Resistant of *Verticillium* wilt and *Fusarium* wilt under field conditions. Good storage and processing qualities.
13. Sohali (1989)				
14. ATV-1 (1989)				
15. ATH-1 (1989)		-		-

1	2	3	4	5
Watermelon				
1. Durgapura Madhu Durgapura (1975)	8	IV, VI, VII, VIII		Well spread vines, Elongated fruit shape, smooth yellowish coloured thin skin. Light green with very attractive flavoured flesh. Large seed cavity, T.S.S. 13-15%, Average fruit weight 400-700gms. Picking starts in 90-95 days. Yield 150-200 q/ha.
2. Sugar Baby IARI (1975)	8	V, VII, VIII	-	An introduction from U.S.A., leaves with deeply cut lobes. Fruits small to medium in size, round, skin dark green with faint perceptible stripes, weighing 3-4 kg/plant. Flesh deep red, fine texture and very sweet (10 to 12% T.S.S.). Seeds small, brown with black tip.
3. Arka Jyoti (F_1)	13	I, VI	79.41	A F_1 hybrid between Gimoon sweet of American and Indian variety. Fruits round, skin light green with dark green stripes, weighing about 6-8 kg/fruit. Flesh deep pink, excellent texture, very sweet with excellent flavour. Seeds small and few.
Dolichos bean				
1. Deepali (1989)				
2. Dasara (1989)				
Cucumber				
1. Sheetal				

Table 15. F_1 hybrids in tropical vegetables developed at various research stations in India

Vegetables	F_1 hybrids	Source
Brinjal (Long)	1. Pusa Hybrid - 5	IARI
	2. ARBH - 2	Ankur seeds
	3. Pant Hybrid - 1	Pant nagar
	4. HOE 1404	Hoechst
	5. ARU-1	DARL
Brinjal (Round)	1. NDB Hybrid - 1	Faizabad
	2. Neembakar	Nemmbakar
	3. Pusa Hybrid - 6	IARI
Brinjal (Small round)	1. MHB-10	Mahyco
	2. MHB - 39	Mahyco
	3. ABH - 1	Anand
	4. ABH - 2	Anand
	5. Hybrid - 2	Rahuri
	6. Sumex - 9	Sumex seeds
	7. Sumex - 19	Sumex seeds
	8. Aruna	Akola
Watermelon	1. Nath - 101	Nath seeds
	2. Nath - 102	Nath seeds
	3. MHW - 6	Mahyco
	4. MHW - 11	Mahyco
	5. Arka Jyothi	IIHR
Tomato (Determinate)	1. ARTH - 3	Ankur seeds
	2. Pusa Hybrid - 2	IARI

(contd..)

Vegetables	F_1 hybrids	Source
	3. NARF 101	Nath seeds
	4. Swarna - 12	Century seeds
	5. NDTH - 6	Faizabad
	6. Nath Amruth 501	Nath seeds, Aurangabad
	7. HOE 303	HOECHST
	8. HOE 606	HOECHST
	9. DTH-4	IARI
Tomato (Indeterminate)	1. ARTH - 4	Ankur seeds
	2. FM - 2	IIHR
	3. KT - 4	Katrain
	4. MTH - 6	Mahyco
	5. FM - 1	IIHR
	6. Nath Amruth 601	Nath seeds
	7. NDTH - 2	Faizabad

* Source : ICAR, (1990). Proceedings of the 11th vegetable workshop held at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, H.P. Project Directorate on Vegetables, New Delhi-12. 174 p.

Table 16. List of vegetable varieties reported resistant to major diseases and pests

Vegetables	Major diseases and pests	variety (s)	Source
Disease resistance			
Brinjal	Bacterial wilt	BB-44	Bhubaneswar
		SM6-6	Vellanikkara
		Hybrid 444	HOECHST, Bombay
		BB-7	Bhubaneswar
		BWR-12	Hesserghatta
		Pant Samrat	Pant Nagar
Okra	Yellow vein mosaic virus	EMS-8	Ludhiana
		AROH-1	Ankur seeds
		BO-1	Bhubaneswar
		BO-2	Bhubaneswar
		HY-7	Coimbatore
		HY-8	Coimbatore
		Okra No. 6	Mahyco-Jalna
		HOE 202	HOECHST
		1.5.B.4	Welcome seeds
		DOH-1	IARI
		DOH-2	IARI
		GOH-3	Anand
		GOH-4	Anand
		Pusa Sawani	NSC, Delhi
		P-7	Ludhiana
		PB-57	Parbhani
		Sel-10	IIHR-Hesserghatta
Tomato	Late blight and Buck eye rot	A-2	Solan
		KT-10	Katrain
		KT-15	Katrain
		1.5.B.6.	Welcome seeds
		TBR-1	Ludhiana
		Solan (Gola)	Solan
		Roma	Katrain
		S-12	Ludhiana
Tomato	Bacterial wilt	BT-10	Bhubaneswar

Vegetables	Major diseases and pests	variety(s)	Source
		LE-79-5	Vellanikkara
		BT-1	Bhubaneswar
Muskmelon	Downy mildew	MR-12	Ludhiana
		Hara Madhu	Delhi
Insect resistance			
Brinjal	Shoot and fruitborer	PBR 129-5	Pant nagar
		SM-17-4	APAU, Hyderabad
		PPC	IARI, Delhi
		Punjab Barsati	PAU, Ludhiana
		ARU-2c	NARL, Almora
		ME-12	Hissar
Tomato	Fruit borer	Punjab Kesari	PAU
		Punjab Chhuhara	PAU
		S-12	PAU
		KS-12	Kalianpur
		HS-102	HAU, Hissar
		Selection-152	IARI
		Roma	IARI
Okra	Fruit borer	EMS-8-1	PAU, Ludhiana
		Ludhiana Sel-2	PAU, Ludhiana
		Punjab Padmini	PAU, Ludhiana
Chillies	Thrips	B-10-A	-
		UC-45	-
		No. 2075	-
		No. 1068	-
	Mites	LIC-13	-
		LIC-45	-
		LIC-36	-
		Bonnapuri	-
Chillies	Mites	Striate mutant	-
		Sabour Annual	-
		Nala mirpa	-

Vegetables	Major diseases and pests	variety(s)	Source
		EC small pod	-
		Green	-
		Sirkakulam	-
	Pod borer	LIC-13	-
Bittergourd	Fruit fly	Hissar - II	Hissar
		Phule-BG-4	Rahuri
		MC-84	Vellanikkara
Muskmelon	Red Pumpkin Beetle and fruit fly	Pusa Madhuras	IARI
		Punjab Hybrid	PAU, Ludhiana
		EC (163888)	(Evaluated at Ludhiana)
		Local Snapmelon	Local types at Ludhiana.

*Source : ICAR (1990). Proceedings of the 11th Vegetable workshop held at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, H.P. Project Directorate on Vegetables, New Delhi-12. 174 p.

Table 17. Disease control measures formulated under AICVIP

Crop/Var. Centre/year	Zone	Name of Disease	Recommended control measures	Efficacy of treatment & Additional/ benefits over control/ha
1	2	3	4	5
<u>Bottle gourd</u>				
1. Var. Local Hesserghatta Udaipur Ludhiana (1975)	IV, VI VII	Powdery mildew *Sphaerotheca*	Bavistin 0.1% at 15 days interval starting after 60 days of planting	Gives complete control of disease and adds 20-25 Q in yield.
<u>Brinjal</u>				
2. Var. Pusa Kranti Hesserghatta (1979)	VII	Cercospora leaf spot	Bavistin 0.1% 4 sprays at 15 days interval commencing 45 days after transplanting	95% efficacy 100-120 Q increased yield.
3. Var. A-61 and Pusa Purple Long Sabour (1983) and Pantnagar (1985)	IV	Phomopsis blight *Phomopsis vexans*	Seed treatment with Bavistin 1 gm/kg of seed + seedling dip in Bavistin 0.05% + 2 sprays of Bavistin 0.05% at 10-15 days interval starting one month after transplanting	Efficacy 90% 50-70 Q increased yield Rs. 2959/- increased profits
<u>Chillies</u>				
4. Var. Sindhur (CA 960) Lam (1981)	V	Fruit rot *Colletotrichum* spp.	Dithane M-45 0.25% 2-3 sprays during fruiting stage	50% efficacy 8-12 Q/ha increased yield of dry chillies Rs. 4,000/- additional profits.
5. Var. Pusa Jwala Sabour (1985)	IV	Dieback and fruit rot (*Colletotrichum capsici*)	Seed treatment with Ceresan wet (0.1%) + 4 sprays of Bavistin 0.05%	80% efficacy 10-15 Q Red ripe chillies

1	2	3	4	5
6. Var. Local Sabour and Rahuri (1985)	IV VII	Diseases and pest complex (Fruit rot, Dieback, Thrips, mites & pod borers)	Preventive spray schedule of Dithane M-45 (0.3%) sprayed alternatively with monocrotophos (Nuvacron 40 EC) 0.5 kg ai/ha.	8-9 Q increased yields
7. Var.Pusa Jwala Lam (1983)	V	Bacterial leaf spot and fruit rot (Xanthomonas vesicatoria)	Preventive spray of Agrimycin 100 ppm + Blitox 0.3% in rainy season. Three sprays in October + one spray in November + Dithane M-45 0.25% at 15 days interval from last week of November to January at 15 days interval.	6-17 Q of fresh chillies
Muskmelon				
8. Var. Local Ludhiana (1975)	IV	Downy mildew (Pseudoperonospora cubensis)	Dithane M-45 0.3% at 15 days interval starting with the first appearance of disease	Efficacy 61% 58% increase in yield
9. Var. Pusa Sharbati Rahuri (1985)	VII	Powdery mildew (Sphaerotheca fuliginea)	Three sprays at 15 days interval commencing from first appearance of disease with calixin 0.05% or Saprol 0.2% or Sulfex 0.2%.	30% efficacy 8 Q increased yield
10. Var. Pusa Sawani Rahuri (1979)	VII	Powdery mildew (Erysiphe spp)	Bavistin 0.1% first spray at the time of fruit setting followed by three more sprays at 15 days interval	98% efficacy 100-150 Q/ha increased yield
Tomato				
11. Var.Sioux Katrain (1975)	I	Late blight (Phytophthora infestens)	Dithane M-45 (0.2%) sprayed at 7 days interval commencing with the appearance of the disease.	96% efficacy saves the whole crop.

1	2	3	4	5
12. Var. Pusa Ruby Rahuri (1983)	VII	Early blight (*Alternaria solani*)	Dithane M-45 (0.25%) or Difolatan (0.2%) 3 sprays at 15 days interval after appearance of disease or 45 days after transplanting	32% efficacy 25-30 Q increased yield
Watermelon				
13. Var. Local Hesserghata (1975)	VIII	Anthracnose (*Colle totrichum* spp.)	Benomyl or Bavistin (0.2%) sprayed at 15 days interval	50% efficacy 80-125 Q increased yield
14. Var.Sugarbaby Rahuri (1975)	VII	Alternaria blight (*Alternaria cucumerina*)	Dithane M-45 (0.2%) or Miltox (0.2%) at 15 days interval starting with first appearance of disease	40-50% 100% increased yield

Table 18. Chemical control measures against major diseases of the tropical vegetables

Vegetables	Diseases	Control measures
Cucurbits	Powdery mildew	Karathane (500 ml/ha)
		Calixin (800 g/ha)
		Sulfex (3 kg/ha)
		Bavistin (1 kg/ha)
		Spraying at 5-7 days interval (3 to 5 sprays)
	Downy mildew	Dithane M-45 (2.5 kg/ha)
		Spraying at 10 days interval
	Anthracnose	Bavistin (0.1%)
		Benlate (0.1%)
		Difolatan (0.3%)
		Topsin (0.1%)
		Spraying at 10 days interval
	Fusarium wilt	Bavistin (0.1%)
		Difolatan (0.3%)
		Soil drenching a5 7-10 days interval
	Damping off	Thiram (3 g/kg seed)
		Difolatan (3 g/kg seed)
		Seed treatment and soil drenching
Solanaceous crops		
Tomato	Damping off	Thiram (3 g/kg seed)
		Difolatan (3 g/kg seed
		Seed treatment and soil drenching
	Late blight	Dithane M-45 (3 kg/ha)
		Dithane Z-78 (3 kg/ha)

...contd.

Vegetables	Diseases	Control measures
	Fusarium wilt	Bavistin (1 kg/ha) Difolatan (3 kg/ha) Soil drenching at 15 days interval
	Early blight	Blitox (3 kg/ha) Spraying at 15 days interval
	Bacterial wilt	Agrimycin (0.01%) Spraying at 15 days interval and drenching in soil
	Buck eye rot	Difolatan (2 kg/ha) Spraying at 10 days interval
Brinjal	Phomopsis blight	Bavistin (1 g/kg) Seed treatment followed by Bavistin 0.5 g/L spraying at 10-15 days interval
	Leaf spot	Cercobin M (0.1%) Spraying at 10 days interval
Chillies	Anthracnose and fruit rot	Seed treatment with Cerasan wet (1 g/kg) or Agrosan GN (1 g/kg) or Difolatan (2 g/kg) followed by Bavistin (1 kg/ha). 4 sprays at 15 days interval
	Cercospora	Blitox (3 kg/ha) Difolatan (3 kg/ha) Spraying at 12-15 days interval
Okra	Powdery mildew	As in cucurbits
	Yellow vein	Dimethoate (0.05%) or Methyl parathion (0.05%) Spraying at 10 daus interval
Leafy vegetables		
	Damping off	As in tomato
	Leaf spot	Blitox (2 kg/ha) Coprox 2 kg/ha Spraying at 15 days interval

Table 19. Pest Control measures formulated under AICVIP

Crop/Var. Centre/year	Zone	Name of insect pest	Recommended control measures	Efficacy of treatment & additional yield/economic benefits over control
1	2	3	4	5
Brinjal				
1. Var. Local Hesserghatta Rahuri and Sabour (1975).	IV VII VIII	Shoot and fruit borer (Leucinodes orbonalis)	Carbaryl 1.0kg ai/ha. Six sprays at 15 days interval with 0.2% concentration	Reduced the incidence of borers from 40.43% in control to 7-10% 50-60 Q/ha increased yield.
Chillies				
2. Var. G4 Lam (1985)	V	Pod borer spodoptera litura	Cypermethrin 0.1kg ai/ha three sprays fortnightly	70-80% efficacy 12-14 Q/ha increased yield
3. Var. G4 Lam (1983) Var. Jwala Ambegogai (1983)	V VII	Pest Complex (Pod borer, Mites, Thrips and aphids)	Chloropyriphos 0.5 kg ai/ha, sprayed at 15 days interval	Rs. 11309/- additional profit over control
Okra				
4. Var. Pusa Sawani Sabour and Hesserghatta (1975)	IV, VIII	Fruit and shoot borer Earias faba E. insulana E. vittela	Carbaryl 1kg ai/ha weekly spray	60% efficacy 50-60 Q/ha increased yield
6. Var. Pusa Sawani Hesserghatta (1975)	VIII	Jassids (Amrasca biguttula biguttua)	Carbofuran 1.0 kg ai/ha soil application	Complete control 50-60 Q/ha increased yield
Tomato				
6. Var. S-12 Ludhiana (1983)	IV	Fruit borer (Heliothis armigera)	Decamethrin (Decis) 2.8 EC) @ 20gm ai/ha sprayed at 15 days interval	70-75% efficacy 100-120 Q/ha increased yield

Table 20. Control measures standardised against major pests of tropical vegetables

Vegetables	Pests	Control measures
Cucurbits	Red pumpkin beetle (*Aulacophora faveicollis*)	i) Collection and killing of adults in early morning hours ii) Application of aldrin (5D) or heptachlor 20-25 kg/ha in the soil in order to control the grub at the time of land preparation or sowing of the crop iii) Spraying 2 L malathion (50 EC) or 2 kg carbaryl (50 WP) in 1000 litre of water/ha at 3-leaf stage followed by another application after 10 days.
	Fruit fly (*Dacus cucurbitae*)	i) Collection and destruction of the infested fruits by burying them deep in the soil ii) Spraying carbaryl (50 WP) 2 kg or malathion 50 EC 2 litres in 1000 litre of water of spraying of a mixture of 1 litre malathion 500 gram molasses and 500 litre of water 2-3 times at 10 days interval from time of flowering.
	Epilachna beetle (*Epilachna* spp)	i) Collection and destruction of grubs and adults in early morning hours ii) Spraying carbaryl (50 WP) 3 kg or malathion 2 litre in 1000 litre of water/ha

(contd.)

Vegetables	Pests	Control measures
Solanaceous Crops (Brinjal, Tomato, Chillies)		
a) Brinjal	Fruit and shoot borer (*Leucinodes orbonalis*)	i) Removal and destruction of affected shoots and fruits alongwith larvae ii) Spraying 2 litre endosulfan (35 EC) or 2 kg carbaryl (50 WP) in 1000 litre water/ ha.
	Stem borer (*Euzophera perticella*)	Same as in brinjal
	Epilchna beetle (*Epilachna* spp.)	Same as in cucurbits
b) Tomato	Fruit borer (*Heliothis armigera*)	Spraying 1.5 litre endosulfan (35 EC) or litre monocrotophos (40 EC) in 1000 litre water twice at fortnightly interval at the time of infestation. picking of ripe fruits before spraying.
	Jassid (*Amrasca biguttula biguttula*)	Same as in tomato
c) Chillies	Thrips (*Thrips* sp.)	Spraying malathion (50 EC) 2 litre or carbaryl (50 WP) 2.5kg or endosulfan 35 EC 1.5 litre in 1000 litre of water 2-3 sprayings at fortnightly interval

(Contd..)

	Vegetables	Pests	Control measures
d)	Okra	Shoot and fruit borer (*Earias vitella*) (*E. insulana*)	i) Spraying carbaryl (50 WP) 2 kg. or 1.5 litre endosulfan If necessary, repeat the application after 10 days. ii) Removal and burning of affected fruits and shoots Harvesting of fruits before spraying
		Jassid	Same as in tomato

Table **21.** Agronomical Practices formulated through AICVIP

Crop/Variety Centre/year	Zone	Type of cultural practice	Recommendation	Additional yield & Economic benefits over control per hectare
1	2	3	4	5
Brinjal				
1. Var. Pusa purple Long Pantnagar (1983)	IV	Spacing and	75 x 60 cm row to row and plant to plant	50-60 q/ha Rs.1500-2500
		Fertilization	100 kg N/ha (basal) 60 kg P_2O_5/ha	
2. Var.Punjab Haryana-4 Hissar (1979)	VI	Spacing	75 x 40 cm row to row and plant to plant	50-80 Q
		fertilizers	100 : 60 NP/ha	
3. Chillies				
3. Var. Local Coimbatore (1979)	VIII	Nitrogen application	100 kg/ha split into 50kg basal 50kg top dressing 30 days after transplanting	50% increased Yield over control
Okra				
4. Var. Pusa Sawani (Rainy season crop) Jabalpur (1983)	VII	Spacings	60 x 30 cm row to row and plant	20-25 Q
		Fertilizers	100:50:50 NPK in kg/ha.	
5. Var. Pusa Sawani Kalianpur (1977)	IV	Chemical Weed Control	Preplant application of Lasso @ 1.5 lg/ha + one hand weeding 45 days after planting	10-15 Q
Tomato				
6. Var. HS101, Pusa Ruby and Sioux Sabour (1979)	IV	Fertiliser	150:60:60 NPK in kg/ha	100-150 Q Rs. 2000-3000
Var. Pusa Ruby, KS2 and Sioux Kalianpur (1985)	IV	Spacing	50 x 30 row to row and plant to plant	Cost benefit ratio was 3.14 to 4.01 yield 100-150 Q

1	2	3	4	5
7. Var.Pusa Ruby Pantnagar (1985)	IV	Irrigation and Mulching	The interval of irrigation determined by each 100mm open pan evaporation was most economical with application of sugarcane trash for mulching 3-4 weeks after transplanting and a hand weeding.	80 Q Rs. 3400/-
Watermelon				
8. Var. Sugarbaby Faizabad (1985)	IV	Spacing and Fertilizers	320 x 120 cm between rows and plants 100:60:60 NPK in kg/ha.	200 Q.

Table 22. Comparison of Fertilizer Recommendations for vegetable crops in different states of India (Zone-wise) (kg/ha).

Zone : Northern India

	Haryana			Himachal Pradesh			Jammu & Kashmir			Punjab			Uttar Pradesh		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Beans (Sem)	30	40	-	-	-	-	-	-	-	-	-	-	-	-	-
Bittergourd	-	-	-	100	50	50	-	-	-	-	-	-	80	60	60
Bottlegourd	-	-	100	75	50	-	-	-	-	-	-	-	80	60	60
Brinjal	100	50	25	45	60	40	-	-	-	125	62	30	100	40-50	40-50
Chilli	**60**	30	30	75	75	50	-	-	-	62	30	30	80-100	40-60	40-60
Cowpea	25	40	0	-	-	-	-	-	-	-	-	-	25	70	50
Cucumber	-	-	-	100	50	50	-	-	-	-	-	-	80	60	60
Cucurbits	50	25	25	-	-	-	-	-	-	100	50	50	60	30	30
Melon	-	-	-	-	-	-	-	-	-	-	-	-	80	60	60
Muskmelon	50	30	25	-	-	-	-	-	-	125	62	62	-	-	-
Okra	100	50	25	75	50	50	-	-	-	62	0	0	60	30-40	30-40
Pumpkin	-	-	-	150	100	50	-	-	-	-	-	-	80	60	60
Spongegourd	-	-	-	100	75	50	-	-	-	-	-	-	-	-	-
Tomato	100	50	50	100	60	60	-	-	-	138	62	62	50-60	50	50
Watermelon	50	25	25	-	-	-	-	-	-	62	40	40	80	60	60

Zone : Southern India

	Andhra Pradesh			Karnataka			Kerala			Tamil Nadu		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Amaranthus	-	-	-	100	50	50	100	50	50	75	25	25
Ashgourd	-	-	-	50	50	0	-	-	-	-	-	-
Bittergourd	-	-	-	62	50	0	-	-	-	20	30	60
Bottlegourd	-	-	-	50	50	37	-	-	-	32	24	24
Brinjal	100	60	60	125	100	50	75	40	25	100	50	30
Chilli	60-160	30-90	60-75	150	75	75	75	40	25	75	35	35
Cluster bean	-	-	-	-	-	-	-	-	-	50	50	25
Cowpea	-	-	-	25	150	100	-	-	-	25	50	0
Cucumber	-	-	-	60	50	80	-	-	-	-	-	-
Cucurbits	-	-	-	-	-	-	70	25	25	-	-	-
Gourds	50	25	0	-	-	-	-	-	-	-	-	-
Muskmelon	-	-	-	100	75	50	-	-	-	80	60	30
Okra	100	50	50	125	75	62	50	8	30	40	50	30
Pumpkin	-	-	-	100	100	40	-	-	-	32	24	24
Snakegourd	-	-	-	-	-	-	-	-	-	32	24	24
Tinda	-	-	-	50	100	50	-	-	-	40	0	0
Tomato	100	50	50	250	250	250	75	40	25	150	100	50
Watermelon	-	-	-	100	88	100	-	-	-	55	55	55

Zone : Western India

	Gujarat			Madhya Pradesh			Maharashtra			Rajasthan		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Ashgourd	-	-	-	-	-	-	50	40	0	-	-	-
Bittergourd	-	-	-	-	-	-	50	40	0	-	-	-
Bottlegourd	25	50	25	-	-	-	50	40	0	-	-	-
Brinjal	100	50	50	100	60	25	90	40	0	80	80	60
Chilli	-	-	-	150	60	40	60-150	30-60	50	70	48	50
Cluster bean	25	37.5	37.5	-	-	-	10	50	50	-	-	-
Cowpea	25	25	25	-	-	-	50	50	0	25	60	60
Cucumber	-	-	-	-	-	-	50	25	50	-	-	-
Gourds	-	-	-	-	-	-	-	-	-	80	40	40
Muskmelon	-	-	-	-	-	-	-	-	-	80	40	40
Okra	60	30	0	80	60	60	100	50	50	60	32	30
Pumpkin	-	-	-	60	50	50	-	-	-	-	-	-
Ridgegourd	-	-	-	-	-	-	50	40	o	-	-	-
Spongegourd	-	-	-	-	-	-	50	40	0	-	-	-
Tomato	75	37.5	37.5	100	50	50	75	40	40	120	80	60
Watermelon	-	-	-	100	50	50	-	-	-	80	40	40

Source : Tandon, H.L.S. (Comp. & ed.), 1987 Fertilizer recommendations for horticultural crops in India - A guide book. Fert. Dev. & Cousult. Org, New Delhi. pp. 112.

Zone : Eastern India

	Assam			Bihar			Orissa			West Bengal		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Amaranthus	-	-	-	-	-	-	25	20	37	50	25	25
Bottlegourd	-	-	-	-	-	-	50	30	50	-	-	-
Brinjal	50	50	50	160	88	90	125	80	110	120	50	50
Chilli	70	40	60	140	80	90	110	70	75	-	-	-
Cowpea	-	-	-	-	-	-	25	50	25	-	-	-
Cucumber	50	45	80	-	-	-	50	30	75	-	-	-
Cucurbits	-	-	-	75	55	50	-	-	-	60	30	30
Okra	50	50	50	140	64	75	112	60	75	50	25	25
Pumpkin	75	80	80	-	-	-	50	30	75	-	-	-
Snakegourd	-	-	-	-	-	-	50	30	75	-	-	-
Sponge gourd	-	-	-	-	-	-	50	30	75	-	-	-
Tomato	45	50	50	-	-	-	125	80	110	100	50	50
Watermelon	68	68	130	-	-	-	62	30	100	100	50	70

Table 23. Common weedicides used in tropical Vegetables*

Vegetables	Weedicides	Dose
Tomato	Nitrofen or oxadizon	1.0 kg/ha pre-emergence
	Metribuzin	0.5-0.75 kg/ha pre-emergence
	Fluchloralin	0.5-1.0 kg/ha pre-plant incorporation
	Pendimethalin	1.0 kg/ha pre-plant incorporation
Okra	Fluchloralin	1.0 kg/ha pre-plant incorporation
Chillies and Brinjal	Nitrofen	1-1.5 kg/ha pre-plant

*Source : Kirti Singh 1986. Report on current status and future prospects of Vegetables and vegetable seed production in India. NDUAT, Faizabad (UP), 40-41

Table 24. Genetically manipulated plants

Crop	Genetically manipulated variety	Special features
Tomato	Monsanto 1987	Resistance to tomato mosaic virus, horn and fruit borer, resistance against herbicide (Phosphosat)
	Dupant 1988	Sulphonyl urea - resistant plants

Table 25- Techniques, objectives and leading vegetables where genetic engineering method is successfully utilised*

Technique	Objective	Vegetable
1. Transfer of defined genes with Agrobacterium	Virus resistance	Tomato
	Insect resistance	Tomato
	Herbicide resistance (BASTA)	Tomato
2. Improving selection with RFLP markers	Pulp improvement	Tomato

*Source - Wenzel, Gerhard 1991. Genetic engineering methods in Plant breeding.
<u>Plant</u> <u>Research</u> and <u>Development</u>
33 : 49 - 58.

Table 26 - Estimated requirement and production of certified seeds of important tropical vegetables (Tonnes)*

Crop	Total requirement	N S C	Organised Seed Companies	Fairly reliable private source
Tomato	360	40	190	80
Brinjal	465	10.0	85	50
Chillies	200	30	68	80
Cucumber	70	2	37	20
Muskmelon	110	2	37	40
Watermelon	320	5	135	100
Bottlegourd	250	3	105	100
Bittergourd	180	8	70	100
Okra	4250	300	1350	800

*Source - Seshadri, V.S. 1988. Proceedings of the first workgroup meeting on vegetable seeds at KAU, Vellanikkara.

Table 27. Quantity of Certified Seeds required annually and area and production of some important vegetable Crops (1988)

Vegetables	Area (000 ha)	Production (000' tonnes)	Requirement of certified seeds (tonnes)
Beans	22	47	1500
Cabbage	83	790	35
Cauliflower	93	685	47
Chillies	826	511	826
Carrot	840	600	360
Eggplant	40	600	16
Okra	750	3000	15000
Onion	287	2450	2583
Peas	95	262	8550
Raddish	40	400	400
Tomato	83	500	42
Turnip	20	400	80
Total	3179	10245	29439

Table 28 - Estimated demand for breeder and foundation seeds of tropical vegetables in India*

Vegetables	FS (Q)	BS (Kg)
Tomato	8 - 10	10 - 12
Brinjal	15 - 18	15 - 20
Chillies	15 - 20	40 - 50
Cucumber	15 - 16	60 - 70
Watermelon	35 - 40	100 - 125
Muskmelon	10 - 12	40 - 50
Bottlegourd	25 - 27	70 - 80
Okra	2000 - 2500	1600 - 2000

*Source - Sheshadri, V.S. 1988. Proceedings of the first workgroup meeting on vegetable seeds held at KAU, Vellanikkara.

Table 29: Major diseases and their control measures to be standardised

Vegetables	Major diseases and control measures to be standardised
Brinjal	Survey of bacterial wilt and root knot nematode .
	Control of little leaf
Chilli	Standardisation of spray schedule for control of dieback and fruit rot
	Seasonal occurrence of diseases
	Control of leaf curl
	Control of powdery mildew
Tomato	Control of early blight
	Control of late blight
	Control of buck eye rot
	Control of spotted wilt virus
	Epidemological studies on tomato diseases
	Control of powdery mildew
Cucumber	Control of downy mildew
Okra	Control of powdery mildew
	Epidemology and virus-vector relationship of enation leaf curl

*Source : ICAR (1990). Proceedings of the 11th Vegetable workshop held at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, H.P. Project Directorate on Vegetables, New Delhi - 12. 174 p.

Table 30. Major insect pests and their control measures to be standardised

Vegetables	Major pests and their control measures
Brinjal	1. Chemical control of pest compex
	2. Chemical control of gall midge (*Asphondylia* sp.)
Tomato	1. Comparison of different schedule of treatments on different varieties of tomato for control of pest complex.
Okra	1. Chemical control of jassids and fruit borer
	2. Establishment of economic threshold of cotton jassid on edible okra
	3. Effects of dates of sowing and insecticides on the incidence of insect pests
Muskmelon	1. Chemical control of pest complex (Red pumpkin beetle, fruit flies and mites)
Chillies	1. Chemical control of pest complex
	2. Seasonal abundance of aphids, mites, thrips and pod borer

*Source : ICAR (1990). Proceedings of the 11th Vegetable workshop held at Dr. Y.S. Parmar University of Horticulture & Forestry, Solan, H.P. Project Directorate on Vegetables, New Delhi - 12. 174 p.

Table 3. Biochemical and processing aspects on vegetables investigated

Vegetables	Biochemical and processing aspects
Tomato	-tomatine content and evaluation of important vatieties for quality and processing characters including estimation of oxalates
Okra	Evaluation of different varieties for quality characters
Chillies	Chemical evaluation of some promising varieties of chillies with reference to colour, pungency, ascorbic acid, carotene content. Effect of different modes of drying and chemical treatments of fruit quality. Treatments 1. Sun, hot air drying 2. Chemical treatment with (2.5%) K_2CO_3 + (2%) Oleoresin 3. Chemical spray and sun drying with (2.5%) Na_2CO_3 + (2%) Oleoresin.
Tomato	Processing trial on tomato

*Source : ICAR (1990) Proceedings of the 11th Vegetable workshop held at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, H.P. Project Directorate on Vegetables. New Delhi - 12. 174 p.

Research on Vegetables in USSR

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USSR is a vast country spread over an area of 22.4 million sq.km. stretching from latitude 37°N to 76°N and longitude 20°E to 180°E with climatic conditions varying widely from one part to another. Its total cultivated area is 210.3 million hectares. This included 92.2 m ha under collective farms and 112.4 m ha under state farms and other state agricultural undertakings. The cultivated areas of USSR constitute mainly southern, western and central part of the country. Total production of vegetables in USSR is 33.78 m tonnes from an area of 2.34 m ha at an average yield of 15 tonnes ha. compared to Indias average yield of less than about 10 tonnes per hectare. USSR is primarily a non vegetarian country. However, average consumption of vegetables in USSR is of the order of 564 gm/capita/day. Compared to this although India with its production of 48.53 million tonnes claims to be the second largest producer of vegetables, next only to China, it is able to provide only about 135 gm of vegetables per capita per day against the dieticians recommendations of 285 gms inspite of the fact that India is primarily a vegetarian country.

Nearly 25 vegetables are grown in different parts of USSR. However, major vegetables grown there are:

Solanaceous crops	:	tomato, sweet pepper, chillies, brinjal
Cole crops	:	cabbage
Bulbous vegetables	:	onion, garlic
Cucurbits	:	cucumber, watermelon, muskmelon, pumpkin and summer squash
Legumes	:	peas, frenchbean
Leafy vegetables	:	spinach
Salad vegetables	:	lettuce

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Problems of Vegetable Production in USSR

Abiotic Stresses:

(1) Unfavourable temperatures regimes low (-15) to 27°C during winter and high 35-45°C (day) and 20°C (night) in summer.

(2) Frost particularly in southern region in May when morning temperature drops to 1 to 2°C.

(3) Drought mainly in control parts.

Biotic Stresses:

1. Diseases:- Fungal, Bacterial and Viral such as
   Fungal:- Phytophthora, Alternaria, Erysiphe , Cladosporium, Fusariun, Pythium

   Bacterial:- Pseudomonas, Sclerotenia, Bacterial leaf spot, Corynebacterium, Xanthomonas

   Viral:- TMV, CMV, Verticillium, Stolbur

2. Mycoplasma

3. Root-knot nematodes

4. Physiological disorders

5. Insect-pests

Vegetable Research in USSR

Soviet Scientists in vegetable research are very open people. There is no restriction on movement of any scientist in research. Research information is shared/ exchanged willingly.

Soviet people are fond of a very free, frank and factual exchange of views on all the scientific, social and cultural aspects. They have a lot of love and respect for India and the Indians as a friendly country. USSR's new social and political reforms through Perestroica and Glasnost have contributed very richly towards openess of the societ people and an instinct for change of their attitudes.

A systematic and comprehensive research programme is under way for improvement of vegetable crops and their production technology in USSR. The USSR's research policy with regard to vegetables is aimed at solving chronic problems of vegetable production and their post harvest utilisation to make available plenty of quality of food for the mankind.

Research Objectives

Major objectives of vegetable research in USSR are:

1. Varietal improvement for yield and quality, suitable for mechanical harvesting
2. Development of varieties and technologies for processing
3. Standardisation of technology for vegetable production in the green/glass house and in open
4. Management of diseases and insect-pests.

Research Infrastructure:

All union scientific Institute of Plant Industry Research is the major institute undertaking research on all aspects of crop improvement in USSR. Vavilov Institute of Plant Industry Research (VIR), Leningrad is the main institution which constitutes nucleus of the All Union Scientific Institute of Plant Industry Research. This institute has eleven zonal stations located in different parts of the country. Each zonal station has several centres/sub stations. Over 50 of these centres are engaged in the research for improvement of vegetable crops. Besides all Union Scientific Institute of

Plant Industry Research there are several other institutes located in different parts of USSR which are also engaged in the improvement of vegetable crops and their production technology. The leading institutes involved in vegetable research in USSR are as follows:

I. Leningrad

The NI Vavilov Institute of Plant Industry Research (VIR)

The Institute is responsible for collection, evaluation and conservation of world germplasms of over 100 cultivated plants including 15 vegetable crops such as tomato, pepper, cabbage, cucumber, peas, beans, carrot, lettuce, onion, garlic, radish, brinjal, okra, melons, squashes etc. The institute also undertakes research for genetic improvement of these crops.

II. Moscow

(i) All Union Research Institute of vegetable crops Breeding and Seed Production, Lesnoy, gordok, Moscow region: Established in 1930, the institute is working for improvement of all important vegetable crops viz. tomato, cucumber, summer squash, cabbage, cauliflower, pea, beans, carrot, radish, onion, pepper etc.

(ii) Scientific Productive Association for Vegetable Growing Russia, Mystici-Moscow.Region: Founded in 1930 the institute conducts research on development of varieties and machines for different purposes and develops technology for mechanisation of vegetable production.

III. Krasnodar

i) All Union Scientific Institute of Plant Industry Research-Crimean Experiment Station, Krimsk: Established in

1935 it became a part of the Vevilov Institute of Plant Industry Research in 1958. The station is devoted to research on tomato, capsicum, brinjal, pea, cucumber, sweet corn etc.

IV. Tashkent

(i) VIR - Central Asia Branch: Established in 1924, the institute undertakes research on collection and evaluation of germplasm and improvement of 30 crops. Among vegetables tomato, capsicum, onion, garlic, egg plant, okra, muskmelon, watermelon, pumpkin, summer squash, squash melon, long melon and leafy greens are important.

(ii) Agricultural Institute, Tashkent: Established in 1930, the institute undertakes research on genetic improvement and production technology of vegetables such as potato, tomato, sweet pepper, cucurbits and peas.

(iii) Uzbek Research Institute of Vegetable Breeding and Potato: The institute was established in 1933. The institute carries out research for developing varieties tolerant to extremes of temperature ie. maxi um of 45°C and minimum of -30°C and standardisation of the production technology in vegetables like muskmelon, cucumber, tomato, sweet pepper, onion, watermelon, pumpkin, carrot, potato, horse radish etc.

(iv) Schroedar Horticulture and Viticulture Research Institute:

The institute is mainly concerned with research on fruit crops. No major programme on vegetable is undertaken.

Research Priorities

1. Breeding varieties for green house and open cultivation and suitable for mechanical harvesting.
2. Developing varieties for processing.
3. Breeding varieties for resistance to disease and insect pests.

4. Breeding vegetable varieties resistant to abiotic stresses.
5. Breeding for improvement of nutritional quality.
6. Heterosis breeding in selected vegetable crops.
7. Standardisation of production technology of the varieties developed.

Research Programmes

The major programmes of research on vegetable crops in USSR research institutes include the following:

Applied Research

1 Collection, evaluation and conservation of germplasm. There is a comprehensive programme on collection, evaluation, conservation and documentation of world germplasm of over 15 vegetable crops at the Vavilov Institute of Plant Industry Research (VIR), Leningrad and its 50 centres all over the country located under its 11 Regional/Zonal Research Stations. Besides this all other institutes also of their own have strong programmes of germplasm collection, evaluation and conservation.

2. Varietal improvement through selection and hybridisation for high yield and superior quality both for fresh consumption and processing at VIR and its zonal stations/ centres, SPAVG Russia, Moscow, Agriculture Institute, Krosnadar, Agriculture Institute, Tashkant and Uzbek Research Institute of vegetable and potato, Tashkent.

3. Development of vegetable varieties for mechanical harvesting at Crimean Experiment station Krimsk, VIR Leningrad, VIR Teshkant, AI Tashkent, URI Tashkent,

SPA Moscow and AURI Moscow.

4. Development of vegetable varieties and standardisation of production technology for their cultivation in the green house as well as in the open - VIR Leningrad, SPA Moscow, AURI Moscow, CES Krimsk, VIR Tashkent, URI Tashkent and AI Tashkant.

5. Breeding improved varieties possessing resistance to biotic stresses like diseases and insect pests - At all institutes, stations, and centres of vegetable research in USSR.

6. Breeding improved varieties resistant/tolerant to abiotic stresses such as high temperature (45°C), low temperatures and drought (-50 C) at VIR Leningrad, Moscow, Krimsk, and Tashkent.

7. Heterosis breeding in crops like tomato, melons, cabbage, cauliflower, cucumber and onion - At Leningrad, Moscow, Krimks, and Tashkent.

8. Breeding for improvement of nutritional quality - At Leningrad, Moscow, Krimsk, Tashkent.

9. Integrated management of diseases and insect pests - At VIR Leningrad, Agriculture institutes, Krimsk and Tashkent, VIR Teshkant, URI Tashkent. SPA Moscow and AURI Moscow.

10. Standardisation of seed production technology and intensification of seed production At VIR Leningrad, CES Krimsk, Agriculture institute Krasnadar, VIR Tashkent, URI Tashkent and Agriculture institute Tashkent. SPA Moscow and AURI Moscow.

11. Biotechnology research for improvement of vegetable crops at CES Krimsk, VIR Leningrad (Pushkin).

Basic Research

The following basic researches are in progress at the centres noted against each in USSR.

Biochemistry	:	CES Krimsk, VIR, Leningrad (Pushkin)
Plant immunity	:	CES Krimsk, VIR Leningrad (Pushkin)
Cyto-genetics	:	CES Krimsk, VIR Leningrad
Molecular Biology	:	VIR Leningrad (Pushkin)

Breeding methodologies for Vegetable Improvement

Breeding methods adopted for improvement of vegetable crops in USSR are not different from those used in India.

The conventional methods followed are as follows:

1) Introduction, evaluation and selection of desirable germplasm including wilt species, cultivated varieties and segragating breeding material.

2. Selection:

    i) Individual plant selection or line selection
    ii) Single seed descent

These methods have been used in self pollinated vegetable crops, in case of mutation breeding, chance recombination and in selecting plants resistant/tolerant to diseases, where a population has not been subjected to epidemic condition. The procedure has been mainly utilised for maintenance of the varieties and improving of the strains and has helped in bringing about uniformity in the cross pollinated crops.

iii) Bulk method along with SSD has been practiced in distant crosses for improvement of TSS.

iv) Mass selection has been commonly used for improvement as well as maintenance of varieties in cross pollinated crops.

v) Mass Pedigree Method: This method has been used in self-incompatible crops like cauliflower and cabbage for improving the varieties and increasing seed set.

vi) Family Breeding: It has been used in cole crops and root crops for varietal improvement.

vii) Selfing and massing mainly in onion.

viii) Recurrent selection including:

a) Simple Recurrent selection

b) Recurrent selection for general combining ability

c) Recurrent selection for specific combining ability

d) Reciprocal recurrent selection

ix) Disruptive selection: It has been utilised in cole crops and root crops for their improvement, disruption of genetic base, breaking of linkages etc.

3. Hybridisation:

The method has been used for crop improvement of all vegetable crops in general. Intercrossing of lines within F_3 generation and onwards has been practiced to develop good quality cultivars for processing and to achieve high TSS.

4. Back cross method

It has been used in transferring characters of simple inheritance, incroporating disease resistance and quality characters, transfer of male sterility in tomato, onion etc.

5) Heterosis breeding

The method has been used in development of F_3 hybrids in tomato, capsicum, cucumber, cabbage, onion etc. However, heterosis breeding is not given much emphasis as very high level of yield and quality has been achieved in the open pollinated varieties.

Achievements of Research

Collection, Evaluation and Conservation of Germplasm

The N.I. Vavilov Institute of Plant Industry Research, Leningrad is engaged in this task. Over 3,50,000 samples of more than 100 cultivated plant species along with their wild relatives are being maintained. They also include germplasm of 15 vegetable crops, namely tomato, pepper and hot pepper) cabbage, cucumber, peas, beans, carrot lettuce, onion, garlic, radish, brinjal, okra, watermelon, muskmelon, squashes/pumpkins. More than 40,000 samples of germplasm of these vegetables have been collected, evaluated and catalogued after thorough studies at N.I. Vavilov Institute of Plant Industry Research, Leningrad and its zonal centres. These include the following.

Crop	No. of collections	
Tomato	5000	
Pepper & Sweet pepper	2000	3000
Chillies	1000	
Eggplant	800	
Cucumber		
Cabbage		
Peas		
Onion		
Potato	12000	

Although crops like okra, gourds viz. ash gourd and snakegourd and oil seed crop of groundnut are not grown in USSR, however, a good germplasm collection has been studied and maintained and catalogued in USSR.

VARIETAL IMPROVEMENT

Considerable progress in the field of vegetable breeding has been made in USSR. This is especially so in tomato, bell/sweet peppers, watermelon, muskmelon, cucumber, cabbage, peas and carrot which are the major vegetable crops in USSR.

The significant achievements of USSR in plant industry research include development of high yielding, disease resistant varieties and F_1 hybrids suitable for fresh consumption and processing, mechanical harvesting and for growing both in the open and in glasshouse/greenhouse, to meet the requirements of that country. Some of the salient trends of vegetable improvement in USSR are as follows.

Tomato is a major crop in USSR in which 50 centres are engaged in research. Open pollinated high yielding varieties resistant to diseases and suitable for processing are preferred for field culture in the open while F1 hybrids are bred for mainly glasshouse cultivation. Highly improved varieties and F1 hybrids suitable for processing, possessing earliness, long shelf life besides resistance to diseases have been evolved. The serious disease include Fusarium (F), Verticillium(V), TMV, Phytophthora infestans nematodes(N), Alternaria Solani. Many of the varieties carry resistance to V, F, N and TMV. Considerable headway has been made in breeding for resistance to Phytophthora which includes rapid screening and race identification.

Following 54 varieties of tomato have been widely adopted for commercial cultivation in different parts of the country, out of the several developed of which 8 are F1 hybrids.

Name of variety		Status	Characteristic	Source
1.	Soyuz-1	F1	Determinate T2 gene	Krimsk
2.	Yargo	OP	Resistant to TMV	Krimsk
3.	Michta	OP	Tm^2 gene	
4.	Titan	OP	Tolerant to TMV jointless	Krimsk
5.	Lastechka	F_1	Resistant to Verti-	
6.	Streizh	F_1	cillium, Fusarium,	Krimsk
7.	Carlsson	F_1	Nematodes, Cladosporium	
8.	Nahodka	F_1	and TMV	
9.	Kubanski	OP	High ascorbic acid content of 27mg/100gm.	Krimsk
10.	Agata	OP		
11.	Seshtava	OP	Dual purpose varieties	
12.	Podorok	OP	for canning and also	Krimsk
13.	Zernista	OP	for fresh consumption	
14.	Kalkesini	OP		
15.	Kubanaskistrombi	OP	Determinate, dual purpose	Krimsk
16.	Volgogradski 5/95	OP	Determinate, dual purpose	Krimsk
17.	Yantar	OP	High TS 6-7% canning	Krimsk
18.	Polyob	OP	Highly productive under good conditions	Krimsk

	Variety	Status	Characteristic	Source
19.	Salyut	OP	Wide adaptability	Krimsk
20.	Veneta	OP	Mechanical harvest canning	Krimsk
21.	Antei	OP	Early, Determinate	Krimsk
22.	Prometei	OP	Late maturity	Krimsk
23.	Karatinevi	OP	Canning	Krimsk
24.	Olympius	OP	Large fruited	Krimsk
25.	Maikopski	OP	High yielding dual purpose	Tashkent Agri.Instt.
26.	Uzozaini	OP		
27.	Temnoterashi	OP		-do-
28.	Uzmash	OP	Early determinate	Uzbek Res. Instt. Tashkent
29.	October	OP	Determinate	-do-
30.	Bahor	OP	Green house variety	-do-
31.	Novinka	OP		
32.	Novinka Kubania	OP	Green house varieties	SPA Moscow
33.	Ermak	OP		
34.	Dardone	OP		
35.	Lunni	OP		
36.	Venkuvosky	OP	Resistant to	SPA Moscow
37.	Veerozh	OP	Fusarium Verticillium	
38.	Lastochka	OP	and root knot nematodes	
39.	Solinshko			
40.	Grenada	OP		
41.	Strizh	OP		
42.	Karvonit	F1	For green house	SPA Moscow
43.	Pioneer-2761	F1	Cold tolerant	AURI
44.	Dubok	OP	Resistant to phytopthora	AURI
45.	Ottawa-30	OP	Resistant to phytopthora	AURI
46.	Dubok early	OP	-do-	AURI
47.	Grontovi	OP	Early, firm fruited cold tolerant	AURI Lesnoi Gordok

Variety	Status	Characteristic	Source
48. Grib.ski	OP	Early firm fruited cold tolerant	AURI Lesnoi Gordok
49. Uzbekistan-36	OP	Drought tolerant	AURI Lesnoi Gordok
50. Kapitak	OP	Drought tolerant	AURI Lesnoi Gordok
51. Progressive	OP	Drought tolerant	AURI Lesnoi Gordok
52. Grot	OP	Resistant to Phytophtora	AURI Lesnoi Gordok
53. Zhigul	OP	Resistant to TMV	AURI Lesnoi Gordok
54. Zhurnal	F1	Resistant to TMV	AURI Lesnoi Gordok

Sweet Pepper

Very high yielding bell peppers have been bred in USSR where it is a major crop for fresh consumption as well as canning. The major diseases are '<u>Verticillium</u>' <u>Phytophthora</u> TMV & CMV. Work on multiple resistant lines is going on. The emphasis laid on fruit quality aspects besides earliness, growth forms and yield is noteworthy. Following varieties have been developed.

Variety	Status	Characteristic	Source
1. Voskovidnea	OP	Tolerant to high temperature and humidity	Krimsk
2. Senyushkin	OP	High yielding	Krimsk
3. Druzhni	OP	High yielding	Krimsk
4. August-Ovski	OP	High yielding	Krimsk
5. Kapitoshka	OP	Tolerant to Verticillium	Krimsk
6. Gift of Maldavia	OP	Tolerant to Verticillium	Krimsk
7. Lastochka	OP	Most popular glass house variety	VIR Leningrad
8. Pedorok Maladavi	OP	Resistant to Verticillium wilt	VIR Leningrad
9. Neghnost	OP	Glasshouse, high vitamin content 2000mg/100gm	VIR Leningrad
10. Vinnipukh	OP	Dwarf, High population density (20 plant/Sq.Meter)	VIR Leningrad

Variety		Status	Characteristic	Source
11.	Izumrat	OP	Dual purpose	VIR Leningrad
12.	Dar Tashkent	OP	Dual purpose	VIR Leningrad & Tashkent
13.	Bolgarski-79	OP	High yielder	VIR Tashkent
14.	Zumrat	OP	Blocky type	Uzbek Research Institute, Tashkent
15.	Vnukoshi	OP	Greenhouse	SPA Moscow
16.	Virash	OP	Greenhouse	SPA Moscow
17.	Novinka	OP	Open Cultivation	SPA Moscow
18.	Kubana	OP	Open cultivation	SPA Moscow
19.	Dardona	OP	Open cultivation	SPA Moscow
20.	Earmark	OP	Open cultivation	SPA Moscow
21.	SPA Hybrids	F1	Resistant to root knot nematodes	SPA Moscow
22.	Sweet Banana	OP	Greenhouse cultivation	AURI Lesnoy

Chillies

Variety		Status	Characteristic	Source
1.	Tulsk	F1	Uniform high yield pugent	VIR Leningrad
2.	Nine other varieties	OP	High yield	VIR Leningrad
3.	Mangilamski-330	OP	Long fruited, pungent	VIR Tashkent
4.	Plovdesky	OP	-do-	VIR Tashkent
5.	Unti	OP	-do-	VIR Tashkent
6.	Morocco	OP	-do-	VIR Tashkent
7.	Pittentini	OP	-do-	VIR Tashkent
8.	Pikantini	OP	Small fruited very pungent	VIR Tashkent

Egg Plant

Eggplant is not a very important crop in USSR yet significant research work done has resulted in the development/ release of improved varieties as follows.

Variety	Status	Characteristics	Source
1. Batiskie	OP	Early highyield 80t/ha both for green house and open	Krimsk
2. Almaz	OP	Early highyield 80 t/ha both for green house and open	VIR Leningrad
3. Aurora	OP	Oblong, purple	VIR Tashkent

Cabbage

Cabbage is one of the most important crops of USSR. Uniformity, early maturity, high yielding varieties besides resistance to black rot and club root are the major breeding objectives. Emphasis has been laid on development of open pollinated lines, although of late F1 hybrids are being developed. Rapid screening techniques developed for black rot is being put to use in its resistance breeding. Self incompatible and cross compatible lines developed for strengtnening the heterosis breeding in cabbage would be of special interest in our country. Some of the important varieties are:

Variety	Status	Characteristic	Source
1. SB-3	OP	High yielding widely and adaptable	AURI Lesnoy Gordok
2. Double cross Hybrids	F1	Canning	AURI Lesnoy Gordok
3. White Round Medium	OP	Dual purpose	SPA Moscow
4. SPA Hybrids	F1	Dual purpose	SPA Moscow

Cucumber

Both open pollinated varieties and F1 hybrids have been developed. As in tomato, open pollinated lines are preferred for cultivation in the open and F1 hybrids for glasshouse. Double crosses and triple crosses are employed for developing F1 hybrids. Resistant lines to different races of powdery mildew and CMV have been bred. Earliness, yield and quality are other selection criteria. Some of the F1 hybrids carry parthenocarpic gene.
The following 19 varieties have been developed. Some of the important ones are as follows.

Variety	Status	Characteristic	Source
1. Neznenski Kuban	OP	Resistant to PM, DMD scab and CMV-1	Krimsk
2. Concurrent (Competor)	OP	High yield, early	Krimsk
3. Parad	OP	High yield, early, processing	Krimsk
4. Rustern	OP	Early to medium	Krimsk
5. Uspeh	F1	Early uniform	Krimsk
6. Brigadenia	Triple cross hybrid	High yield and quality widely adaptable	Krimsk
7. Prezev	Triple cross hybrid	Very early, processing	Krimsk

Variety	Status	Characteristic	Source
8. Signal	Triple cross hybrid	Very early	Krimsk
9. Hycrid VIR	F1	Greenhouse	VIR Leningrad
10. Uzbekski-740	OP	High yielding, superior quality	Uzbek Res.Instt. Tashkent
11. Porod	OP	Tolerant to mildews	Uzbek Res.Instt. Tashkent
12. Raive-645	OP	High yielding, processing	Uzbek Res.Instt. Tashkent
13. Markilanoki 822	OP	High yielding	Uzbek Res.Instt. Tashkent
14. Raive 645	OP	High yielding	Uzbek Res.Instt. Tashkent
15. Pervenets	OP	High yielding	Uzbek Res.Instt. Tashkent
16. Uzbekistana 268	OP	High yielding	-do-
17. Karnasic	F1	Resistant to PMD & DMD	Uzbek Res.Instt. Tashkent
18. Vodolei	OP	Multiple (leafspot, Pseudomonas, PMD, DMD) resistant open cultivation	AURI Lesnoy Cardok
19. Electron	OP	Multiple (leafspot Pseudomonas, PMD, DMD resistant, open pollinated	AURI, Lesnoy Gordok
20. Gribovocnanka	OP	Green house cultivation Processing, resistant to PMD, DMD, whitefly, mites	AURI, Lesnoy Gordok
21. Parthenocarpic F1 hybrids		Resistant to drought, ascochyta blight, low temperature	AURI, Lesnoy Gordok

Watermelon

Very high yielding varieties with superior quality, short vine/plant types, resistant to <u>Anthracnose</u> and <u>Fusarium</u> wilt have been developed in Krymsk and Tashkent regions. These varieties are as follows.

Vegetable Production in India - some constraints and managerial remedies

V.S. Seshadri*

Vegetable crops grown in India number over 50 different kinds of leafy, fruit and other varieties and starchy tubers as well. The diversity of production system is quite unique. With such a diversity, India is reckoned as the second largest producer of vegetables, next only to China. The production is estimated around 45 million tonnes from a cropped area of 4.0 million hectares (excluding potato and tubers), which works out roughly 2.5 to 3.0% of total cropped area. This is very low against the background of predominantly vegetarian population. This works out to 120-130 g/capita consumption compared to 250g in China. Even this low level does not fully reflect the consumption pattern of rural households, where it may go down even to 80 g a day. Low productivity levels in vegetable crops is the main limitation to reduced availability (Table 1).

Table 1. Productivity levels in vegetable crops

Crop	India	Japan	China	France	U.S.A.	World average
			(tonnes per hectare)			
Tomato	9.63	52.00	15.80	60.10	54.76	25.09
Cabbage	5.07	40.27	17.38	21.16	20.00	21.62
Cauliflower	7.34	12.73	13.12	12.86	14.23	13.64
Onion	8.49	44.01	15.75	34.53	40.19	13.79
Green peas	2.75	6.84	5.44	5.25	8.93	6.08
Green beans	2.15	7.66	9.57	18.18	5.75	6.88

(FAO Production statistics 1989)

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Bulk of the increase in vegetable production during the past decades has come from increase in the area rather than in yields, possibly with the exception of potato. Obviously, the production of vegetables has increased substantially in response to market forces, or urban market demands. The recent example of increase in vegetable area, to meet urban demands, in eastern U.P. can be traced to the establishment of industrial townships in Sultanpur, Faizabad, Rae-Bareli and Gonda districts. The incentive effect of expanding market demand has not been so strong to motivate the farmers to adopt yield increasing measures. We can still find individual farmers driving up their bullock carts to the nearest town. Of course, this pattern is slowly changing to truck transportation operated by middlemen.

Major constraints

The main constraints to increased vegetable production can be enumerated into several factors. They can be broadly grouped as;

1. Environmental and climatological
2. Technological
3. Socio-economic

Under the first category, vegetable cultivation is susceptible to unforeseen natural calamities like hailstorm, floods, cyclone, drought, ground frost etc. More often, the off season cultivation of vegetables suffer from such calamities. Because of increasing urban demands, vegetable crops are being cultivated in risky regions of unfavourable environment and hence optimum yields are not obtained. Protected cultivation may be the answer but it is a high cost, high energy and sophisticated system with very restricted applicability in India.

quality seeds. The estimated requirement of vegetable seeds at the country's present production level, is reported to be around 20,000 tonnes, for tropical and sub tropical kinds and 200 tonnes for temperate ones. Among these, peas constitute 6000 to 7000 tonnes, bhindi around 5000 tonnes, and onion 2500 tonnes. If we have to achieve the targeted production of 120 million tonnes (Table 2) by 2000 A.D., naturally the seed requirement has to be more than doubled. The existing level of vegetable seed production is mainly shared by private sector seed companies to about 25 to 30% and farmers keep their own seeds in certain kinds. Govt. programmes including public sector corporations at Centre and States contribute a very tiny fraction of 5 to 10% of the total requirement. Weak seed production mechanism has resulted in wider gap between technology available and technology adopted, in vegetable crops.

Table 2. Vegetable - production Targets*

Period	Area (Million ha)	Production (Million tonnes)	Yield (tonnes/ha)
Present	4.0	40.0 - 45.0	10.0
Short term (1990-95)	6.0	75.0	12.5
Long term (2000 A.D.)	8.0	120.0	15.0

*(VIII Plan Projections Govt. of India)

The major problems faced in vegetable seed production system are a) inadequate and unbalanced development of different components required for viable, demand responsive vegetable seed industry. b) lack of post-harvest equipment/facilities/operation

It is the second category viz. technological constraints which demand our attention. These include inter alia, limited number of improved varieties, inadequate and untimely supply of quality seeds, lack of appropriate package of inputs for optimum productivity, inefficient plant protection cover against pests, diseases and weeds and non-availability of competent Extension machinery for transfer of appropriate technology.

In the third category, market mechanisms especially limited market support and infrastructure and inadequate facilities for transport, packing, storage etc. leading to huge post-harvest losses amounting to 25 to 30% demand attention. Low priority in national planning and non-availability of reliable production statistics, are other aspects which speak of lack of appreciation of the Govt. organizations on the importance of vegetable production.

Since the availability of more land for vegetable cultivation will be very much restricted in future years because of limitation or irrigation and fast urbanization and industrial development, efforts should be directed more towards raising productivity levels.

The managerial measures to tackle the several constraints (enumerated above) are considered below, one each under technological category and under socio-economic factors, as typical examples to attract immediate attention.

Improving the productivity

1. Quality seeds : To remedy the problem of low productivity, one has to look at the basic requirements viz. availability of

at level of technology which is economically efficient.

c) Weakly organised programmes by Govt. agencies resulting in leakage of breeders and foundation seed multiplication.

ii) Onion : Taking for example, the case of onion seed production, the importance is felt because of bulb export of nearly three lakh tonnes. The export requirement of uniform quality of bulbs in shape, size and colour and of good storage capacity, has not been met mainly because of disorganised state of seed production. Even some private companies do not distinguish and maintain seed production separately for <u>rabi</u> and <u>kharif</u> varieties. Against a total requirement of the country of 2500 tonnes of onion seeds, only about 100 tonnes can be assigned to govt. programmes, 250 tonnes to private sector and the rest by farmers themselves.

The major difficulty is the absence of quality control in seed production viz. inadequate and inefficient bulb storage facilities (in the case of rabi), lack of proper bulb selection for the succeeding seed crop, absence of adequate isolation distance for seed crop, improper maintenance of moisture level in seeds due to inadequate seed storage facilities (with air conditioners and dehumidifiers) with no arrangement of buffer seed stocks to offset erratic price trends and inadequate seed processing facilities. Last but not the least, is the absence of F_1 hybrid varieties, which alone can bring uniformity in bulb characters and raise the bulb productivity level from the national average of about 9 tonnes/ha. compared to 30 to 40 tonnes in advanced countries.

iii) Hybrid seed: Another major constraint leading to low productivity in vegetable crops, is the absence of F_1 hybrid varieties.

The present area under hybrid varieties may be around 25,000 ha. in tomato, mainly from imported seeds and indigenously produced seeds from crossing selected imported parents. Next in importance is the cabbage where nearly 6000 to 8000 ha. are reported under hybrid varieties whose seeds are entirely imported. Only a few private seedsmen have developed commercial hybrid seed production facilities through labour intensive hand pollination in tomato. Further very few seed companies have technological competence and R & D facilities for commercial hybrid seed production. The import component in the hybrid seed contributes to the major share in the cost of hybrid seeds marketed presently. Because of adverse and varied climatic conditions in vegetable growing regions, growing of F_1 hybrids would not be uniformly economical in all parts of the country, but will be preferred in selected regions and in a few high value crops like tomato, cabbage, capsicum, cauliflower etc.

Import of hybrid seeds is not a substitute solution, but can only serve as a catalyst for the development of indigenous hybrid seed production technology. The cost effective technology for growing F_1 hybrid varieties has to be developed by the use of a) indigenous parents b) indigenously produced hybrid seeds and c) disease resistant parents to reduce the cost of plant protection cover. The public sector seed industry has yet to take the lead in developing commercial hybrid seed production technology.

iv) Projections : The objective at the national level is to evolve a 'National Vegetable Seed Policy' which will ensure "successful, economic and dependable supply of quality vegetable seeds". The basic requirement for formulation of such a policy their own R & D efforts instead depending continuously on imports and paying huge royalties. Proliferation of "Seed traders" who do not produce vegetable seeds themselves, should be discountenanced. The farmers should not be carried away by short term remedy of seed imports and the seed industry by resourting to quick and easy profits from imports. The Govt. should ensure that nation's long term interests are of paramount importance.

Enhancing the availability

Another important facet of vegetable production which acts as a disincentive, is the disorganised state of markeging services. The long channel from the growers to the retail outlets, involves a chain of middlemen, transport contractors, "ahrtiyas" of wholesale mandies, who advance funds to the farmers. Further, it is the trade which obtains market information and induces the farmer to go in for production of a particular kind of crop or specific variety. In the process the trader retains a larger share of consumer price leaving farmer's return meagre and not attractive enough to motivate him to invest in yield increasing innovations. Due to high perishability of vegetables, the producer has little choice but to unload the produce at whatever price is offered. He is unable to benefit from higher market prices in more distant locations or out of season since his marketing reach is limited. The glut-scarcity syndrome affects the vegetable farmer in one direction.

i) Market price : High retail price is partly accounted for by the presence of numerous intermediaries in the market. They dominate the operations and claim to absorb most of the market risks and flustuations especially in demand and supply, fickleis the availability of a data base on current status and needs of vegetable seed production. An initial survey should collect reliable statistics on vegetable and vegetable seed production. A National Vegetable seed Programme will have to be formulated which will identify a) programme components b) sector-wise responsibility, institution/agencies, c) breeding and research responsibility d) commercial production management e) quality control measures f) processing, handling, pricing and marketing mechanisms g) availability of processing machinery, spare parts and their maintenance h) Storage facilities and maintenance of buffer seed stocks i) Extension and training facilities j) credit and financing arrangements and k) seed technology research input. A Co-ordination body called "National vegetable Seed Committee" may be constituted to monitor the execution of composite vegetable seed production and marketing programmes.

At the field level, a National Vegetable Seeds Corporation should be established to oversee and co-ordinate Govt. sponsored production programmes. The existing operational procedures in the enforcement of Seed Act should be reviewed. Seed Certification staff and quality control personnel should have scientific competence and adequate laboratory facilities.

Looking to the future prospects, it is recognised that there are immense potentialities in improving vegetable seed production. Good quality seeds alone can make a big impact to increase the productivity levels in vegetable crops by atleast 25 to 30%. Seed productivity- seed yield/hectare should be improved by efficient management techniques. Further private seed industry and public sector organizations should absorb modern technologies through a Vegetable Growers Co-operative Marketing Society which markets hill vegetables grown there and cabbages in trucks are supplied as far as to Calcutta city in May-June. National Diary Development Board has started retail marketing of vegetables in Delhi. In South Gujarat, it is reported that Co-operative institutions are engaged in supplying of fruits and vegetables to export markets in Gulf countries through Bombay. Besides NAFED, there are 12 state/central level societies and 275 primary marketing societies engaged in marketing of fruits and vegetables. However, their total turn over is reported to be only Rs. 120 crores out of which 45% is accounted by NAFED alone.

iii) Post harvest losses : Post harvest losees invariably occur at any point in the long marketing channel. That 25 to 30% of f fruit and vegetable production valued at Rs. 3000 crores, is even now lost to the nation yearly during post harvest, is a very sad reflection of the status of vegetable production and marketing. It is of course possible to replace these losses in quantity by increase in production, if the levels of the losses remained constant. What is actually happening is that an increase in the production results in the increase of proportion of losses due to marketing inadequacies in handling the extra volume and economic losses may be greater still. Reiteration of sophisticated systems and technologies like "Cold chain" of advanced countries, may have little relevence to our needs. Post harvest losses erode the grower's income for his produce and push up the consumers price.

iv) Survey : A national survey on post harvest losses in vegetables should be undertaken to pinpoint 'where' 'how' and 'why' they occur and enough data and information will have to be ness of consumer preferences and perishability. Farmer's share of the consumer price may range from 30 to 45%. In a sample survey conducted in Karnataka by Indian Institute of Horticultural Research, Bangalore (1984), it was computed that 50.47% of the overall retail price of vegetables, is taken away by the Commission charges. A study by the Directorate of Marketing and Inspection of Govt. of India (1985) found that onion producers in Maharashtra got 41 to 42% of retail price depending upon the channel private or institutional. In contrast, wheat and paddy farmers received 65 to 66% of consumer price. In the case of other vegetables which are more perishable than onion and faced with more volatile demand, the farmer's share is bound to be lower. Interestingly institutional presence as intermediary, has only marginal effect on the farmer's share.

Thus interests of growers and consumers have to be protected. Govt. cannot effectively operate a price support mechanism barring in potato and onion. In marketing of vegetables (also of fruits) several lakhs of self employed persons are engaged and it will not be advisable nor practicable on socio-economic grounds to completely displace the private trade. But the necessity of creating alternate marketing channels to work in completion, needs no emphasis.

ii) Co-operative institutions : There have been some successful attempts in Bangalore and Hyderabad cities where co-operative growers organizations undertake collection, storage, grading, pricing and marketing of fruits and vegetables in retail outlets. This system is reported to be handling only a small volume of urban trade, due to which it does not exert any influence on the on the local vegetable prices. In Nilgris (Tamil Nadu) there is actually interlinked parts of a total system to be shaped into a powerful vehicle for the economic prosperity of small farm families and nutrition security of rural landless labourers and urban slum dwellers.

Today in the field of Nutrition and Dietetics, salad vegetables are components of healthy diet, even in the advanced countries where processing industries are well developed. In future, healthy foods will be mostly horticulture products only. In India, realisation and appreciation of the immense potentialities of vegetable production and consumption, have to be promoted.

Vegetable cultivation, of late has gone into commercial s scale-especially for urban makets and has become a specialised activity. Vegetable farmer can no longer afford to function as a grower and harvester merely relying on his instincts and centuries of experience. He should be enabled to emarge as a full scale farm manager with enterpreneurial abilities and negotiating skills. Farmers should be trained and encouraged to do what successful businessmen to, acquire and constantly update information on new technologies and merketing trends, applying management skills to reduce costs, improve efficiency and maximise productivity. It is a good beginning that some business organisation in Calcutta city have promoted high technoloty hybrid vegetable production in Diamond Harbour area south of Calcutta. Unfortunately most of the vegetable farmers are left largely to their own resources and only the enterprising few and those with resource endowment seem to derive benefits from vegetable growing.

collected. Then only efforts can be made to reduce these losses by formulating a "**LOSS PREVENTION PLAN** through better varieties, handling, packing and storage facilities.

Often marketing of vegetables is considered in isolation and without taking a 'holistic' approach of the entire gamut of production and marketing systems, it would not be possible to mitigate the post harvest losses.

v) Projections : Obviously a "Loss Prevention Plan" should be adequately funded to develop a data base collected from the surveys. Field work in close collaboration with individual farmers, traders and intermediaries, is essential, so that careful recording of economic value of each marketing point and volume handled, are done. While the National Horticulture Board has developed sufficient infrastructure for collecting market statistics of arrivals, the next stage is reached to identify the vulnerable points in the entire marketing chain and steps will have to be devised to prevent and at least reduce post harvest losses. An awareness of the economic dimensions of these losses should be promoted. A more close co-ordination among the Agricultural Marketing Directorate (Dept. of Rural Development) National Horticulture Board, and State Departments of Horticulture, would be necessary to launch a NATIONAL LOSS PREVENTION PLAN.

Future Strategies

Vegetable production has been treated on low priority category and on conventional approach like pre-occupation with seeds fertilizers, water, soil etc., as disparate elements almost as if they are self sustaining factors in themselves. But they are

The impact of burgeoning population of 840 millions of people will be increasingly felt in the current decade in the area of vegetable production and consumption and it points towards a crisis in the country's ability to feed and maintain the population at a healthy level. A multipronged strategy of of boosting vegetable production and consumption should be evolved comprising inter alia two important basic components (enumerated earlier) viz. a "National Vegetable Seed Policy" and "Loss Prevention Plan" in post harvest operations, besides others. A 'total system' approach as has been done in 'Technology Missions' (in oil seeds) should be thought of, deliberated and developed with suitable modifications, to tackle the various problems of vegetable production and consumption.

Vegetable seed industry in India

Vishnu Swarup*

Seed is a living biological capsule containing within it the entire genetic and biochemical make-up of a plant. It has, therefore, attracted attention of scientists of many disciplines, like plant genetics and breeding, agronomy, physiology, biochemistry, plant pathology and entomology. Advancement in genetic improvement and production technology of vegetable crops is directly related to development of seed industry. The efficiency and growth of seed industry depend upon the availability of new and better varieties, proper maintenance and evaluation of the varieties and controlled production of good quality seeds.

Research and development

The research and development, therefore, form an integral part of a modern seed industry. The seed production and distribution is an interface between the plant breeder and the farmer.

Vegetable Improvement

Scientific improvement of vegetables in India has a history of about five decades. Until the year 1942, vegetable seeds were being imported from the European seed companies, Sutton & Sons (England), Valmorin (France), Ohlsen Enke (Denmark), Royal Sluis (Holand) and a few others to meet the requirements of growers. It was only during the Second World War when the supplies of vegetable seeds from abroad were almost stopped, that the Government of India started to lay emphasis on seed production in the country. Successful attempts were made to produce seeds of temperate vegetables at Quietta (Baluchistan) in 1942-43. Almost during the same period production of temperate vegetable seeds was started in Kashmir and Kulu Valley. Later in 1949, the Central Vegetable Research Station was established at Katrain in Kulu Valley which was later transferred to the Indian Agricultural Research Institute,

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New Delhi in 1955, to intensify research on improvement and seed production of vegetables. Vegetable research was further strengthened by the grant of ad-hoc research schemes of the Indian Council of Agricultural Research in different States from 1946 onwards. Seperate vegetable research divisions or departments were established in the Central Institute of ICAR like the Indian Institute of Horticultural Research, Hesserghatta in 1968 and Indian Agricultural Research Institute, New Delhi in 1970, followed by various State Agricultural Universities at Hissar (Haryana), Ludhiana (Punjab) and Coimbatore (Tamil Nadu). With the initiation of the All India Co-ordinated Vegetable Improvement Project by ICAR in 1970-71 multidisciplinary co-ordinated research began on vegetable crops at various centres in different agroclimatic regions. It has provided a useful facility to research workers for national testing of improved varieties and agronomical practices and exchange of germplasm.

Seed Industry

Development of improved varieties necessitated the establishment of a well organised seed industry in the country. Consequently, the National Seeds Corporation was founded in 1963, to organise the development of an efficient seed industry and to provide services for seed certification, seed quality control, seed processing, packaging, seed marketing and training in various aspects of seed production. Afterwards, the State Seed Corporations were set up in different States to meet the requirements of quality seeds in different regions. The State Farm Corporation of India, Associated Agricultural Development Foundation, State Agricultural Universities, Tarai Seed Development Corporation (U.P) and the Central Institutes of ICAR (IARI and IIHR) also multiply and distribute seeds of vegetable crops. Another significant development in seed industry was the enforcement of Seed Act of 1966 from October, 1969, in all the States of the country. The Central Seed Committee set up by the Government of India was given the responsibility to administer Seed Act in the country and fix standards for seed certification, purity, germination etc. besides, the release and notification of improved varieties. There are Central as well as State Seed Certification Agencies. Later the Central Seed Testing Laboratory was established in Delhi and also State Seed

Testing Laboratories in different State of the country. About fifteen years ago, the National Seed Programme (NSP) was undertaken with the assistance of the World Bank, which is now in its third phase. During the second phase of NSP, vegetable crops were also included in the programme. In 1988 the Government of India libaralised the import of seeds of hybrid pollinated varieties. Simultaneously there were developments in private seed industry also. Both public and private organizations have made important contributions to the growth of vegetable seed industry in India.

Seed Requirements

The total demand of vegetable seeds is about 29,500 tonnes annually of which 25-30 per cent is met by the private companies, 10-15 per cent by the public sector and the rest from their own seeds saved by the farmers. The area under vegetable crops is about 4.5 million hectares with a production of 41.2 million tonnes. The consumption of vegetables per capita per day in India is only 120 g, which is far below the recommended dietary standard of 280 g. It is estimated that by 2000 AD the requirement of vegetables in the country would be about two to three times more than the present production. Both area and productivity have to be increased to meet the national requirement of vegetables. Expansion and strengthening of seed industry on modern scientific basis would, therefore, be necessary for production of the required quantity of quality seeds.

Crop Productivity

Unfortunately, the average productivity of vegetables in India is only 9.15 tonnes per hectare. In general, the average yield in most of the vegetable crops is very low as compared to those in developed and developing countries.

Productivity is influenced by variety, environment, soil, production technology and protection from diseases and insect pests. More than 150 improved open-pollinated varieties developed by the public institutions are released in various vegetable crops which out-yield the local cultivars. However, only 30 to 40 percent of growing area is covered under these improved varieties except in a few cases. It is, therefore, necessary to saturate the growing areas with high yielding varieties.

Hybrid varieties

One of the most efficient and rapid methods used in bringing out increased productivity in vegetables is the exploitation of hybrid vigour. Through heterosis breeding, it is possible to achieve manifold increases in yield along with better quality of produce and disease resistance. Uniformity of produce and maturity due to genetic homogeneity and favourable dominant gene combinations are the additional advantages of F_1 hybrids. Unfortunately, in our country, the progress in developing and popularising hybrid varieties have been slow and without much impact on vegetable production. In India, the first F_1 hybrid varieties of tomato and capsicum were released for commercial cultivation in 1973 by the Indo-American Hybrid Seeds. Later with the success of F_1 hybrids, a few other private seed companies also introduced seeds of F_1 hybrids of important vegetables in the market. In October, 1988, the Government of India under the new seed policy allowed the import of F_1 hybrid and other improved vegetable seeds under open general licence at a much reduced custom duty of 15 per cent. The main objective of the new seed policy is to make available the best quality seeds to farmers. The National Seeds Corporation has also imported seeds of F_1 hybrids of cabbage and tomato for distribution to farmers. Many joint ventures with some leading foreign seed companies have come up recently in the private sector. It is estimated that about 50,000 tonnes of vegetable seeds, particularly, tomato and cabbage, have been imported in the country since the liberalisation of import of seeds.

Another important aspect of hybrid vegetables is the export of hybrid seeds. The production of hybrid seeds is a global activity. Many international seed companies of U.S.A., Holland, Denmark and Japan are producing hybrid seeds in some Asian, South American and Southern European countries where the labour is less expensive. It also ensures availability of seeds for marketing in different parts of the world round the year. Recently China has taken up production of F_1 hybrid vegetable seeds for export on a large scale with the assistance of some important foreign seed companies. In India, a few private seed companies produce hybrid seeds on contract for export. Although the export of seeds is not substantial at present, it has a great potential to increase in future.

The hybrid varieties have proven beneficial to many in different ways, such as, higher yield and higher returns to farmers, premium price for produce in the market to traders and better recovery and quality products for processors, as in case of tomato. Hybrid seed production provides built-in protection of proprietory rights of the hybrid varieties to seed companies unlike open pollinated varieties, appreciable profits to seed producing farmers, and gainful employment to youths in rural areas as it is labour intensive.

The vegetable seed industry both in public and private sectors, must be expanded and streamlined to meet the challenge of increased demand of quality seeds by the end of the present century. It is possible to achieve the required targets in seed production by adopting certain measures, apart from the development of superior high yielding, disease resistant and better quality of hybrids. These measures include modernisation of seed industry with better equipment, machinery, efficient seed storage and packing facilities, and trained personnel, strong inhouse research and development division and intensification of research on various aspects of seeds and seed crop including seed physiology, seed pathology, entomology and agronomy. Biotechnology including tissue culture technique which has become an important aid in plant improvement should receive attention in research institutions. The seed producing enterprises should identify the best areas suitable for producing seeds of a particular vegetable. The vegetable crop growing areas may not necessarily be also the best for seed production. There is hardly any useful information available on this aspect in our country.

Even though the vegetable seed industry is highly competitive, it has the most challenging but rewarding future in India.

Sustainable vegetable production in India - Prospects and policy planning

Dr. K.G. Shanmugavelu*

Vegetables play a vital role in the human nutrition. They provide vitamins and minerals in the diet besides supplying protein and energy. To meet the full dietary needs of the common men, to eliminate malnutrition deficiency disorders and to relieve the pressure on cereals, there is a greater need of vegetables.

India is the second largest producer of vegetables in the world next to China. India's share is 12% of the world production compared to 23% of China. The total area under vegetables is estimated to be 4.14 m ha including tuber crops. The percapita consumption of vegetables is just around 75 g as against the dietary requirement of 200 g. This will be 55 million tonnes. Besides the direct human needs, the country has also to make provision for export as well as processing and also allowance for spoilage. When considering these factors, by 2000 AD, the production target would be 91.25 million tonnes which would account for an area of 5 million hectares, assuming an average yield target of 20 t/ha: The cultivable land-man ratio has been declining from 0.48 ha in 1951 to 0.28 ha in 1981 and this may go down to 0.15 ha in 2000 A.D.

1. Crop Improvement

So far more than 175 improved varieties of vegetables have been released in India by the concerted efforts and devoted horticultural scientists from various central institutes and Agricultural Universities and Private Agencies. These improved varieties are high yielding, about three to five times greater than the local varieties. In certain cases, these varieties are resistant/tolerant to pests and diseases also. However, according to an estimate, it seems that only 30 to 40% of the growing area has been covered under

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varieties. It is therefore very essential to flood the vegetable growing area with these improved varieties. While developing varieties, the vegetable breeders should aim to produce varieties with high nutritional value, good keeping quality, better transportability and processing quality. While we feel proud of these significant achievements, there is such to be done in evolving suitable hybrids through heterosis breeding in tomato, brinjal, capsicum, cabbage, cauliflower, cucumber and onion and breeding varieties having multiple resistance to biotic and abiotic stress.

Hybrids

In India, the first F_1 hybrid tomato and capsicum were released for commercial cultivation in 1973. New hybrid tomato covers nearby 50,000 ha hybrid cabbage about 20,000 ha. Hybrid tomato has yielded 70 t/ha which is double the yield of the existing open pollinated varieties. The hybrid varieties have proved beneficial to many in different ways, such as higher yields, and higher returns to farmers, a premium price in the market for the traders, and better recovery and quality products for processors. Research has been in progress in the production of F_1 hybrid vegetables in India. The Central Institutes and the State Agricultural Universities have evaluated and identified hybrid varieties in several vegetable crops. They are Punjab, F_1 muskmelon, Arka Jyothi watermelon, Arkanavneet in brinjal, Pusa synthetic cauliflower, Pusa Sanyog in cucumber, Azad hybrid brinjal and Co.2 hybrid bhindi.

Private seeds men have also produced F_1 hybrids. Some of these F_1 hybrids are in tomato, Rupali, Vaishali, and Naveen from Bangalore, Hybrid S-15, Hybrid S-16 and Samiruchi from Jalna and SG-12 and SC-9 from Calculatta; in capsicum Bharat from Bangalore in cabbage Ganesh Globe, No. 8 and Harirant from Jalna, in cucumber Priya and in watermelon Madhu and Milan from Bangalore. However, the spread of these F_1 vegetables is facing problems such as availability of adequate quantity of seed materials, exorbitant prices and high cost input.

Production of hybrids should be integrated with resistance breeding. In tomato especially hybrids resistant to leaf curl will be favoured all over India. In Okra, yellow vein mosaic resistant hybrids will be preferred. Resistant hybrids will bring down the cost of production by reducing the expenditure on plant protection. The main criterion to evolve hybrids is to identify self incompatible lines and cytoplasmic male sterile lines. These have been identified in cabbage, in pink onions, tomatoes; and in muskmelon monoecious female parents, and also in cucumber (only female flower) in various institutions and Research Stations and their hybrids are being evaluated.

2. Biotechnology

The attention of biotechnologists throughout the world is focussed in this new field to produce new plants of great interest. In vegetable crops bio-technology can be adventageously utilised in plant tissue culture and genetic engineering.

A. Tissue culture is particularly helpful when used in conjunction with plant breeding progremme. It enables the timely increase and hastens the availability of new cultivars. *In vitro* cultures may be successfully employed for obtaining viable hybrid plants, which usually do not yield viable progeny, through culturing of apical maistem. For mesophyll protoplasts in lettuce, leaf discs and hypocotyl segments in *A. hypochondriacus*, embryos in okra, leaf discs and stem segments in tomato, protoplasts in Brassica, flower buds in broccoli, embryogenesis in brinjal, leaf segments in beans etc. have been employed successfully to produce plantlets. Scientists should not stop and satisfied with producing plantlets. But these plants should be commercially exploited.

B. Genetic engineering

Several vegetable crops are susceptible to biotic and abiotic stress which limit their productivity. Among the various methods of crops improvement, transfer of wild genes resistant to some of these stresses is most promising.

Resistance to herbicides is being incorporated in crop plants. Elegent methods of DNA transfer are now available. A new era in genetic engineering has been ushered. Genetic engineering can also be used to correct in balance of amino acid profile in vegetables.

We have to go a long way to accomplish in this area.

3. Production of vegetables under abiotic stress

4. Drought

Out of 142 million hectares of gross cultivated area in our country, more than 100 million hectares are dependent upon natural rainfall. By 2000 AD, 47% of the cropped area will be under rainfed. Therefore it is necessary that contingency plans are to be prepared for any eventerality which may be the failure of rainfall, delayed rainfall, irregular rains and normal rains.

Future approach

i) Crop productivity should be stabilised through appropriate breeding. The hybrids or varieties so produced should be drought tolerant or drought resistant.

ii) Crops which are more resistant or tolerant then the crops under rainfed cultivation should be identified. If the crops are not available in our country, they may be obtained from abroad and tried in our country. Short duration varieties capable of escaping drought may be identified.

iii) The productivity of the crops/varieties should be increased through breeding, genetic engineering or by developing appropriate package of practices. Since the farmers in the rainfed areas are poor, the technologies that recommended should be low cost technologies.

iv) Planning of the inter and sequencial cropping systems is very necessary for bringing stability and economic benefits to the farmer. If one crop fails, the other crop should give income to the farmer. Already developed cropping systems in the vegetable crops should be fully exploited.

B. Salt tolerance of vegetable crops

It is estimated that there are about 7 million hectares of saline, alkaline areas in the country. It is also estimated that every year India is losing about one lakh hectares to these conditions due to improper drainage or other factors. However, the extent of salinity is varying from state to state and the incidence is highest in Punjab (16%), Delhi (15.3%), Haryana (13.9%), West Bengal (15.50%), Gujarat (11.04%) and Uttar Pradesh (6.30%). There are certain vegetable crops which can survive under these difficult conditions. In many of the rainfed areas, salinity, alkalinity is a problem.

The development of vegetable crops and varieties suitable for growing in saline soil is one of the major tasks in increasing the productivity. The salt-tolerance of a variety can be judged by i) its resistance to high salinity levels, ii) its productive capacity at a given level of salinity as compared to that in non-saline soils.

At Tamil Nadu Agricultural University, Coimbatore, the available germplasm of all the vegetable crops at the Department of Olericulture was screened fro salt tolerance. The study has revealed that species and varieties have exhibited varied levels of tolerance, to salt. Among them, cucurbitaceous vegetables especially bottle gourd was found to be most tolerant upto 1.50 M and the order of tolerance decreased as indicated below: redish: variety scarlet Jaunpur, Newar (1.25 M), French beans UL.1 (1.25 M), Co.1 Amaranthus (1.25 M), tomato PKM (1.00 M), Onion Ac. 463 and 450 (1.00 M), cabbage BoC 25 (1.00 M), 63 and CS (0.75 M), and sweet potato 183, 1881, 18.71 (0.75 M) and Coriander Pusa - 360 (0.75 M).

Based on 20 years of work at the Department of vegetable crops, Hariyana, Agricultural University, Hissar, to different vegetables can be classified in three groups, on the basis of their salt tolerance to salinity.

Salinity tolerance of a crop not only varies among crops/ varieties but depends upon environment and cultural practices also. Therefore to have more realistic assessment of salinity tolerance of a given crop, the value of soil salinity at which initial yield decline begins and percentage yield decline with per unit increase in salinity is given in table below for different vegetable crops.

Table 1 : Relative salinity tolerance of different vegetables (based on 50% reduction in yield over non-saline control.

	Salinity tolerance (Eca)	
Upto 4	4-6	6-8
Green peas meths, beans and radish	Sweet potato, tomato garlic, brinjal, carrot, cauliflower, chilli, muskmelon onion, okra, potatoes, lettuce, bell pepper artichoke	Fennal, Palak, Spinach, turnip, radish Carrot, Onion buffaloe gourd, cabbage

Table 2. Soil salinity (Eca) at which initial yield decline begins and percent yield decline with per unit increased in salinity

Crop	Soil salinity at which initial yield decline begins	% yield decline with per unit increase in salinity
Bean	1.0	19.0
Broad bean	1.6	9.6
Broccoli	2.8	9.2
Cabbage	1.8	6.2
Carrot	1.0	14.0
Cucumber	2.5	13.0
Onion	1.2	16.0
Pepper	1.5	14.0
Radish	1.2	13.0
Potato	1.7	12.0
Spinach	2.0	7.6
Sweet potato	1.5	11.0
Tomato	2.5	9.90
Turnip	0.9	9.0

Since large area of the cultivable land has become saline/ sodic, efforts should be taken to select the relatively tolerant vegetable crops and varieties and further tolerance should be built up in then through plysiological and breeding methods. Various agronomical techniques will be of great help to avoid hazardons salt effects.

4. Biofertilizers

Micro organisms convert about 130 million tonnes of nitrogen every year nito fertilizer nitrogen. It is possible to meet a large part of the total nitrogen demand through proper husbandry of microorganisms in crop production systems. Biofertilizers are used to supplement the nutrient requirements of crops. Some of the micro-organisms Rhizobia (Symbiotic bacteria) and Azozpirillum and Acetobacter, (non symbiotic bacteria) are found useful in crop production. These biofertilizers save about 20-25% of Nitrogenous chemical fertilizers. The usefulness of these biofertilizers have not been exploited in vegetable crop husbandry. Adequate quality of biofertilizers need to be supplied to the farmers in time. The major constraint involves the relation between research institutions and industry. A transfer of technology between the research institution and industry is essential. The innovations or recommendations have to be disseminated through the extension workers to the farmers effectively. Therefore, a strong extension and training programmes in this field is very essential.

5. Seed production

Vegetable production can be improved if the vegetable growers are able to get good quality seeds of improved varieties at adequate quantity. A serious constraint faced by the vegetable growers is the non availability of good quality vegetable seeds of improved varieties in adequate quantities at the time of sowing. It is always advisable to produced good quality and reliable seeds by themselves, rather, than depending on the seedsmen who supply spurions seeds which ultimately burn their fingers of the vegetable growers. In this content, training and testing of vegetable seeds should be imparted to the growers. It is also suggested that a Co-operative society may be formed in the village where vegetables are pre-eminently grown, for vegetable seed production and distribution. This may be cheaper than the cost of the seeds obtaining from the seedsmen.

During 1988, the Government of India has liberalised the import of vegetables seeds as per the new seed policy. It has slushed the import duty on seeds to 15%. The limited number of F_1 hybrids in vegetable crops and the extremely limited availability of seeds have influered the Government in allowing the import of hybrid seeds of vegetable crops under the new seed import policy. While the seed industry has hailed this new policy, farm scientists and breeders in the various Agricultural Research Institutes and Universities have opposed to the new seed policy, because while importing seeds, it is likely, the new pests and diseases may creep in along with the seeds.

Some private seed agencies organise commercial hybrid seed production by contracting with the farmers in a group of adjacent villages. The farmers grow these vegetables for production of seeds under close survillence and guidance and the seedsmen supply the seeds of the parents and inputs and train the farmers in the techniques of hybrid seed production. This kind of management of hybrid seed production on a commercial scale should be taken up by the public sector with suitable modifications and Government support. In fact, this gap in commercial hybrid seed production of vegetable varieties has diverted the farmers to private seedsmen who charge exhorbitant prices for the hybrid seeds produced, marketed or labelled by them.

6. Pests and disease management

Integrated pests and disease management is very essential for vegetable production and the information on vegetable culture is scanty. The wide spread use of pesticides leaves residues for a considerable time, causing toxic symptoms to vegetation, fishes and birds, besides contaminating soil water, environment etc. Residual toxicity is a serious problem particularly for the export Oriented produce. Another serious problem is the development of resistance to chemicals. Using integrated measures including biological control will alleviate the above problems and studies on this aspect need to be intensified for various vegetable crops. One of the basic components of integrated pest management is to develop varieties resistant to major pests and diseases.

7. Expansion of area under vegetables

Vegetable cultivation is normally confined to inferior villages and in the suburbs of towns and cities. Besides vegetables are drawn from far off places. This is not sufficient to meet the demands of the people. We have to encourage the people to grow vegetables in the back yards of their humas to meet their daily requirements. However, consequent in population explosion, every inch of land in urban areas is utilised for construction, of houses and skyacreppers. In such cities, it is difficult to grow vegetables. To overcome such problems, vegetables, can be grown at terraces to meet the requirements of household members. River beds, tank beds, area near lakes have to be utilised for raising vegetable crops. Rice fellows can also be utilised for raiding short duration vegetables crops with the available soil moisture.

The vegetable cultivation has to be extended to the interior places in pace with the development of roads or other means of communication. This makes its necessary, to draw the priorities for extending the area. Town and cities should get the first preference, next in the order could be hills, then beds of tanks, lakes, rivers and canals and lastly the interior villages.

The extension activities pertaining to vegetable cultivation are lacking and have no distinct locus standi. In this context, it is suggested that the vegetable estates (vegetable belts) should be established properly with the existing areas and advice rendered to the growers in vegetable culture with profit motive.

It should be the responsibility of the Stage Governments to organise the growers into suitable co-operatives so that they can derive the benefits of the collective measures. It should also be the responsibility of the Governments to see that proper facilities for various kinds of operations are placed at the disposal of the growers in the form of custom service. The custom service can be organised either through co-operatives or through Governmental organisations.

The growers are also required to be encouraged to grow vegetable from the export point of view. Excellent market opportunities are available in Europe, West Asia and South East Asia and middle East countries. The major constraint for increasing the export is the non-availability of quality produce suitable for export as most of the varieties grown in our country are not suitable for this purpose. Besides this, economic constraints like high cost of production, high air-freight charges, packing cost, etc. also act as detergents for increasing exports. Steps should be taken for removing these constraints by adopting proper measures.

There are large number of indigenous vegetables particularly leafy, on which no systematic studies regarding their nutritional value and agro-techniques have been done. Leafy vegetables belonging to different species of Amaranthus, Portulace, Trigonella, Alternanthera, Basella, Colosia and various other species should be collected and evaluated for their nutritional and other desirable characters.

Tropical Vegetables - their nutrient contribution and conservation of nutrients

Dr. Usha Chandrasekhar*

The importance of fruits and vegetables in our daily diet is well known. Vegetables are rich and comparatively cheaper sources of vitamins and minerals. Their consumption in sufficient quantities provide taste, palatability and increases appetite and provides fair amount of fibre. These are currently reckoned as important adjunct for maintanence of good health and beneficial in protecting against some degenerative diseases. They also play a key role in neutralising the acids produced during digestion of proteinous and fatty foods and also provide valuable roughage which promotes digestion and helps in preventing constipation. Growing of fruits and vegetables offer greater employment opportunities and because of intensive cropping are much more remunerative than the cereal crops. Data given in Table 1 indicates the production, productivity of the fruits, vegetables and tuber crops.

Table 1. Horticultural crops projections upto 2000 A.D.

	Area m.ha	Production 1986-87 m.ha	Productivity t/ha	Targets (in m. tonnes) 1995	2000 A.D.
Fruits	2.94	26.50	9.02	32-36	40-50
Vegetables	4.32	44.96	10.26	60-65	80-90
Potato	0.99	14.14	15.89	17	20
Cassava	0.16	1.35	8.44	1.75	2.15
Sweet Potato	0.27	5.21	19.30	6.5	8.0

Even though the production and productivity has markedly increased in the recent past, the per capita availability of these is much below the minimum nutritional requirements. A

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minimum per capita consumption of 280 g. of vegetables including tubers in essential. However present level of production could supply only 130 g. per capita per day and thus annual requirement works out to be 83 million tonnes.

Cucurbit vegetables contain all the nutrients in fair amounts and among these vegetables, kakrol contains the highest amount of protein and carbohydrate. Pumpkin contains carotenoid, bitter gourd is rich in vitamin 'C' Sponge gourd and kakrol contain higher amounts of carotenoids. Bittergourd contains high amount of iron also and all the cucurbit vegetables are fair sources of Thiamine and riboflavin. Biochemically the cucurbits are characterised by bitter principles called cucurbitacins. Tapioca contributes for energy from its starch and is also rich in vitamin 'C'. Legumes such as cowpea, cluster beans and dolichos beans are rich in protein, carbohydrate and also contain appreciable amounts of calcium and phosphorus. Cluster beans contain higher amounts carotene a vitamin A precursor. Onion provides fair amounts of energy, calcium, phosphorus and provides higher thiamine. Yams provide higher energy, fair amounts of calcium, Phosphorus and greater amounts of thiamine, riboflavin and is also rich in carotenoids. Sweet potato also provides good amount of energy, calcium, phosphorus and vitamin C.

Though vegetables are good sources of protective nutrients, its conservation to maximise the benefit is a matter of great importance.

How to realize maximum nutrient contribution from vegetables?

The major measures to realize maximum nutritive value from vegetables are to cook the vegetables without nutrient losses. Following are a few hints to ascertain maximum nutrient preservation.

1. Buy fresh vegetables and use them while they are fresh to retain maximum nutritive value.
2. Wash them before cutting to avoid water soluble vitamin loss.
3. Whenever possible, cook with skin so that the nutrients nearer to skin portion is not lost and soaks in. If need be, remove

skin after cooking. Skins are good sources of fibre as well.

4. Cut the vegetables only just prior to cooking to prevent oxidation of nutrients. In order to prevent vitamin losses cut the vegetables into large pieces and avoid larger surface area of exposure.

5. Cook the vegetables in sufficient amount of water. Pressure cook the vegetables whenever possible and do not discard excess water, if any, after cooking. Use the excess water in other preparations.

6. Do not over cook vegetables as it will result in loss of flavour, colour and texture and prolonged cooking can also destroy nutrients.

7. Avoid reheating of vegetables. As far as possible serve the cooked vegetable hot ie., soon after cooking to realize the maximum benefit.

8. Avoid high temperature cooking like frying to get better benefits.

9. If vegetables are processed for future use, adopt appropriate technology to minimize nutrient loss.

10. Avoid post harvest losses in vegetable production.

Thus there are several measures to conserve the protective nutrients from vegetables and the researches conducted have shown beneficial impact of such measures and methods of cooking. Much more work in this area is needed to improve its post harvest technology so that wastage could be avoided and much of the vegetables produced can be used by the common man. More research in the area of vegetable preservation and maximization of nutrient conservation is recommended.

Economics of Vegetable production and marketing

V. Radhakrishnan*

Vegetables play a very important role in human nutrition, supplying the much needed vitamins, minerals, roughages etc. In poor countries, importance of vegetables is not adequately appreciated on account of inadequacy of information on health education on the one hand and inability to meet requirements of items of staple food, on the other. At lower levels, income elasticity of demand for staple food tends to be quite high and whatever increase in incomes that take place, gets substantially absorbed by increase in demand for staple food. At higher and higher levels of family incomes, the proportion of income spent on items of staple food tends to decline and the proportion spent on other items of food tends to increase. Thus, at higher levels of income, vegetables and other horticultural products find increasing importance in the country's economy.

Vegetable cultivation is yet to attain an important place in Indian Agriculture. Of the total cropped area of about 173 million hectares, vegetables occupy only about 3 million hectares (1.73%). In as many as ten states, percentage of area under vegetables to total cropped area is much lower. Though agro-climatic factors play an important role in this, the relative unimportance of vegetable cultivation is also due to other reasons such as preoccupation with

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the production of staple food crops, lack of awareness about the role of vegetables, non-availability of good quality vegetable seeds, inadequacy of technical know-how etc.

Costs, Returns and measures of performance

All production decisions are basically economic decisions. Hence the farmer ought to devote his resources of land, labour and capital in such a way as to maximize net returns. Net returns are the differences between total revenue and total cost (TR-TC) and maximization of net returns means maximizing this difference. Costs and returns could be computed for the farm business as a whole or for different enterprises. Among the resources available to the farmer, some such as land cannot be augmented in the short run, while others such as manure, fertilizers, casual labour etc. can be. In other words, some resources are fixed in supply while others are variable. On this basis, costs are grouped into two, viz. fixed costs and variable costs. Thus, in the short run, level of production can be increased or decreased only by changing level of variable resources or inputs; for example by varying level of use of fertilizers, plant protection chemicals, casual labour etc. Costs involved in the use of variable factors or factor services are called variable costs. Costs associated with use of fixed factors or factor services are called fixed costs. Fixed costs are so called because they do not vary with level of output. Variable costs are those which vary with level of output. Fixed costs have to be incurred even if production is temporarily suspended. Examples of items of fixed costs are rent on land, land revenue, depreciation on machinery and implements, wages of permanent labour etc. Fixed costs are also known as overhead costs. Total cost consists of fixed and variable costs. Since average cost is cost per unit of output, which is the sum of average fixed and average variable costs, average fixed cost per unit of output and hence average total cost per unit of output will be lower at larger level of output (within certain limit) than at lower level of output. There is no distinction between fixed and variable costs in the long run because in the long run, use of each and every resource is variable. In other words, there are no fixed costs in the long run. As noted above, net returns are returns over total costs. In order for any enterprise to be economic, there must be reasonable net returns. However, in those short run situations when positive net returns cannot be made or in other words, losses are inevitable, it is worthwhile to continue production so long as total returns are higher than total variable costs. Thus, return over variable costs is another measure of performance. By continuing production rather than closing down completely, losses which are unavoidable, can be minimized. Thus, the endeavour should be to maximize profits, but when losses are inevitable the endeavour should be to minimize losses.

Yet another measures of performance is break-even analysis where the level of break even output (BEO) is estimated as,

$$\text{BEO} = \frac{\text{Total fixed cost per farm}}{\begin{array}{c}\text{Price per}\\ \text{quintal}\end{array} - \begin{array}{c}\text{Variable cost}\\ \text{per quintal}\end{array}}$$

At break-even output total cost is just equal to total returns.

Cost of cultivation can be computed inputwise or operation wise or both. In the former case, cost of use of each and every input is computed and totalled and in the latter case, cost of each and every operation beginning with land preparation or nursery preparation is identified and totalled.

The following cost concepts are used in inputwise tabulation of costs, viz.

Cost A1: This mainly represents paid out costs and includes cost of following:

i. Hired human labour

ii. Hired bullock labour

iii. Owned bullock labour

iv. Hired machinery charges

v. Own machine labour

vi. Seed (farm produced as well as purchased)

vii. Plant protection chemicals

viii. Manures (farm produced and purchased)

ix. Fertilizers

x. Depreceation on implements and farm buildings

xi. Irrigation charges

xii. Land revenue, cess and other taxes

xiii. Interest on working capital

xiv. Miscellaneous expenses

Cost A2: Cost A1 + rent paid for leased in land

Cost B : Cost A2 + imputed rental value of owned land + imputed interest on owned fixed capital (excluding land)

Cost C : Cost B + imputed value of family labour.
Cost C is the total cost noted earlier.

As can be seen, some of the items of cost are not actually incurred such as cost of farm produced seed, cost of farm produced manures, cost of family labour etc. It might appear that these costs need not be accounted for. It is not correct to ignore such costs. That would result in under-estimation of cost. More over some of these, if not used on the farm can be sold to others. Over and above these, there would also be the problem of non-comparability of costs of different farmers, if these costs are ignored. Thus, some farmers may use only family labour while others may use only hired labour and if cost of family labour is not accounted for, it will not be possible to compare their performance. Since resources used from within the farm and farm family are not paid for, how do we account for them? Farm produced material inputs can be evaluated on the basis of prices prevailing for such items in the locality. This is known as imputation. A similar approach can also be adopted in case of family labour.

Another concept of cost is that of opportunity cost. Opportunity cost of anything is the next best alternative that is forgone. For example, by using a particular resource, say fertilizers in the production of say, brinjal rather than in the production of say, tomato, or bittergourd, the opportunity of producing a certain quantity of tomato or bittergourd is lost. If the next best alternative to brinjal is tomato, the opportunity cost of fertilizer in the cultivation of brinjal is the number of additional units of tomato which could have been produced had the fertilizer been used for tomato rather than brinjal. The concept of opportunity cost helps the decision maker in maximizing returns from the use of limited resources.

Empirical findings on costs and returns of vegetable cultivation

There are not many studies on cost of cultivation and economics of vegetables. Available information however, indicates that vegetable cultivation is a paying proposition. In a study in a major vegetable growing area in Kerala, Selvin (1982) obtained the following results.

Table 1. Costs and Returns of vegetable cultivation in Malappuram district (Rs./hectare)

		Pumpkin	Ashgourd
Cost A1		3457	3076
A2		4440	4073
B		4985	4603
C		7898	7325
Output (kg)		14228	17201
Gross income Rs.		9797	11362
BC ratio based on Cost A1		2.83	3.69
-do-	A2	2.21	2.79
-do-	B	1.97	2.47
-do-	C	1.24	1.55
Farm business income		6339	8286
Family labour income		4812	6859
Net income		1899	4037
Farm invest income		2444	4568
Return over variable cost		3566	5697
Value of output/labour day		45.57	56.81

It can be seen that according to the study, ashgourd cultivation was more profitable and efficient than that of pumpkin.

Results of three case studies in Palghat district in Kerala during Kharif 1990 are given in Table 2.

Table 2. Inputwise cost of cultivation of vegetables in Palghat district (Rs./ha)

	Tomato	Bhindi	Cowpea
Hired human labour	2371.00 (26.67)	4915.00 (53.33)	3273.00 (35.64)
Hired bullock labour	408.00 (4.59)	408.00 (4.43)	543.00 (5.91)
Seed	62.00 (0.70)	74.00 (0.80)	74.00 (0.81)
Manures and Fertilizers	988.00 (11.11)	642.00 (6.97)	494.00 (5.38)
Plant protection chemicals	618.00 (6.95)	173.00 (1.88)	926.00 (10.08)
Irrigation (included in labour) Interest on working capital	245.00 (2.76)	282.00 (3.06)	291.00 (3.17)
Cost A1	4692.00 (52.77)	6494.00 (70.46)	5601.00 (61.00)
Rent paid for leased in land	-	-	-
Cost A2	4692.00	6494.00	5601.00
Imputed rental value of own land, and interest on fixed capital	2594.00 (29.17)	2722.00 (29.54)	3581.00 (39.00)
Cost B	7286.00 (81.94)	9216.00	9182.00
Imputed value of family labour	1606.00 (18.06)	Nil	Nil
Cost C	8892.00	9216.00	9182.00

Note : Figures in Parantheses are percentages to Cost C.

In all these cases, cultivation took place in own land. Family labour was used only by the tomato farmer. One of the major items of cost was that of human labour. Labour use per hectare was as given below:

Labour days	Tomato	Bhindi	Cowpea
Male	133	104	30
Female	136	189	195
Total	269	293	225
Total mandays*	235	246	176

*Female labour was converted into male labour on the basis of wage rate which was Rs. 20/- and Rs. 15/- respectively per man and woman respectively.

The different income and efficiency measures computed in respect of the three cases are given in Table 3.

Table 3. Income and efficiency measures of vegetable cultivation in Palghat district (per hectare)

Particulars	Tomato	Bhindi	Cowpea
Total production (Qtls.)	741	618	1173
Total returns (Rs.)	14,820	15,450.00	20,527.00
Net returns (Rs.)	5,928.00	6,234.00	11,345.00
Farm business income (Rs.)	10,128.00	8,956.00	14,926.00
Family labour income (Rs.)	7,534.00	6,234.00	11,075.00
Farm investment income (Rs.)	8,522.00	8,956.00	14,926.00
Production per man day (Qtl.)	3.15	2.51	6.67
Value of output for one manday (Rs)	63.00	63.00	117.00
Benefit cost (output/input) ratio at cost C	1.67	2.49	2.24

It is found that agricultural labourers with meagure land of their own, leasein riceland during summer season for the purpose of vegetable cultivation in many areas in Kerala where regular leasing-in and leasingout of land is illegal. Left to the owners themselves, the land would have been left uncultivated. By leasingin land, agricultural labourers who have hardly any land of their own and who normally would not have farm work to do during that period, are able to get some income not only by way of net returns from vegetable enterprises but also by way of imputed wages of family labour. In a village adopted by the Kerala Agricultural University near Trivandrum leasing in land for vegetable cultivation is a regular practice. Costs of cultivation of two major vegetables grown in the village during 1989-1990 summer are given in Table 4.

Table 4. Cost of cultivation of vegetables in Palappur Village of Trivandrum district (1989-90 (Rs./ha.)

Particulars	Bittergourd	Snakegourd
Seed	100.00 (0.26)	150.00 (0.31)
Lime	-	500.00 (1.02)
Manures	12060.00 (30.80)	12600.00 (25.73)
Fertilizers	315.00 (0.80)	535.00 (1.09)
Pandaling materials	3150.00 (8.04)	4525.00 (9.24)
Plant protection chemicals	96.00 (0.25)	74.00 (0.15)
Implement charges	193.00 (0.49)	163.00 (0.33)
Interest on working capital	633.00 (1.62)	889.00 (1.82)

(Contd.)

Table 4 contd...

Particulars	Bittergourd	Snakegourd
Cost A1	16547.00 (42.25)	19436.00 (39.69)
Land lease charges	1250.00 (3.10)	1250.00 (2.55)
Cost A2	17797.00 (45.45)	20686.00 (42.24)
Interest on fixed capital	473.00 (1.21)	678.00 (1.38)
Cost B	1827.00 (46.65)	21364.00 (43.62)
Cost of family labour	20890.00 (53.34)	27610.00 (56.38)
Cost C	39160.00	48974.00

Note : Figures in parantheses are percentages to Cost C.

More than one-half of the cost was accounted for by family labour and, in fact, the entire labour used was family labour. In view of the importance of human labour, more details about its use are given below:

	No. of labour days used	
	Bittergourd	Snakegourd
Male labour days	340	422
Female labour days	175	270
Child labour days	187	217
Total labour days	702	909
Total mandays*	596	778

*Wage rate for male, female and child labour in the locality was @ Rs. 35/-, Rs.30/- and Rs. 20/- per day. These rates were used for imputations and female and child labour were converted into male labour on the basis of relative wage rates.

The most important use of labour was for irrigation accounting for about 50% of total labour use for bittergourd and about 60% for snakegourd. This was so because, these crops were irrigated through pot watering.

Data on production and different measures of income are given in Table 5.

Table 5. Production and measures of income in respect of vegetable cultivation in Palappur Village (per hectare)

Particulars	Bittergourd	Snakegourd
Total production (excluding spoilage of about one percent)	17600 kg.	41300 kg.
Total returns (Rs.)	60984	61331
Net returns (Total returns-Cost C)	21920	12357
Farm business income (Rs.)	44437	41895
Family labour income (Rs.)	42714	39967
Farm investment income (Rs.)	23547	14285
Benefit Cost (Output/input) ratio at Cost C	1.56	1.25
B/C ratio at Cost A1	3.69	3.16
B/C ratio at Cost A2	3.43	2.97
B/C ratio at Cost B	3.34	2.87
Output per man day (kg.)	29.53	53.08
Output per man day (Rs.)	102.32	78.83

Vegetable marketing

Marketing which includes activities such as timely harvest,

c) Buying and assembling - Assembling involves bringing together either different quantities of a wide variety of items for resale at a single establishment or a large quantity of similar items for sale. Successful buying requires an ability to estimate customers' needs in advance.

d) Selling - Besides making transfer of ownership, it also involves identifying prospective customers, stimulating demand, packaging and providing information and service to buyers.

2. Physical distribution

This involves moving the products from their times and places of production to their times and places of consumption, and consists of the following:

a) Storage - This is particularly important when seasonality in production or consumption are involved. For some products, storage improves quality and for certain manufactured items storage facilitates economy in production.

b) Transportation - Markets are geographically seperated from prodution areas and transportaion makes products available at places, buyers want them.

3. Supporting activities - These support or contribute to the carrying out of other marketing activities. These include the following:

a) Marketing financing - somebody must finance marketing activities - Essentially, there are two main sources of credit viz. trade credit and bank credit.

assembling, cleaning, grading, packaging, handling and transportation etc. play a very important role in determining the profitability of vegetable farming. In fact, in the modern world, marketing includes many other activities besides those mentioned above. It is said that marketing begins with the consumer and ends with the consumer. Marketing is not just making, whatever is produced by the producer, available to the consumer. Marketing and production are interlocked. Cundiff *et al* (1974) define marketing "as the managerial process by which products are matched with markets and through which transfers of ownership are effected". They classify marketing activities into three general categories, containing nine activities in all, as indicated below:

1. Merchandising activities - These consist of activities necessary to determine and meet market needs in terms of products and to stimulate demand. These consist of four separate activities, viz.

a) Product planning and development - which endeavour to ensure that products possess characteristics which conform closely to buyer needs, wants and desires. Apart from product qualities, this includes preparation of the product for the market.

b) Standardization and grading - A standard specifies the basic qualities/characteristics a product must have, to be designated by certain grades. The qualities must be those desired by the buyers. Standardization and grading are essential for efficient marketing. Both make it possible for customers to purchase by description rather than by inspection. Grading helps in streamlining the handling and storage and transportation of farm produce, for it facilitates mixing of lots belonging to different owners.

Price difference between the processed product and the raw product should not be unduly higher than the processing and the related costs. One of the common measures of marketing efficiency is the extent of marketing margins. Marketing margins are the differences between price paid by the consumer on the one hand, and the price received by the producer for the produce on the other or for an equivalent quantity of produce. Marketing margins vary, depending upon the nature and extent of marketing services rendered and on the length of the marketing channel. Marketing channel is the route taken by the commodity on its way from the producer to the consumer. Other things remaining the same, lower margin is an indication of marketing efficiency. As suggested by Acharya and Agarwal (1987) this can be measured as :

$$ME = \frac{V}{I} - 1$$

Where ME = Index of marketing efficiency,

V = Value of goods sold (consumers price)

I = Total marketing margins

Marketing margins for agricultural commodities in general and vegetables in particular, in India are generally high on account of some of the inherent characteristics of the products on the one hand and on account of marketing environment on the other. These includes bulkness of the product in relation to value, seasonality of production, small size of marketable surpluses, perishable nature of the products, multiplicity of marketing charges, trade allowance, adulteration and lack of grading, secrative nature of transaction, incorrect, faulty weighment, superfluous middlemen, defective transport, lack of market information, lack of storage facilities etc.

b) Marketing risk bearing - risks arise from unexpected supply and demand changes and natural hazards.

c) Obtaining and analysing marketing information - Availability of good quality market information is very essential for efficient marketing - information which may include sources of supply, cources of demand, trends in them, prices etc. The degree of importance of the various activities in actual marketing situations are different for different products. They are also different in different economics.

The different marketing activities create place, time, form and possession utilities to the product. By moving the produce from the farm where it is produced to the consumer household where it is consumed, marketing is said to add place utility. Marketing adds time utility by making commodities which are produced seasonally, available throughout the year. Often and more so in advanced economies, the form or forms in which the consumer wants the produce is entirely different from the form in which the farmer sells the product. By making commodities available in those form in which the consumers want them, marketing creates form utility. By facilitating changes in ownership, marketing also creates possession utility. Creation of these various utilities involves varying levels of costs. Pricing efficiency would requires that price differences between the farmers' selling price on the one hand and the consumers' buying price on the other, are not unduly higher than the costs involved in creating these utilities. Thus price difference for a particular product between two places, should not be unduly higher than transportation and handling costs. Price difference between the harvesting season and the pre-harvest season should not be unduly higher than storage cost.

There are different marketing channels for vegetables in India as indicated below:

1. Producer-Consumer
2. Producer-retailer-consumer
3. Producer-wholesaler-consumer
4. Producer-wholesaler-retailer-consumer
5. Producer-commission agent-wholesaler-consumer
6. Producer-commission agent-wholesaler-retailer-consumer

The first three channels are relatively unimportant.

Often, sales of vegetables to wholesalers take place at the farm itself and harvesting, transportation and handling are done by the buyer. Though the farmer is relieved of the problems connected with marketing and in that sense, it is a good system. Many a time, the price received by the farmer may not be competitive. In his study on vegetable marketing, Selvin (1982) found that farmers were mostly selling their produce at the farms to pre-harvest contractors. Farmers received only 50 to 54% of the retail price of pumpkin and ash gourd respectively. It was found that the netmargin (profit) of buyers was quite high. Details of marketing margins as reported by him are given below:

Table 6. Marketing margins for vegetables in Malappuram district 1982. (Rs. per kg.)

	Pumpkin	Ashgourd
Price received by the farmer	0.64 (50.00)*	0.63 (53.85)
Price paid by consumer	1.28 (100.00)	1.17 (100.00)
Marketing margin	0.64 (50.00)	0.54 (46.15)
Total marketing cost	0.11 (8.59)	0.11 (9.40)

(contd.)

(Table 6 contd.)

	Pumpkin	Ashgourd
Net margin of intermediaries	0.53 (41.41)	0.43 (36.75)
Index of marketing efficiency $(\frac{V}{I} - 1)$	1.00	1.16

*Figures in parantheses are percentages to retail price.

Marketing costs incurred by the intermediaries ranged from 8.59 to 9.40% of the retail price and net margins of intermediaries ranged from 37 to 41%. The net margin was quite high. The indices of marketing efficiency were very low at 1.00 and 1.16.

A recent study conducted in Tamil Nadu Agricultural University by Gopal (1988) gave the following results:

Table 7. Marketing Margins for Beetroot in Madurai district (Rs./kg.)

Price received by the farmer	0.80 (36.36)*
Price paid by consumer	2.20 (100.00)
Marketing margin	1.40 (63.63)
Total marketing cost (including commission)	(36.81)
Net margins of intermediaries	0.59 (26.82)
Index of marketing efficiency	0.57

* Figures in parantheses are percentages to retail price

Here Index of Marketing Efficiency was as low as 0.57 and net margins of intermediaries were also high.

Inefficiency of the marketing system results in lower returns to the farmer or higher prices to the consumer or both. By increasing marketing efficiency, it is possible to improve the economic well-being of farmers and consumers.

Co-operative Marketing

When farmers join together on co-operative lines for purpose of marketing their produce, it should be possible for them to mitigate a few of the marketing problems they would be facing. The Royal Commission on Agriculture (1928) stated that "group marketing must be more efficient than marketing by individuals, especially in conditions such as those which exist in India where the individual producer is such a small unit. The ideal to be aimed at is, therefore, co-operative sale societies which will educate the cultivator in the production and preparation for market of his produce and will provide sufficient volume of produce to make efficient grading possible and will bring the Indian producer into direct touch with the export market and with the large consumers in India".

Some of the advantages of co-operative marketing are the following:

1. Reduction in marketing costs through large volume;
2. Better prices through better bargaining ability;
3. Better credit facilities from co-operative credit institutions;
4. Supply of quality goods to consumers;
5. Help in growing better crops through provision of production requisites, etc.

Co-operative marketing in India has a history of over three quarters of a century. The structures of markeging co-operatives in India consists of the National Agricultural Co-operative Marketing

Federation (NAFED), the state co-operative Agricultural Marketing Federations and secondary or primary marketing societies. A three tier system exists in a few states, while a two tier system exists in others, though the Committee on co-operative Marketing (1966) recommended a two-tier structure, with apex society at the state level and primary societies at mandi levels. Though the societies are mostly general purpose institutions, there are also some which are exclusively meant for specific commodities and the latter includes vegetables. Marketing societies are mostly functioning as commission agents. Co-operative marketing has not made much headway in the marketing of agricultural produce and this is more so in case of marketing vegetables. For example, in none of the studies mentioned above, presence of marketing societies was reported. Many factors are responsible for this. These include, absence of spontaneity in the setting up of co-operatives, target hunting, weak organizational links, poor management, absence of member-loyality, concentration of distribution activity, etc.

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Applications of radiations and isotopes in horticultural crops

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Nuclear techniques in agricultural research have played a significant role in increasing food production. These techniques as employed in agricultural research are largely based on the use of isotopes (both stable and radioisotopes) and radiations. There are several research areas in which the use of radiations and radioisotopes has attained prominance. Some of the most important areas of practical importance are mutation breeding, plant nutrition, fertiliser and water management, insect pest control, pesticide residue problems, food preservation, etc. In every branch of agricultural science, isotopes and radiations find a place as indispensable research tool. In fundamental research in plant biochemistry, physiology, pathology, microbiology, etc., radiations and radioisotopes have extensive applications. However, it is not intended here to go into all these aspects. The discussion will be confined to nuclear techniques which have immediate practical applications in increasing productivity and production of crops in general and horticultural crops in particular.

Soil fertility and fertiliser management

Isotope tracers provide an excellant tool for the measurement of soil nutrient availability, movement and fate of applied nutrients and fertiliser use efficiency in crops. The basis of determining soil nutrient availability (A-value) and fertiliser use efficiency is the isotope dilution that occurs in the soil-plant system. When fertilisers are applied to soil, the crop plant has two sources of nutrients namely, the native soil source and the applied fertiliser source. The plant derives a given nutrient from the soil in direct proportions of its availability from these two sources. By the use of labelled fertilisers, it is thus possible to determine how much quantity of nutrient the plant absorbs from the applied fertiliser and how much quantity from the native soil source. The quantity of a nutrient the plant derives from the

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fertiliser gives a measure of the utilisation of the applied fertiliser while the quantity of the nutrient that is derived from the soil gives a measure of the nutrient availability in the soil.

Several fertilisers labelled with the radioisotopes of the nutrient elements are available which can be used in studies of this kind for evaluating the efficiency of utilisation of applied fertilisers. For example ^{32}P-labelled superphosphate, amophos, etc. can be used for evaluating the use efficiency of these fertilisers as a P source to the crop. ^{35}S-labelled ammonium sulphate can be used to study the use efficiency of the fertiliser as a sulphur source. Labelled fertilisers are also available for micronutrients. For the major nutrients N and K, suitable radioisotopes that can be used in experiments do not exist. The radioisotopes of these elements are too short-lived to be of use in fertiliser experiments with crop plants. For N, the stable isotope (^{15}N)-labelled fertilisers are, therefore, used in soil fertility and fertiliser use efficiency evaluation.

Root activity

Radioisotopes are used to trace the root activity pattern of crop plants. Information regarding root activity pattern of crop plants would help plan spacing the crops in mixed cropping systems with minimal interspecific completition for below-ground resources. Economic and scientifically sound method of fertiliser application in crop gardens can be evolved based on the information on the most active root zone of the crops. This is achieved by restricting fertiliser application to the soil zone or area of maximum root activity.

The results of tracer studies with ^{32}P conducted at the Radiotracer Laboratory, KAU, had shown that in black pepper, more than 85% of the root activity is confined to an area of 30 cm around the vine suggesting that application of the fertilisers in this area would render the most effective absorption of the applied nutrients. Cashew tree was found to be a surface feeder with over 50% of the root activity in the top 15 cm soil layer. Root activity within 2 m radius around the tree accounted for nearly 85% of the total activity. Thus for cashew, fertiliser application within a circle of radius 2 m around the tree appears to be the most suitable method of fertiliser application. Cocoa is also a suface feeder with roots traversing more than 150 cm distance laterally; virtually leading to competition between adjacent plants spaced at 3 m apart.

Soil water management

Water management is of prime importance in crop gardens. With the advent of nuclear technique using neutron moisture probe, it is now possible to monitor soil moisture regimes in the field. This non-distructive measurement of soil moisture is based on the principle of thermalisation of fast neutrons by hydrogen atoms in the water molecules. The thermalised neutrons are measured to calculate the moisture content of the soil.

Sterile-male technique (Sterile insect technique)

The method is used in various areas to eradicate and/or control insect pests of agricultural and veterinary importance. The method is either used alone or in integrated pest management programmes. In this approach, males of the pest insect are reared in the laboratory, rendered them sexually sterile by irradiation and released in overwhelming numbers, into the problem area. Mating of the sterile males with normal females, leads to the suppression of the population growth. The first insect to be totally eradicated in this way was the screw worm, a destructive fly pest of livestock in the USA. Other instances where sterile-male technique is being tried are for the control of pink boll worm of cotton, mediterranean fruit fly, olive fruit fly, etc.

The method has, however, limitations. It is not applicable for most pests. Nevertheless, it has features that could contribute to a better solution for a wide range of pest problems in an effective, economical and ecologically sound manner.

Mutation breeding

One of the most important contributions of radiations has been in creating new variability in cultivated plants by inducing gene mutations and chromosomal aberrations. In mutation breeding programmes, the variability on which the selection is applied is generated by treating the seeds with radiations or chemical mutagens in contrast to the hybridisation where the variability is created by hybridising two different types. Gamma, X-, neutron and beta rays are used as the irradiation source. Mutation breeding by irradiation has been successfully done in several crops including ornamentals for evolving varieties with desirable characteristics.

Food preservation

One of the beneficial applications of atomic energy is in preserving food stuffs for prolonged periods. The process called 'food irradiation' has unique advantages over conventional methods of food preservation such as canning, dehydration and salting, etc. Irradiation of food does not lead to loss of flavour, texture, odour and other desirable qualities of foods.

The application of low doses of radiation (15 krad) arrests sprouting of onions and potatoes. This dose of radiation can also destroy tuber moth, a devastating pest of potato. Low doses of radiation of less than 50 krad are effective in delaying the natural process of ripening in fruits. Thus shelf life of mangoes can be extended by about a week and that of bananas up to two weeks. Further, gamma irradiation can eliminate the seed weevil seen in the stone of the mango.

Chemical disinfestation methods such as fumigation, require repeated treatments as they do not destroy the insect eggs. These chemicals also leave harmful residues in the treated materials. Low dose irradiation completely sterilises or kills the common grain pests including their eggs.

India is a major spice producing and exporting country. Spice export trade is always faced with stringent quality requirements relating to insect infestation and microbial contamination. Fumigation of spices with chemicals like methyl bromide, ethylene oxide and propylene oxide, leaves undesirable residues in the produce. Single treatment of spices with gamma radiation (1Mrad) can make them free of insect infestation and microbial contamination without loss of flavour. Several countries have given legal approval for food irradiation accepting the method as safe upto an average dose of 1 Mrad. This dose has been recommended by the FAO/IAEA/WHO Joint Expert Committee as safe from the health and toxicological points of view. About 30 countries have given clearance to over 40 items of irradiated foods.

Genetic Resources in tropical vegetables - activities of NBPGR

V.K. Muralidharan*

In 1976 the National Bureau of Plant Genetic Resources was established at IARI Campus, New Delhi. Soon Regional Stations were established in Shimla, Shillong, Jodhpur, Akola-Amaravati, Bhowali, Trichur and base centres at Cuttack, Hyderabad and Ranchi. Quanrantine stations were established at Hyderabad and Delhi.

The Regional Station, Trichur is in the KAU Campus at Vellanikkara. The station is meant for carrying out exploration and collection in Kerala, Tamil Nadu and S. Karnataka and for maintenance, evaluation and documentation of these resources at the Regional Station, Trichur. It is also a plant introduction station for the humid tropics of India. A genetic resources programme on selected medicinal and aromatic plants is also carried out at the station.

The constant and sustained disturbances to the habitat is leading to erosion of genetic resources of crop plants and their wild relatives. Adoption of new high yielding varieties relegates the old landraces to extinction. If not saved now, these may be lost for ever. The objective is to locate and collect these resources and maintain these by regeneration every year (vegetatively propagated material) or conserve seeds produced in Gene banks (short/long term) so as to make these available to

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users when needed. Descriptor data are collected and catalogues are prepared so that breeders engaged in varietal improvement programmes are able to use these materials. By consensus among experts a set of descriptors are formulated for each of the crops. The IBPGR has published such descriptor lists for all major crops. Conservation is also done by tissue culture technique and by storage under liquid nitrogen at the Headquarters of NBPGR.

The NBPGR has been vested with global responsibility of conserving genetic resources of Okra, Brinjal and responsibility for Asian collection of chillies.

Exploration and collection in Kerala, Tamilnadu and S. Karnataka.

From 1978 to 1983 multicrop exploration and collection programmes were carried out in all the districts of Kerala, southern districts of Tamilnadu and eleven districts of Karnataka. Besides, forests of silent valley, Karappara, Nelliampathy, Dhoni, Parambikulam, Vellani, Idukki, Pathanamthitta, Kulathupuzha, Thenmala and Wynad (Kerala), forests of Coorg, Mysore, Chickmangalur, Mangalore, Karwar and Shimoga (Karnataka) and Courtallam, Tirunelveli, Nilgiris, Palani, Kolli, Kalrayan (Tamilnadu) were explored in parts for collection of wild relatives of crop plants.

In 14 exploration trips 4603 collections in 25 major vegetable crops and a few each in 6 minor crops were made. Table 1. A duplicate set was sent to H.O. for distribution to other Regional Stations or for maintenance and evaluation there. From 1984 crop specific collections trips were undertaken. Specific explorations for any of the vegetables crops was not undertaken during 1984-1987 but vegetable crops were collected wherever available during multicrop or other crop specific explorations. Thus 1138 collections were made in the same crops from Trichur, Palghat, Parambikulam, Wynad and Idukki, Pathanamthitta and Southern districts of Kerala, Nilgiris, Coimbatore and northern districts of Tamilnadu and Coorg, S. Cannara and southern districts of Karnataka.

In 1989 crop specific explorations were carried out for cultivated and wild Abelmoschus and Solanum under a collaborative programme with IBPGR. A collaborative exploration for chillies with IIHR, Bangalore, were also undertaken. 526 collections were made in 14 crop species of which major collections were in Okra (138), Chillies (49), Brinjal (171), Bittergourd (23) and Cowpea (89). In 1990 crop specific explorations were continued for the three species and a total of 270 collections were made in 12 crop species of which major collections were in Okra (90), Chillies (74) and Brinjal (87). The areas covered entire states of Kerala, Tamilnadu parts of Karnataka and parts of Andhra Pradesh. The collections extended to the forests also and several wild relatives and species of the same genera were collected in the genus Solanum and Abelmoschus (Table 2).

In making the collection Gene Pool sampling was adopted wherever possible, otherwise, single plants (special characters) or a small quantity of seeds which the farmer is able to spare were collected. In wild species populations were small and whatever possible was collected.

Maintenance, evaluation and documentation

Characterisation and evaluation for yield resistance to pests, diseases, drought, salinity and other stress factors make collections immediately useful to plant breeders for varietal improvement.

The station has been identified as a main centre for tuber, spice and condiment crops and for some fruits. Collections made in all vegetable crops are sent to Headquarters from where these are distributed to Regional Stations which are main centres for these crops, or maintained and evaluated at Headquarters itself.

The Regional Station, Trichur as a duplicate centre, grows collections of Cowpea, Winged bean, Bittergourd, Brinjal, Chillies and Okra. In the past vegetables like Pumpkin, Ashgourd, Bottle gourd, Snakegourd were tried but as cropping is possible only in the main monsoon season these were found to be adversely affected by heavy rains. Further these require larger area which is a limitation to this station.

The crops are grown in rows (1-5) usually 3m x 50 cm/25 cm spacing. (Cowpea, Chillies, Winged bean), 1½ x 1½ m spaced beds for bittergourd and 1 m x .50 m for Okra. Cultural practices adopted are from Package of Practices (KAU). Controls are repeated after every 20-30 accessions. Better collections are grow in replicated trials also. Cowpea (*Vigna unguiculata*): 469 collections are available at the station. Most of these have been characterised and evaluated for yield and pest or diseases when found. IC 42955 (1036 kg/ha pods) No. 49-82-18 (800 kg/ha. pods), No. 93-82-28 (830 kg/ha pods), No. 88-82-13 (1736 kg/ha pods), IC 44738 (2073 kg/ha pods), No. 7-83-26 (1746 kg/ha pods), IC 45431 (793 kg/ha pods), IC 97736 (1535 kg/ha pods), IC 68806 (1580 kg/ha pods), IC 97736 (1200 kg/ha grain), IC 45466 (1095 kg/ha grain) have been found promising in trials between 1980-1989. These have yielded higher than or on par with highest control (Kanakamani, New Era, Pavizam and Kuruthola (local). Resistance to Aschochyta blight which occured in 1986 was scored with the help of Pathology division (KAU) 69 collections were low to very low in reaction to the disease. 45 promising varieties are now in trial. Several collections were supplied to KAU and other agencies (See under Germplasm exchange).

Winged bean (Psophocarpus tetragonolobus)

172 collections with several selections/sub collections are available at the station. With the resurgence of interest in this highly nutritive crop, all India Co-ordinated trials were undertaken at this station also. The entire collection was characterised. GRWB 11. yielding 9377 kg/ha of pods and IIHR 12 (9669 kg/ha of pod), were superior to others while IIHR 12 yielding 752 kg/ha seeds and IIHR 13 (730 kg/ha seeds) were better for seed production.

Okra (Abelmoschus esculentus):

Okra collections during 1978-1989 have been very variable in performance. Collar rot infection has been so severe that more than 50% of the collections ere lost. At present the beds are drenched with Bordeaux mixture before sowing. 111 collections which are distinctly different are available at the station. During 1990, old collections (125) and new collections (150) were grown and observed in detail on the basis of descriptor list (BPGR) for Okra. It was found that several duplicates were present. These were combined and only those which are different are maintained separately. Morphotypic study was also carried out. Tentatively over 40 morphotypes have been identified, which will be confirmed during this year. Promising collections were : with 8 or more number of fruits/plant: Nos. 10, 178, 422, 780, 813, 868; Fruits longer than 25 cm: Nos. 777, 877, 874, 811, 825, 856, 865, 871, 878. For the sake of brevity other characters are not mentioned but can be given to interested persons. A catalogue on Okra germplasm was published in 1990.

Chillies (*Capsicum annuum* and *C. frutescens*)

281 collections with 81 sub collections are available at the station. Chillies (*Capsicum annuum* and *C. frutescens*) has been a very difficult crop to grow. Germination is extremely variable. In some years, many collections do not germinate in spite of storage under identical conditions.

A catalogue was published in 1983 on collections available. Evaluation for 44 characters was done in 1990.

IC 88498 and IC 88503 yielding more than 50gm of fresh fruit per plant was superior to others, IC 88506, 88507, 88523 yielded above 40 grams/plant. No. 54-81-14, *C. frutescens* collection was handed over to Department of Olericulture, KAU for further development in 1986.

Bittergourd (*Momordica charantia*)

144 collections with 86 sub collections are available at the station. The crop grows well in the monsoon season on well

drained soils. Yellowing and decay are noticed under continuous heavy rainfall. The collections has been fully characterised. Performance has been variable over the years. Later formed pods mature in quick succession and it has been difficult to keep up with harvesting in time. The plants are not allowed to grow in full because of mixing up with other collections if allowed. However upto 5000 kg/ha pods have been obtained in harvests during August-September. Promising lines are IC 45338, IC 85605, IC 85638, IC 44415, IC 44434, IC 44436 and IC 68306. A wild form collected from Malampuzha forests bears a large number of fruits, though small and appears to be able to withstand excessive rains better. A catalogue is under preparation.

15 collections which had been found to be more tolerant under field condition to fruit fly were sent to Professor, Entomology, Vellayani for studies of under artificial infestation.

Brinjal (*Solanum melongena*)

During 1990-91 NBPGR/IBPGR carried out exploration and collection in the Southern region. 156 collections are now being maintained at the Station. These were observed for all descriptor states as per IBPGR publication on Egg plant. 10 collections yielded between 15-21.7 T/ha fruits while SM.7 (KAU) yielded upto 10.9 T/ha only. 8 collections were found to be resistant to bacterial wilt, phomopsis blight, shoot borer and stem borer. Promising lines were V. 4811, V.89/0-95, yielding over 20 T/ha; V 89/0-34, V.90/0-148 yielding over 20 fruits per plant; multiple resistance No. 89/0-80A, V.89/0-82, V.89/91 A; V.90/153A, V.90/0-1607, V.90/0-165, V.89/0-155 and V.90/0-138. A catalogue is under preparation.

Wild relatives

The station maintains many species under the genus *Solanum* and *Abelmoschus* as given in table 2.

Germplasm exchange

1442 collections invegetable crops were distributed to several agencies for plant improvement programmes (Table 3). The Kerala Agricultural University, Vellanikkara and Vellayani were supplied the maximum number of collections.

Germplasm conservation

The Headquarters and Regional Stations recognised as main centres deposit the collection in the Gene Bank at NBPGR, New Delhi. Thus 3635 collections are stored as base collection in the National Gene Bank at Delhi. Working collections are at Headquarters and with Regional Stations.

Conclusions

The Regional Station has independently and in collaboration carried out extensive exploration and collection programmes in the southern region of the country and amassed a total of 6537 collections in 25 tropical vegetable crops from 1978-1990. In recent years exploration programmes are chalked out after seeking requirements of Agricultural Universities and crop based ICAR Institutes. International crop research Institutes also operate in collaboration with NBPGR.

The collected resources are being studied in detail for morphological characters and their reactions to various stress situations whenever it occurs. The data are available to plant breeders to choose donors either through catalogs or periodic reports at workshops or through annual reports.

The collected germplasm is conserved at the Gene Bank. This effort is yet incomplete but considerable progress has been made.

Thus the National Bureau of Plant Genetic Resources and its regional stations play a very significant role in collection, maintenance, evaluation, documentation and exchange of genetic resources of vegetable crops.

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Table 1. Vegetable germplasm collected 1978-1990

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Legume															
1. French bean	*Phaseolus Vulgaris*	2	-	-	80	24	33	7	1	55	9	-	-	-	211
2. Pea	*Pisum sativum*	-	-	-	7	-	2	-	-	7	-	-	-	4	20
3. Lablab bean	*Dolichos lab lab*	2	2	-	116	24	68	60	57	30	10	-	-	-	369
4. Velvet bean	*Styzolobium deeringianum*	-	-	-	9	2	-	-	-	1	1	2	-	-	15
5. Cowpea	*Vigna unguiculata*	85	16	8	328	384	214	58	100	44	23	1	89	5	1355
6. Sword bean	*Canavalia* sp.	-	-	-	57	8	17	-	-	2	1	-	-	-	85
7. Winged bean	*Psophocarpus tetragonolobus*	-	2	-	53	3	-	-	1	3	-	-	-	-	62
8. Lima bean	*Phaseolus lunatus*	-	-	1	12	3	11	-	-	4	-	-	-	-	31
9. Clusterbean	*Cymopsis tetragonolobae*	-	-	-	40	-	24	7	11	4	1	-	-	1	88
Cucurbit vegetable															
10. Cucumber	*Cucumis sativus*	-	2	-	38	127	24	8	7	3	3	-	13	1	226
11. Pumpkin	*Cucurbita pepo* & *C.moschata*	-	3	-	67	92	57	16	25	22	2	-	7	-	291
12. Bittergourd	*Momordica charantia*	-	4	2	67	130	65	13	33	16	7	1	23	2	363

(contd.)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
13. Snake gourd	<u>Trichosanthes angula</u>	-	3	-	11	44	8	3	10	2	2	-	6	-	89
14. Smoothgourd	<u>Luffa aegyptica</u>	-	4	-	5	8	7	-	2	-	4	-	1	-	31
15. Ridgegourd	<u>Luffa acutangula</u>	1	4	-	37	40	40	3	16	14	-	-	6	3	164
16. Ash gourd	<u>Benincasa cerifera</u>	-	3	1	25	78	37	1	-	5	-	-	8	1	159
17. Bottle gourd	<u>Legeneria sicerarea</u>	-	-	-	20	11	49	9	10	8	3	-	7	1	118
<u>Others</u>															
18. Brinjal	<u>Solanum melongena</u>	-	3	1	95	43	69	18	14	19	7	-	171	87	527
19. Chillies	<u>Capsicum</u> spp.	28	13	-	262	243	218	58	53	55	19	-	49	74	1072
20. Amaranth	<u>Amaranthes</u> sp.	9	5	-	98	104	40	-	-	-	-	-	5	-	261
21. Okra	<u>Abelmoschus esculentus</u>	-	2	8	150	208	111	20	25	9	4	3	138	90	768
22. Tomato	<u>Lycopersicum esculentus</u>	-	-	-	45	2	19	4	5	5	2	-	3	1	86
23. Drumstick	<u>Moringo oleifera</u>	-	-	-	29	11	12	10	20	6	5	-	-	-	93

(contd.)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
24. Onion small	*Allium* sp.	-	-	-	19	-	-	-	-	-	-	-	-	-	19
25. Onion	*Allium cepa*	-	-	-	1	-	4	5	3	11	10	-	-	-	34
	Total	127	66	21	1671	1589	1129	300	393	325	113	7	526	270	6537

Basella, Coccinia, Radish, Carrot, Chyote and wild Trichosanthes sp.
Abelmoschus sp., Momordica sp., Cucumis spp. were also collected.

Table 2. Collection and maintenance of wild related and other species of Solanum and Abelmoschus

Solanum		1989-90	Abelmoschus		1989-90
S. melongena var insanum	-	20	A. angulosus	-	8
S. incanum	-	3	A. setinervis	-	15
S. macrocarpum	-	1	A. moschatus var moschatus	-	3
S. torvum	-	15	A. moschatus var tuberosus	-	1
S. indicum	-	31	A. manihot var tritraphyllus	-	2
S. robustum	-	1	Abelmoschus Nat. hybrid	-	1
S. giganteum	-	1	A. ficulneus	-	3
S. verbascifolium	-	5			
S. aculintissinum	-	3			
S. pubescens	-	6			
S. khasianum	-	8			
S. ferox	-	3			
S. nigrum	-	4			
S. sisimbrifolium	-	2			
S. elaignifolium	-	1			
S. auriculatum	-	2			
S. trilobatum	-	5			
S. seaforthianum	-	3			
S. species	-	7			
S. mamosum	-	1			
S. surattense	-	4			

Other related species of vegetable crops collected by the station.

1. Momordica charantia (wild) foot hills of Malampuza
2. Trichosanthes perottetiana
3. Cucumis sp.
4. Momordica subhangulata

Table 3. Germplasm Exchange

1981	Okra	3	Deptt. of Olericulture, KAU, Vellanikkara.
	Bittergourd	3	do
	Snakegourd	2	do
	Ridgegourd	3	do
	Smoothgourd	2	do
	Canavalia	2	do
	Velvet bean	3	do
	Winged bean	4	do
	Bittergourd	12	do
1982	Chillies	177	Agriculture College, Dhavana, Karnataka
	Cowpea	10	Deptt. of Olericulture, KAU, Vellanikkara
	Chillies	184	Agra University, Agra, U.P.
1983	Okra	15	Professor, Plant Breeding, College of Agriculture, Vellayani, Trivandrum.
	Bittergourd	14	do
	Snakegourd	4	do
	Cucumber	1	do
	Brinjal	8	do
	Chillies	20	Deptt. of Olericulture, KAU, Vellanikkara, Trichur.
1984	Cowpea	50	CARI, Andaman
	Okra	5	do
	Chillies	25	do
	Bittergourd	50	do
	Winged bean	19	Botany Deptt., University of Calicut
1985	Cowpea	76	National Pulse Research Institute, Pudukottai, Tamilnadu.
	Winged bean	12	University of Budwan, W. Bengal

...(contd.)

1987	Chillies	60	College of Horticulture KAU, Vellanikkara
	Chillies	13	do
1988	Bittergourd	19	Vivekandanda Parvatiya Krishi Anusandhan Sala, Almora, U.P.
	Sword bean	20	do
	Chillies	21	Deptt. of Olericulture, KAU, Vellanikkara
	Cowpea	125	Deptt. of Entomology, KAU, Trivandrum
	Okra	15	do
	Bittergourd	15	do
1989	Bittergourd	115	Deptt. of Olericulture, KAU, Vellanikkara
	Bittergourd	50	College of Agriculture, KAU, Vellayani, Trivandrum
	Okra	20	do
1990	Okra	29	CSRC (KAU), Kannara.
	Cowpea	99	Deptt. of Entomology, KAU, Vellanikkara
	Chillies	60	Punjabrao Krishi Viswavidyalaya, Akola.
	Bittergourd	51	Agricultural Research Station, KAU, Mannuthy.
	Abelmoschus wild sp.	6	Deptt. of Olericulture, KAU, Vellanikkara.
	Total	1417	

Genetics and breeding of Okra (<u>Abelmoschus</u> <u>esculentus</u> (L.) moench)

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Okra (<u>Abelmoschus esculentus</u> (L.) moench), belong to the family Malvaceae is an important vegetable crop value for its immature tender and green fruits in India. It is commonly known as lady's finger or okra in English, gombo in French, quiabeiro in Portuguese, quimgombo in Spanish and bamiah in Arabic. In India it is known by several names in different regional languages such as bhindi (Hindi), bhendi (Assameese and Marathi), bhida or bhinda (Gujarati), bhende or bendekayi (Kannada), benda or bendakay (Telugu), dhendas (Bengali), pendi (Punjabi), gandhmula (Sanskrit), vendai or vendaikkay (Tamil), vendi (Oriya), ramtaroi (Chhotanapur - Bihar), and venda (Malayalam). The fruits are eaten mainly boiled in culinary preparations as sliced and fried pieces. It is also slice dried in sun for its year round consumption. Okra fruits are rich in calcium (90 mg/100g fresh weight) and provide a valuable supplementary items in the tropical diet which is basically starchy in nature lacking calcium and iron.

Origin and geographical distribution

The geographical distribution of the genus - <u>Abelmoschus</u> mainly covers South and Southeast Asia and Africa. Van Borssume-waalkes (1966) considered southeast Asia (Burma, Indo-China, Indonesia, Malaysia and Thailand) as the region of maximum diversity of the genus - <u>Abelmoschus</u>. Charrier and Hamon (1982) extended the region of maximum diversity to Indo-Pakistan sub-continent as well as West Africa. After the domestication of cultivated species of okra in Africa (de Candolle, 1883) the cultivated forms probably migrated to the mediterranean area

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and later to India. Its introduction to tropical and subtropical America probably took place during the pre-Columbian period (Thakur & Arora, 1986). The origin of cultivated okra may thus to polyphyletic as suggested by Joshi and Hordes (1976).

Germplasm resources

The International Board of Plant Genetic Resources (IBPGR) has taken the lead in collecting and evaluating germplasm of okra and related wild species since 1980 and has designated NBPGR as one of the global base centres for okra germplasm conservation. In order to bring together curators, researchers and users of okra germplasm to work in close collaboration for their mutal benefits, it was suggested to establish a global okra network, during the International Okra Genetic Research Workshop organised by IBPGR and NBPGR at New Delhi during October 1990. It was further suggested to establish an International Data Base for Okra (IDBO) at IBPGR Regional Office for South and Southeast Asia. The IBPGR will operate the IDBO until its transfer to the NBPGR i.e. two year after its initiation comprising all the data received from the co-operating member countries. The proposed active collection centres with responsibility to regenerate evaluate and distribute okra germplasm are - India, Ivory Coast, Philippines, Brazil, USA and Papua New Guinea. A separate network Cordinating Body would provide central link between all members and to stimulate the realization of the network. The coordinating body will consist of three members i.e. the representative of the Institute holding the base collection (as Chairman), a representative from Asia and one from Africa on tenurial basis. The regional officer of South and Southeast Asia will act as the Secretariat to the organising body. They will ensure the active association of IBPGR with the coordinating body. The okra germplasm presently available at global basis has been listed in Table 1.

Taxonomy and systematic status

The taxonomy of <u>Abelmoschus</u> is complex and presently there is a need to complement the morphological and ecological observations with cytological information. Cultivated okra and related wild species were originally grouped into the genes <u>Hibiscus</u>, section <u>Abelmoschus</u> by Linnaeus (1737). <u>Abelmoschus</u> was established by Medikus (1787) based upon the nature of dehiscent capsule and re-established by Schumann (1890) based on the caducity of the calyx and further confirmed by Hochreutiner (1924) based upon the adnation of the calyx to the petal base and staminal column. It is distinguished from the genus <u>Hibiscus</u> by the characteristics of the calyx which is spathulate, with five short teeth, connate to the corolla and caducous after flowering (Kundu & Biswas 1973, Terrell and Winters, 1974).

About 50 species have been described by the taxanomist under the genus <u>Abelmoschus</u>. Hochreutiner (1924) however distinguished 14 species with several varieties of <u>Abelmoschus manihot</u> and <u>A. moschatus</u>. Van Borssum Waalkes (1966) further revised the taxanomic status and classified only six species in the genus <u>Abelmoschus</u> with several species and varieties. Further modifications in the systematic status of the genus <u>Abelmoschus</u> done by the working group of International Okra Genetic Resources Workshop held at New Delhi, 1990 are as follows:

Classification developed by VAN BORSSUM WAALKES (1966)		Classification adopted by the INTERNATIONAL OKRA WORKSHOP (1990)	
1.	<u>A. moschatus</u> Medikus	1.	<u>A. moschatus</u> Medikus
1.1	ssp. <u>moschatus</u> var. <u>moschatus</u>	1.1	ssp. <u>moschatus</u> var. <u>moschatus</u>
1.2	ssp. <u>moschatus</u> var. <u>betulifolius</u> (Mast.	1.2	ssp. <u>moschatus</u> var. <u>betulifolius</u> (Mast.)
1.3	ssp. <u>biakensis</u> (Hochr.) Borss.	1.3	ssp. <u>biakensis</u> (Hochr.) Borss.
1.4	ssp. <u>tuberosus</u> (Span.) Borss.	1.4	ssp. <u>tuberosus</u> (Span) Borss.

2.	A. manihot (L.) Medikus.	2.	A. Manihot (L.) Medikus.
2.1	ssp. manihot		
2.2	ssp. tetraphyllus (Roxb. Hornem.) Borss. var. tetraphyllus	3.	A. tetraphyllus (Roxb. ex Hornem.) R. Graham
		3.1	var. tetraphyllus
2.3	ssp. tetraphyllus var. pungens (Roxb. Hochrr	3.2	var. pungens (Roxb.) Hochr.
3.	A. esculentus (L.) Moench (including A. tuberculatus Pal & Singh)	4.	A. esculentus (L.) Moench
		5.	A. tuberculatus Pal & Singh
4.	A. ficulneus (L.) W & A ex Wight	6.	A. ficulneus (L.) W&A ex Wight
5.	A. crinitus Wall.	7.	A. crinitus Wall.
6.	A. angulosus Wall. ex W & A	8.	A. angulosus Wall. ex W&A
		9	A. caillei (A. Chev.) Stevels

Note:

In the context of above classification:

* 'Guinean' type of okra = A. caillei
* 'Soudanien' type of okra = A. esculentus
* A.manihot var. caillei A.Chev.= A. caillei
* A. caillei was identified wrongly earlier as A. manihot ssp. manihot (Flora of Tropical West Africa, Kew Botanic Gardens)

The morpholotical and cytological evidence support presently distinction of 9 species of Abelmoschus as summarised below:

1. Abelmoschus moschatus Medikus (n = 36)

   A polymorphic species, both cultivated and wild forms are available. It has a wide geographical distribution ranging from Central and West Africa, Asia and Northern Australia. The ssp. biakensis occurs only in Papua New Guinea near the sea. The ssp. tuberosus is particularly resistant to drought and fire due to its tuberous roots. No changes have been made in the classification developed by Van Borossum Waalkes (1966).

2. *Abelmoschus manihot* (L.) Medikus (n = 30, 33, 34)

The species is cultivated mainly in the Far East, Indian Sub-continent and Northern Australia. It is less frequently found in Amercia and Tropical Africa.

3. The ssp. *tetraphyllus* var. *tetraphullus* and the var. *pungens* have been raised to species level as *A. tetraphyllus* var. *tetraphyllus* (n = 65; 69) and *A. tetraphyllus* var. *pungens* (n = 69). These are morphologically distinguished from *Abelmoschus manihot* mainly on the basis of indumentam. The var. *tetraphullus* grows at low atltitude bewteen 0 to 400m. in the region of Indonesia and Philippines, Papua New Guinea and New Ireland. The var. *Pungens* grows at altitude between 400- 1600m in Indonesia and Phillippines.

4. *A. esculentus* (L.) moench (n = 60-70)

   The species is cultivated as a vegetable in most tropical and sub-tropical region of Africa (Sudani-Sahelian Zone), India and America. The Sudanian type of okra belongs to *A. esculentus*.

5. *A. tuberculatus* (Pal and Singh) (n = 29) has been separated from *A. esculentus* of Van Borssum Waalkes. It is endemic to U.P. (Saharanpur), Rajasthan (Ajmer) and Indore (Central India).

6. *A. finculneous* (L.) W. & A. ex wight (n = 36, 39)

   The wild species with the largest distribution stretching from Africa to Asia and Australia. Its status has not been altered.

7. *A. crinitus Wall.*

   A. wild species, confined to Asia. Its taxonomic status is not contested.

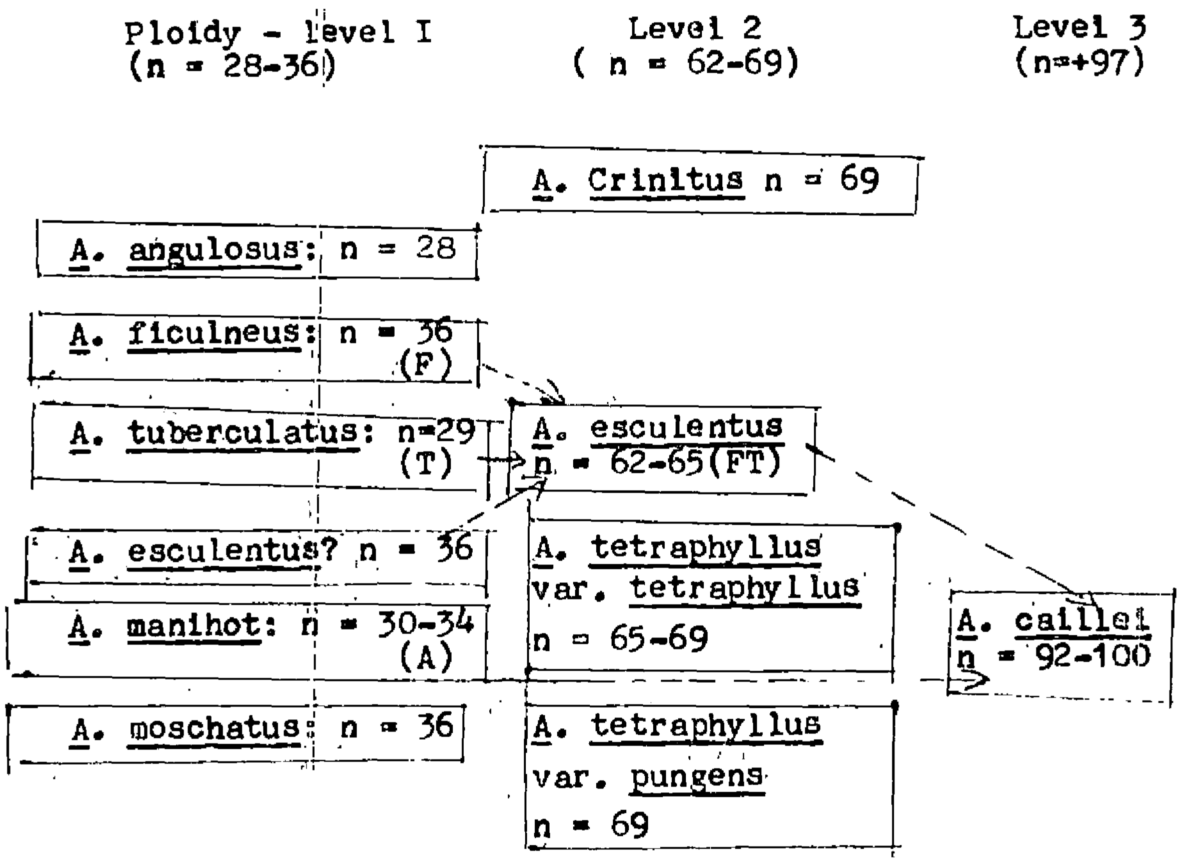
8. *A. angulosus* Wall. W. & A. (n = 28)
   Wild species confined to Asia. No change in its taxonomic status.

9. *A. Caillei* (A. Chew.) Stevels (n = $\pm$ 97)
   A second edible okra species with a distribution limited to west and Central Africa. *A. caillei* (Ghana sp. or Guinean type of okra) was udentified wrongly earlier as *A. manihot* ssp. *manihot* (Flora of Tropical West Africa, Kew Botanical Gardens)

Cytology and Interspecific hybridization

Three polidy levels of the genus *Abelmoschus* have been recognised (Charrier 1984) which has been summarized in Fig. I

Fig. I : Cytogenetical relations in Abelmoschus (Charrier, 1984) with some amendments to the classification of VAN BORSSUM WAALKES (1966)



Relations between ploidy - level I species

Interspecific crosses have been attempted in 4 out of six ploidy-level I species and the results are summarised below:

In the cross combination A. tuberculatus (n=29) x A. ficulneus (n=36) only sterile F_1 hybrids were obtained. Average of 1.63 bivalents were observed per PMC (pllen mother cell) indicating little genome homology. The amphidiploid developed through colchiploidy of F_1 hybrid showed 65 bivalents which is equivalent to the chromosome number of the cultivated species A. esculentus (2n=130). This artificial amphidiploid (reconstruction of A. esculentus 2n = 130) was genetically unbalanced, being compbtely sterile (Joshi et al. 1974).

Crosses of A. tuberculatus (n=29) x A. manihot (n=34) gave sterile F_1 hybrids with 63 univalents indicating no affinity between the genomes of the parental species (Kuwada, 1974, Pal et al.. 1952; Joshi and Hardas, 1956).

Other cross combinations between A. *manihot* x A. *moschatus* and its reciprocal (Skovsted, 1935; Hamon & Yapo, 1986); A. *manihot* x A. *ficulneus* and its reciprocal (Pal et al., 1952), A. *moschatus* x A. *ficulneus* and its reciprocal (Gadwal et al., 1968), A. *tuberculetus* x A. *moschatus* (Gadwal et al., 1968) have not produced any F_1 hybrids.

Relation between ploidy level I and ploidy-level (2 species

In order to identify the parental species of A. *esculentus*, a number of interspecific crosses have been attempted which have been summarised in Table 2.

Meiotic studies of the hybrids between A. *esculentus* (n = 62, 65) and A. *tuberculantus* (n = 29) revealed almost perfect *tuberculatus* pairing of the genome of A. *tuberculatus* with 29 chromosomes of A. *esculentus*. The F_1 hybrids gave 29 bivalents + 36 univalents (Joshi *et al*., 1974) or 29 bivalents + 33 univalents (Kuwada, 1966) A *tuberculatus* is thus accepted as one of the ancestors of A. *esculentus*. Concerning the complementary genome of A. *esculentus* a considerable but incomplete pairing was observed in the cross A. *esculentus* x A. *ficulneus*. This cross could not be obtainedby direct pollination (Pal *et al*, 1952) but through *in vitro* culture of the F_1 hybrid. Cytological studies of the PMC revealed 27 bivalents + 46 univalents indicating good affinity of the homologus chromosome. The possibility of a A. *esculentus*(?) race 2n = 72, as reported by Teshima (1933), Ugale et al Ugale (1976) and Kamalova (1977) needs further investigations for identifying the source of missing genome n = 36.

Kuwada (1957 b, 1961) obtained a fertile aritificial amphidiploid 2 n = 192 between A. *esculentus* 2n = 124 and A. *manihot* 2n = 68 called Nori-Asa.

Crosses between ploidy-level I species and *A. tetraphyllus* are not well documented. Pal *et al.* (1952) obtained sterile hybrids in cross between different forms of *A. manihot* in wide sense. No viable hybrid seeds were obtained in cross between *A. tetraphyllus* and *A. manihot* s.s and *A. moschatus* (Hamon & Yapo, 1986). Ugale *et al.* (1976) reported perfect pairing of the genome of *A. esculentus* (?) with 36 chromosome of *A. tetraphyllus* (2n = 130) in the interspecific hybrids.

Relation between ploidy-level and species

Viable but sterile hybrids in cross between *A. esculentus* and *A. tetraphyllus* were reported by Gadwal (cf.) Joshi and Hardas, 1976) and Hamon and Yapo (1986). No data on genome affinity are available.

Successful cross combination between *A. esculentus* (n=65) and *A. tetraphyllus* var. *tetraphyllus* (n=69) was obtained by Dutta (1970, 1975, 1978, 1979). The F_1 were vigorous and sterile. The amphidiploid developed through colchiploidy of F_1 hybrid were fertile with good fruit and seed set. Cytological studies of the F_1 hybrids revealed 36 bivalents and 62 univalents, indication one genome of *A. tetraphyllus* var. *tetraphyllus* is common with that of *A. esculentus*. The sterility in the hybrid was mainly due to the failure of development of female gemetes. The induced amphidiploids showed regular meiosis forming 134 bivalents (Suresh Babu, 1987). Artificial and spontaneous amphidiploids between these two species have been realised by Jambhale and Nerkar (1981a, b).

Relation between ploidy-level 3 species

Hybridization between A. caillei and A. manihot (Asian origin) produced viable hybrid seeds (Siemonsma, 1982a, b), Jambhale and Nerkar (1981a) and Hamon & Yapo (1986). Crosses between A. esculentus and A. caillei gave viable hybrids with reduced fertility (Singh & Bhatnagar, 1975, Singh (in: Joshi and Hardes, 1976). Hamon and Yapo (1986) and Hamon (1987) reported on the crosses A. caillei x A. tetraphyllus. Viable but sterile hybrids were obtained. Siemonsma (1982) proposed a hypothesis that A. caillei (Guineen okra) may be a natural amphidiploid of A. esculentus and A. manihot. The fertile amphidiploid Nori-Asa between these two species realised by Kuwada (1957a, 1961) resembles A. caillei in morphological characters. Kondaiah et al. (1990) made crosses between A. caillei and A. tetraphyllus and with two induced amphidiploids i.e. A. esculentus-manihot and A. esculentus-tetraphllus. Cytological studies in cross between A. tetraphyllus x A. caillei gave 66.5 bivalents and 6.52 univalents whereas, in cross between A. esculentus - tetraphyllus x A. caillei, 71.98 bivalents and 18.22 univalents were observed in addition to trivalents and tetravalents indicating high degree of homology between the genome of A. tetraphyllus and Abelmoschus caillei which suggests that A. tetraphyllus could have contributed two genome to A.caillei. Chromosome pairing behaviour in the F_1 of A. esculentus - manihot x A. caillei gave 46 bivalents and 13 univalents. It is likely that out of 46 bivalents majority could be due to genome homology between A. manihot and A. caillei. It thus indicates indirectly that A. manihot might have contributed one genuine and A. tetraphyllus two genomes to A. caillei.

Floral biology

Okra plant takes 22-26 days from vegetative phase to generative phase and another 22-26 days from flower bud initiation to anthesis. Each flower (hermaphrodite) opens at an interval of 2-3 days. Flowering may continue from 40 to 60 days. Anthesis takes place in the morning 8-10 am) and is influenced by temperature and humidity. Anther dehiscence (trans verse) commenses 15-20 minutes after anthesis and is complete in 5-10 minutes (Purewall and Randhawa, 1947). Okra pollen grains are pentoporate and spinate. The spines and pores are alternate to each other. The pollen size varies from 48u to 15.1 . Number of anthers per flower as well as number of pollen per anther is affected by the position of flower on the stem. Maximum number of pollen grains are obtained at 2nd to 4th flower position on the stem. Pollen production per anther is higher at the apical region when compared to basal region (Srivastawa, 1982). Though pollen grains are polysiphonous, yet only one pollen tube is functional ultimately (Nair et al, 1974). Pollen grains germinate in-vitro in 25% sucrose solution (Srivastawa, 1982) and remain viable in storage at 50% RH for 55 days (Dubey & Singh, 1968a).

The stigma is receiptive at anthesis while pollen fertility is maximum an hour prior to and an hour after anthers. (Srivastawa, 1969). Fertilization is complete 2-6 hour after pollination. About 90% pollen tubes are received by ovoules positioned at 7 to 14 in the capsule (Chandra & Bhatnagar, 1975).

Okra is an often cross pollinated crop and crossing ranging from 0.34 to 60% have been reported by many researchers (4 to 19% by Purewall & Randhawa, (1947), 4 to 31.7% by

Venkitaramani (1953), upto 42.2% by Mitidieri and Ven covsky (1974); upto 20% by Joshi and Hardas (1976); 6.34 to 27.3%, Akenova and Fatokun (1984), 11.8 to 60% by Martin, F.W. 1983), Bees and black ants and bumble bees are the pollen carriers. Fruits are ready to harvest 3-6 days of anthesis. Fibre formation starts from fruit tip during 5-6th day and by 9th day its highly fibrous (Nath, 1976).

Most of the sub-tropical okra cultivars (A. esculentus) are little influenced by photoperiods ranging from 10 to 18 hours. The Guineen type (A. caillei) requires shorter critical photoperiod between 12h to 12h and 40 minutes. Sowing in the long photoperiod may result in vegetative phase for a period of 3-9 months. (Siemonsma, 1982). Insertion of a single long day (LD 16h.) among 4 short day (10h.) prevents floral induction regardless of the position of the LD in the SD sequence. The treatment 3 SD + 1 LD + 3SD gave 100% flower initiation (N Woke 1986).

Crop Improvement

The major objectives pertaining to crop improvement are high yield, wider adoptability, resistance to insect pests and diseases, and good organoleptic qualities. Specific characters such as fruit length (long or short), colour (dark green), fruit shape (smooth or prominent satures), fruit consistancy show regional preference of the local consumers as well as the need for export or processing industry. Major disease problems which require immediate attention are yellow vein mosaic virus, Enation leaf curl virus, Fusarium wilt, powdery mildew, Cercospora, nematodes, borers, jassids and aphids.

Variability and correlation studies in Okra

Work done on crop improvement is mainly restricted to the species *A. esculentus* with the exception of studies on *A. manihot* in Papua New Guinea and on the Guineen type of okra (*A. caillei*) in West Africa.

A study on the co-efficient of genotypic and phenotypi variance, heritability, genetic advance and correlation studies are useful guides for selection. Morphological differences among the Indian and North American varieties are comparatively smaller than that of varieties from Africa (Girenka, 1983). High genotypic and phenotypic variance, high hertitability and genetic advance for plant height, inter nodal length, number of branches, number of fruits per plant, fruit length, earliness and yield per plan have been reported by several scientists. (Singh 1975), Mishra (1979), Palaniveluchanny and Muthukrishnan (1982), Girenko *et al.*, (1985), Reddy *et al.*, (1985), Maksaud *et al.*, (1986), Yadav (1986) and Koria et al., 1987).

Correlation studies indicate that fruit yield is positively correlated with plant height, number of nodes per plant, fruit length and fruit girth, fruit weight, fruit number, early flowering and branching, (Sing *et al.*, (1974); Rao and Kulkarni (1975), Rao (1978 a, b), Mahajan, *et al.*, (1979) and Swamy *et al.*, 1978). Path coefficient analysis indicates that fruit weight, fruit number per plant have direct positive contribution to yield while fruit length, fruit number per branch have the highest indirect contribution to yield (Ajimal et al., 1979).

Genetical studies

Genetics of quantitative characters

Genetics of yield and yield components in okra have been studied by several workers. Both additive and non-additive genes are involved in controlling the yield and yield components. Total yield is mainly controlled by additive or additive x additive gene effects indicating the employment of pedigree breeding methods for its improvement. Non-additive gene actions have been reported for plant height, node numbers, days to flowering, fruit length, fruit girth, number of fruit per plant and number of branches per plant indicating the exploitation of heterosis in these parameters (Rao and Kulkarni, 1978), Singh & Singh (1978, 1979), Partap et al., (1980), Thakar et al., (1981), Partap and Dhankar (1983), Kerala and Sharma (1987), Shukla et al., (1989).

Genetics of qualitative characters

Presence of purple pigment at the petal base is controlled by a single dominant gene and in the fruit by a dominant gene 'Pf'. The presence of pigment in the stem, pedicel, epicalyx and petal veins in controlled by duplicate gene. Three genes are involved in the control of pigmentation in the petiole and leaf veins. (More and Vibhute 1983). Cut leaves and fruit spines each is controlled either by single dominant gene (Jasim, 1967) or by incomplete dominant gene (Nath and Dutta, 1970), pod shape (angular vs. round) is digenic with epistalic effect (Jasim, 1967). Short day trait in okra is controlled by a single recessive gene, (Wyatt, 1984).

Genetics of diseases and Insect pests resistances

Resistance to yellow vein mosaic virus in _A. esculentus_ (IC. 1542) is controlled by two complementary recessive alleles yV1, yV1 and yV2 yV2. Singh _et al._, (1962). Resistance to yellow vein mosaic virus in _A. caillei_ (Ghana species) is controlled by two complementary dominant genes with additive effects. (Sharma and Dhillon, 1983). A single dominant gene controls the resistance to YVMV in _A. manihot_ (2n = 66) and _A caillei_ (2n = 194), (Nerkar and Jambhale 1985).

Resistance to powdery mildew (*Erysiphe cichoracearum*) in okra line 155, derived from advance generation of the cross *A. esculentus* x *Abelmoschus manihot* is controlled by a single incomplete dominant gene (pm), (Jambhale and Nerkar 1983).

Resistance to leaf hopper (*Amrasca devastans*) in okra AE 22 is controlled by a single recessive genes. Resistant varieties have more and longer hair on the mid rib and leaf lamina than the susceptible varieties, (Uthamasamy and Subramanyam 1985).

Pure line selection for crop Improvement

Okra variety Pusa Makhmali a pure line section from West Bengal was evolved and released for commercial cultivation by Indian Agriculture Research Institute, (Singh and Sikka 1955). The variety has good horticultural qualities but is highly susceptible to YVMV. Another variety evolved through pure line selection is Co-1 (plants and pods are scarlet red) released by Tamil Nadu Agricultural University, Coimbatore, in 1976. The anthocyanin pigment of the fruit is not stable and changes to green on cooking.

Pedigre selection for Improvement

Okra variety PUSA SAWANI tolerant to yellow vein mosaic virus was evolved by crossing the tolerant line IC 1542 with Pusa Makhmali (susceptible to YVMV) and selecting the desired recombinants tolerant to YVMV in the advanced generations. Pusa Sawani yields 70 quintals/acre.Singh *et al*., (1962). Tolerance to Y,V,M,V in Pusa Sawani has been lost and presently it is highly susceptible.

Interspecific hybridization for crop improvement

The average yield loss in okra due YVMV infection has been estimated as high as 93.30 per cent when the plants are infected within 35 days of germination, (Sastry and Singh 1974). Sources of resistance/tolerance to YVMV have been located in A. Caillei, A.manihot, Abelmoschus tetraphyllus, var. tetraphyllus, A. manihot var. pungens and A. crinitus. (Nariani and Seth, 1958), Singh et al. (1962), Dutta and Singh 1975), Singh and Thakur (1979), Sharma and Sharma (1984) Jambhale and Nerker 1986).

Okra variety Parbhani Kranti resistant to yellow vein mosaic virus was evolved by crossing A. esculentus (n = 65) (Pusa Sawani) with Abelmoschus manihot (n = 33). The F_1 was partially fertile. The partially fertile F_1 was back crossed twice with Pusa Sawani and the recombinants were selected in the advanced generations of BC_2F_8. The variety Parbhani Kranti was released for commercial cultivation during 1985. It is a high yielding variety and is resistant (symptomless carrier) to YVMV. Yield potential (120 q./ha, Jambhale and Nerkar (1986), Nerker and Jambhale 1985).

Another variety Pb-7 resistant to Y.V.M.V. have been evolved at Punjab Agriculture University, Ludhiana using Abelmoschus Caillei (Ghana sp.) as a source of resistance to yellow vein mosaic virus, it has been identified as a national variety by the AICVIP workshop during 1990. Yield 125-130q/ha.

Okra varieties ARKA ANAMIKA and ARKA ABHAY with resistant to YVMV have been evolved using A. tetraphyllus var. tetraphyllus (n = 69) as source of resistance to YVMV at IIHR, Bangalore, during 1990. Its pedigree is detailed obverse.

1970 A. *esculentus* x *A. tetraphyllus* var. *tetraphyllus*
IIHR 20-31 (n = 65) n = 69

F1 hybrid (sterile) 2n = 134, (36IIs) 62 Is)

Induced Amphidiploid (fertile) 2n = 268

BC_1

BC_2

BC_3

BC_3 F_{10} ARKA ANAMIKA } Resistant to YVMV.

1990 ARKA ABHAY

Okra variety ARKA ANAMIKA has been identified as a superior variety at national level by the AICVIP workshop during 1990. Yield potential of Arka Anamika and Arka Abhay varies from 175-250 q. per hectare depending upon the season. Both the varieties bear fruit in 2 flushes and respond highly to pruning operation, Dutta & Singh (1989, 1990), Dutta (1990).

Hetrosis breeding

Heterosis in yield has been reported ranging from 29.5% to 76.7% (Joshi *et al* 1959), Poshiya and Shukla 1986), Agarrado and Rasco, 1986). Heterosis for earliness and other yield component like fruit number, fruit weight, higher germination, plant height have been reported by several worker, (Joshi *et al*.,(1959), Raman (1965), Jalani & Graham (1973), Sharma and Mahajan (1978), Poshiya and Shukla (1986), Radhika, 1988). Several okra hybrids resistant to YVMV and possessing higher yield have been evolved and are being tested under AICVIP. These are enlised obverse:

Hybrid variety	Source
Hybrid-7	Tamilnadu Agricultural University Coimbatore.
Hybrid-8	-do-
GOH-3	Gujarat Agricultural University, Anand
GOH-4	-do-
DOH-2	Indian Agricultural Research Institute, New Delhi
DOH-4	-do-
DOH-6	-do-

Mutation breeding

Genetic male sterility in okra has been induced through mutation breeding using -rays. The character is governed by a single recessive gene when present in a homozygous conditions. The character can be exploited for hybrid seed production by hand pollination. In comparison with fertile lines, approximately 70 per cent saving in time and manual labour can be achieved in the production of hybrid seeds using male sterile of Okra (Dutta 1971). Okra variety EMS-8 resistant to YVMV has been evolved using chemical mutagens at PAU-Ludhiana. Mutation breeding has also been attempted to evolve early okra varieties resistant to YVMV (Nirmala Devi, (1982), Ahraham & Bhatia, (1984), Jambhale & Nerkar, 1984 and 1985).

Future Thrust

There is an immediate need to evolve okra varieties showing combined resistance to yellow vein mosaic virus, Enation leaf curl virus and nematodes. Resistance to Fusarium wilt, powdery mildew, jassid resistance, shade and cold tolerance need further attention.

Hybrid varieties suitable for processing industry and export need the next priority.

Table 1: Okra Germplasm Collections

S.No.	Source	Germplasm maintained	No. of catalogued accession
1.	NBPGR - India	1700	558
2.	IIHR - Bangalore	125	-
3.	PAU - Ludhiana	120	-
4.	GAU - Junagarh	129	-
5.	CAUT - Bhubaneswar	27	-
6.	KAU - Vellanikkara.	48	-
7.	Ag.Res.Co-operative Hort. Research Section - Sudan	132	91
8.	Institute of Plant Breeding, UPLB College, Laguna, Philippine	703	-
9.	Plant Genetic Resources Centre Gannoruwa, Sri Lanka	130	47
10.	IDESSA, B.P.635 Bauaka 01, Ivory Coast	3500	-
11.	Senegal Institute of Agricultural Research - Senegal	400	200
12.	Universidade Fedral de vicosa vicosa, UFV, Brazil	203	150
13.	EEI (Estacuo Expt. de Itaguai, Perugro - Rio, Brazil)	290	-
14.	ESALC, Caiza Postal: 33 BRAZIL	170	-
15.	Senegal Institute of Agricultural Research Centre for Horticultural Development, PCB 3120, Dakar - SENEGAL	400	172
16.	National Centre for Genetic Resources of Biotechnology (NACGRAB), Nigeria	374	-
17.	Agronomy Department, University of Ibadan, Nigeria	450	296.

Table 2: Results of crosses between Abelmoschus *esculentus* and ploidy-level 1 species (positive = viable seed)

Cross *A. esculentus* x	Chromosone numbers	Authors	Indicated cross	Reciprocal cross	Bivalents in meiosis
A. tuberculatus		PAL et al., 1952	Positive	Positive	
	130 x 58	JOSHI & HARDAS, 1956; JOSHI et al., 1974	Positive	Positive	28.8 (27-29)
	124 x 58	KUWADA, 1966	Positive	Positive	27-29
A. manihot	72 x 60	TESHIMA, 1933	Positive	negative	0
	(126-134)x60	CHIZAKI, 1934	Positive		0-7
		SKOVSTED, 1935	Positive	positive	
		USTINOVA, 1937	Positive	negative	
		SINGH et al., 1938	Positive		
		USTINOVA, 1949	Positive	negative	
		PAL et al., 1952	Positive	positive	
	124 x 68	KUWADA, 1957 a	Positive	positive	7
		HAMON & YAPO, 1986	negative	negative	
A. ficulneus	130 x 72	PAL et al., 1952	negative	negative	
		GADWAL et al., 1968; JOSHI et al., 1974	negative		27.5 (26-28)[2]
A. moschatus	130 x 72	SKOVSTED 1935	positive	negative	
	130 x 72	GADWAL et al., 1968 JOSHI et al., 1974	negative		8.3 (3-16)[2]
		HAMON & YAPO, 1986	positive	negative	

[1] The article deals with a cross between *A. esculentus* and *A. ficulneus*, but the description of the latter species corresponds to *A. manihot*.

[2] Hybrids obtained by embryo- and/or ovule-culture.

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Genetic improvement of chilli

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Chilli (Capsicum sp.) is a quintessential spice in every Indian cusine and is cultivated in the tropical and subtropical regions of the world. Green chilli, chile powder, Cayenne peppers, tabasco, paprika, sweet or bell peppers, pimentos and Serrano pepper are all derived from the fruit (berry) of various species of Capsicum.

Annual trade of chilli in the world is 55 to 60 thousand tonnes which is 16.7% of total spice trade in the world. It occupies an area of 9.27 lakh ha with a production of 7.05 million tonnes on global basis.

India ranks first in area and production of chilli in the world producing 780 thousand tonnes from an area of 814.1 thousand ha. Amdhra Pradesh has the largest area and production (177,000 ha and 2,93,000T respectively) followed by Maharashtra (1,38,000 ha and 68,000 T respectively) and Karnataka (1,35,000 ha and 1,76,000 T respectively). Productivity is maximum in Andhra Pradesh (1653 kg/ha) and the lowest in Madhyapradesh (203 kg/ha). India is a major exporter of chillies and during 1987-88 the export was 6122 tonnes worth of Rs. 83,34,000/. Still chilli occupies 17% share in India's Export.

Origin and distribution :

Based on lack of reference of Capsicum in ancient languages Decandolle (1886) concluded that no capsicum is indigenous to old world. Historians agree on the new world origin of Capsicum. The centre of diversity of common cultivated pepper C. annuum is Mexico with a secondary centre in Guatemala. C. frutescens is widely distributed throughout the tropical and subtropical Americas and was domesticated in central America. The centre of origin of

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C. baccatum is probably Bolivia (Heisser, 1976). The genus Capsicum quite clearly is South American in origin (Smith and Heisser, 1957).

Capsicum was carried to the Old world by the early explorers, being introduced into Spain by Columbus in 1493. Cultivation spread from Mediterranean area to England by 1545 and to Central Europe by end of 16th country. The Portughese brought Capsicum to India from Brazil prior to 1585 for cultivation.

Taxonomy:

Cultivated chilli varieties offer many difficulties in classification because of their great number, the transitory nature of many of them and the constant creation of new ones through hybridization and selection. Early taxonomic treatment of the genus resulted in more than 100 species and botanical varieties (Irish, 1898). Linnaeus in Species Plantarum (1753) (Hortus cliffortianus) described two species C. annuum and C. frutescens. Bailey (1923) recognized only one species C. frutescens and proposed 5 botanical varieties of C. annuum as suggested by Kutze (1891) under C. frutescens.

Modern taxonomists based on extent of variability recognized the cultivated Capsicum into five species (Pickersgill, 1980). (Table 1). C. pubescens R&P is domesticated to temperate regions while the remaining species in tropical countries.

Table 1. Cultivated species of Capsicum and their distribution

Species	Distribution
1. C. annuum L. (Syn. C. purpureum, C. grossum C. cerasiformae)	Columbia to Southern USA and throughout Latin America, Asia.
2. C. baccatum L. (Syn. C. pendulum, C. microcarpum, C. angulosum)	Argentina, Bolivia, Brazil, Colombia, Ecuador, Paragua, Peru etc.
3. C. frutescens L. (Syn. C. minimum)	Colombia, costa Rica, Guatamala, Mexico, Puerto Rico, Venizuela.
4. C. chinense Jacq. (Syn. C. luteum, C. umbilicatum, C. sinense)	Bolivia to Brazil, Belize, Costa Rica, Mexico, Nicaragua, West Indies.
5. C. pubescens R&P	Bolivia to Colombia, Costa Rica, Guatemala, Honduras, Mexico.

Interspecific hybridization :

Despite of constancy in chromosome number, attempts on inter specific hybridization has succeeded only in a few cases (Pickersgill 1971). In the interspecific hybridization involving *C. annuum* and *C. frutescens* partial success was obtained by Pradeepkumar (1990). Fertile hybrids between *C. annuum* and *C. chinense* were obtained by Pradeepkumar (1990). Abnormal development of embryo, endosperm and F_1 plants were noticed in *C. annuum* x *C. baccatum*, *C. frutescens* x *C. baccatum* and in reciprocal crossess.

Studies by Pickersgill (1967) showed that *C. frutescens* is the most closely related species to *C. chinense* and high level of cross combatibility between the two species was reported by Eshbaugh (1975). Smith and Heisser (1957) observed that the cross, *C. sinense* x *C. pendulum* can be made with some difficulty with *C. pendulum* as female parent. Studies by Eshbaugh (1975) indicates the similarity among purple flowered species *C. cardenasii*, *C. eximium*, and *C. pubescens*.

Chromosome number and morphology :

The diploid chromosome number was reported as 2n = 24 for each of the species. Chromosome size is referred as both small and large. Spontaneous occurence of triploids, tetraploids, trisomics etc., was reported in chilli.

In *Capsicum sp.* polyembryonic seedlings were reported. Haplo-diploid twins were rare in the species, where as purely diploid twins were frequently seen and from these, a few haploid seedlings were identified (Morgan and Rappleye, 1958).

Botany and floral biology :

Root system is restricted to top 30 cm soil layer. Water stagnation of more than 24 hours results in collapse of plants. Anthesis takes place 5-6 AM with dehiscence of anthers 8-11 AM (Padda and Singh, 1971). Dehiscence of anthers, pollen fertility and stigma receptivity was maximum on the day of anthesis.

Though considered as a self pollinated crop, natural cross

Diagnostic keys were prepared by IBPGR (1983) and EUCARPIA Capsicum working group for the field identification of the five cultivated Capsicum species.

1. Seeds dark, corolla purple ....C. pubescens

1. Seeds straw-coloured, corrolla white or greenish white ..... (rarely purple) 2

   2. Corolla with diffuse yellow spots at bases of lobes .... C. baccatum

   2. Corolla without diffuse yellow spots at bases of lobes 3

      3. Corolla purple 4

         4. Flowers solitary . . . . .C. annuum

         4. Flowers 2 or more at each node..... C. chinense

      3. Corolla white or greenish-white..... 5

         5. Calyx of mature fruit with annular constriction at junction with pedicel .... C. chinense

         5. Calyx of mature fruit without annular constriction at junction with pedicel 6

            6. Flowers solitary 7

            7. Corolla milky white, lobes usually straight, pedicels often declining at anthesis....C. annuum

            7. Corolla greenish white, lobes usually slightly revolute, pedicels erect at anthesis....C. frutescens

After conducting flavanoid analysis in three Capsicum species, Lopes et al (1978) suggested that there exists greater affinity between C. annum and C. frutescens than between C. pendulum and and C. frutescens. Based on Starch gel electrophoresis, Mc leod (1979) classified 14 taxa into five biological species. Based on electrophoresis of peroxidase isozyme extracted from functional leaf, Wang and Ma (1987) assigned eight Capsicum to four groups. Protein electrophoretic studies by Pradeepkumar (1990) revealed species specific protein bands in C. chinense, C. baccatum and C. chacoense. Among five species Viz. C. annuum, C. frutescens, C. chinense, C. baccatum and C. chacoense, close relationship was established between C. chinense and C. frutescens.

pollination was reported upto 78%. The extent of natural cross pollination in chilli is furnished below:

NCP (%)	Pollination Vector	Place of report	Reference
7 - 39	Honey bees & Thrips	U.S.	Odland and Porter (1941)
58 - 68	Insects	Lam	Murthy and Murthy (1962)
1.77-54.91	Insects	Mexico	Compodonica (1983)
31.0-78.0	Insects	New Mexico	Tanksley (1984)

Combining ability analysis :

Gene actions of economic characters were studied by combining ability analysis and generation mean analysis. Salient results are presented below:

Characters	Gene action	Authority
1. Plant height	Additive	Soh *et al* (1977)
	Non-additive	Thakur *et al* (1980) Rao and Chhonkar (1983)
2. Fruit length	Additive	Lippert (1975)
	Non-additive	Rao & Chhonkar (1983)
3. Average fruit weight	Additive	Ahmed *et al* (1982)
4. Fruits/plant	Additive	Ahmed *et al* (1982)
	Non-additive	Thakur *et al* (1980)
5. Fruit yield/plant	Additive	Ahmed *et al* (1982)
	Non-additive	Thakur *et al* (1980) Dikil and Anikeenko (1981)
6. Earliness -	Non-additive	Gopalakrishnan (1986)
7. Capsaicin content	Additive	Bajaj *et al* (1980), Park and Takatashi (1980).

Manifestation of heterosis :

The first report on heterosis in chilli came from Deshpande (1933). Reports on manifestation of heterosis for economic characters are reviewed.

Characters	Authority
Plant height	Joshy and Singh (1980), Murthy and Lakshmy (1983) Krishnakumari (1984), Uzo (1984), Pious (1985).
Branches/plant	Joshy and Singh (1980), Sontakke (1981).
Fruit length	Rao et al (1981), Pious (1985)
Average fruit weight	Gopalakrishnan (1986)
Fruits/plant	Uzo (1984)
Fruit yield/plant	Pandey et al (1981), Gopalakrishnan (1986)
Earliness	Sontakke (1981), Krishnakumari (1984), Uzo (1984), Pious (1984), Gopalakrishnan (1986), Pradeepkumar (1990).
Capsaicin content	Park and Takatashi (1980) Nowaczyk (1981).

Inheritance of important discrete characters :

Characters	Inheritance	Authority
Fruit orientation	Pendulous dominant over upright	Deshpande (1933)
Fruit apex	Pointed incompletely dominant over blunt	Deshpande (1933)
Immature fruit colour	Purple dominant over green	Deshpande (1933)
Clusterness	Solitary dominant over clusterness	Gopalakrishnan, (1986)
Destalkness	Stalked dominant over destalked	Gopalakrishnan (1986)
Pungency	Pungency dominant over non pungency	Greenleaf (1952)

Production and resistance breeding :

Many high yielding and improved varieties are developed. They include Andhra Jyothi, Bhagyalekshmy, Sindhur, X.235, Jwala, N.P. 46 A., Pusa Sadabahar, K-1, K-2, CO-1, CO-2, MDU-1, KAU Cluster, Jwala Sakhi, Jwala Mukhi, Sel 1, Muselwadi, J-218, Pant C-1, B.R. Red etc.

The bell pepper varieties include Arka Mohini, Arka Gaurav, Arka Basanth, California Wonder, Yolo wonder, Hungarian wax, Bharath F_1 hybrid etc.

Fruit Quality in chilli :

Chilli is considered a high value crop because of high capsaicin, Oleoresin and colour. Highly pungent, glossy, thin, destalked and deep red coloured varieties with clustered habit will have export value.

Quality parameters of a few selected chilli lines are given below :

Varieties	Vit. C (mg/100g)	Oleoresin (%)	Total extractable colour (ASTA units)	Capsaicin (%)	Crude fibre (%)
X 235	145.20	13.40	106.06	0.68	22.70
K.C.S. 1	145.20	10.00	112.12	0.49	24.85
TC-1	145.20	9.69	96.96	0.48	27.86
Sel 1	220.00	13.90	119.09	0.44	31.97
KAU cluster	220.00	10.00	136.36	0.52	31.01
J. 218	176.00	9.70	-	0.72	26.00
Muselwadi	176.00	9.70	106.06	0.56	25.10
CA 586	132.00	12.40	118.18	0.64	26.50

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Crop improvement in Cowpea

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Cowpea forms an important component in the tropical cropping systems of India. It is a multiseason and multipurpose crop, cultivated either as a monocrop or in mixed cropping situations with other crops, particularly cereals. Also it is grown as a backyard crop, near small farm houses, in a wide range of environments, often on poor soils with marginal moisture and with no fertilisation. Its importance is realised on account of its drought tolerance and adaptation to wide range of soil types. In substistance agriculture on small farms, nitrogen fixing ability of cowpea is of special advantage. It is grown throughout India for its long green pods as vegetable, seeds as pulse and foliage as fodder.

It is variously named as lobia, rawan, barbatti, chaula or chowlee, black eye pea, kaffir pea, china pea, southern pea, crowder pea etc.

Cytotaxonomy

Vigna is a pantropical genus of about 170 species, 120 in Africa (66 endemic), 22 in India and Southeast Asia (16 endemic), and a few in America and Australia (Faris, 1965). Its affinities with *Phaseolus* and *Dolichos* led to a confused taxonomy, clarified by Verdcourt (1970) who recognised five subspecies of *V. unguiculata.* Two sub species are wild : subsp. *dekindtiana* in the African Savanna zone and Ethiopia, subsp. *mensensis* in forests, with scabrous, dehiscent pods and seed dormancy not found in the cultivars.

The common cultivated cowpea everywhere is subsp. *unguiculata* (pods 10-30 cm long, pendent, seeds 5-12 mm long, very rarely shorter than 6 mm); the other cultivated subsp. *cylindrica* (pods 7.5 - 13 cm long, usually erect, seeds 5-6 mm long), and *sesquipedalis* (pods larger than 30 cm, flabby; seeds usually 8-12 mm long), are widespread in India, and the Far East but, though they have

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been introduced to Africa, are not found in traditional African farming systems.

The cytotaxonomy of Vigna is relatively simple, being uncomplicated by polyploidy ($2n = 2x = 22, 24$) and with apparently little genetic and no chromosomal divergence of the cultivars from their putative ancestor. The five sub species of *Vigna unguiculata* are interfertile but all attempts to hybridize cultivars with other *Vigna* species, notably *V. luteola*, *V. marina* and *V. nilotica*, proposed as wild progenitors have failed (Faris, 1965).

Germplasm resources

In order to preserve and utilise the genetic variability for improvement of food legume crops, the IBPGR has, during its first decade of work, given high priority to several legume crops. Since 1976, the IBPGR organised and/or supported collecting missions for various food legumes in many parts of the world. In this endeavour, the Board has collaborated closely with international centres or programmes especially of CIAT (*Phaseolus* beans), ICRISAT (Groundnut, Chickpea and Pigeon pea), ICARDA (Faba bean and lentils), IITA (Cowpea), AVRDC (mungbean and soybean) and INTOSY (soybean) and numerous national programmes in Africa, Asia, Australia, Europe and Latin America. The largest collections of cowpea (12000) are held at IITA. The NBPGR, India, holds sizeable collections of various Asiatic *Vigna* species and pulse crops. The assemblage and conservation of Vigna germplasm was also carried out by AVRDC.

Floral biology

Floral biology of cowpea is typical of a papilionaceous plant. The flowers are cleistogamous. Flowers open early in the morning, close before noon and fall off the same day. The extra floral nectaries at the base of corolla attract ants, flies and bees. But a heavy insect is necessary to depress the wings and expose the stamens and stigma. The pollen is sticky and heavy. Due to these reasons cross pollination is very low. Natural cross pollination to an extend of 1.0 - 4.26% was reported in cowpea and the pollinating agents were Bumble bees or wild honey bees.

Breeding objectives

1) Ideal plant type (2) High harvest index (3) Breeding for intensive cultivation (4) High stable productivity (5) Suitable plant morphology and habit (6) Breeding for pest and disease resistance (7) Quality improvement.

Crop improvement

Being a self pollinated crop, breeding methods normally followed for self pollinated crops are used in cowpea also. Selection, hybridization and mutation breeding are the methods usually adopted.

Selection

Pureline selection is the method of selection practiced. Selection, evaluation and yield trials are the three steps involved here. From a mixed lot, superior plants are selected and they are grown for evaluation for a few generations. In each generation undesirable ones are eliminated and desirable ones are carried forward to the next generation. The selected lines are grown for yield trials. They are compared between themselves and to a standard variety, at several locations (multilocational trial). If a promising strain is obtained from the selections, it is multiplied.

Hybridisation

This is done to combine different characters present in two plants together in a single plant. The parents selected for hybridization must be true breeding for getting uniform F_1 progeny. For resorting to hybridization, there are three steps viz. emasculation, protection and pollination. Emasculation is done on the previous day evening, of flower buds which are to open the next day. The buds are then covered with paper bags to prevent entrance of foreign pollen. Pollination is done between 5-7 am.

The hybrid seeds collected after crossing are grown to get the F_1 generation. From the F_1 seeds, F_2 generation is raised in which there is maximum segregation. Selection is necessary at this stage. There are two methods of selection - bulk population method of selection and pedigree method of selection.

In bulk population method, the seeds of all the F_2 plants are bulked together for the first 3-4 generations and after that selection is made. In pedigree method from the F_2 onwards selection is made and the seeds of each selected line is grown separately. Then preliminary yield trial and comparative yield trial are conducted. If any line is found superior to the standard check variety, the seed is multiplied.

Mutation breeding

Mutation breeding is adopted in self pollinated crops to create additional variability. In these crops, matural variability is less. Any new variation produced can be easily located. This method of breeding is suited for legumes. Male sterile lines of cowpea and protruded stigma types of cowpea were produced by mutation breeding.

Varieties

CO 4

CO4 was selected from the exotic V. unguiculata Russian Giant. It is suitable for rainfed as well as irrigated conditions and matures in 85 days. The plants are erect and seeds are greyish-brown when cooked. Average seed yield is 916 kg/ha and under irrigated conditions it averaged 1572 kg/ha. CO4 has field resistance to stemfly and tolerance of wilt, rootrot and mosaic diseases.

Pusa Phalguni

This variety was selected from the canadian variety 'Dolique Due tontin'. It is dayneutral, bushy and dwarf, pods are dark green, erect and 10-12 cm long. Pods are ready for harvest in 60 days and the yield is about 90 q/ha.

Pusa Barsati

This is a selection from a collection from Phillippines. It is an early variety for the rainy seasin. Pods are light green for pods/plant, where dominance variance was important. The environmental variance was of lower magnitude. Partial dominance was observed for all the characters, except days to flower and pods/plant for the cross No. 2-1 x Culture - 1 where complete dominance and over-dominance was observed, respectively.

Apte *et al* (1987) reported that when seed yield/plant, harvest index and 10 yield components were investigated in 50 *Vigna unguiculata* genotypes, high heritability was found for 100-seed weight, seeds/pod and days to maturity. Percentage genetic gain was the greatest for 100-seed weight, plant height, branches/plant and seeds/pod. 100 seed weight and seeds/pod were suggested as selection criteria.

Thurling and Ratinam (1987) used yield data from a diallel cross of 10 lines. The crosses involving high yielding parents were significantly higher yielding than crosses involving low yielding parents. They concluded that parental yields provide a sound basis for an initial screening of prospective parents.

Thiagarajan *et al* (1988) assessed genetic divergence among 7 parents and their 12 hybrids. The characters namely dyas to 50% flowering, 100 grain weight and plant height contributed maximum towards genetic divergence.

Thiyagarajan (1989) carried out genetic variability studies with seven parents and their F_1s and showed that there existed moderate variability for plant height, clusters/plant, pods/plant and yield/plant. Days to 50% flowering, days to maturity, plant height, pod length, seeds/pod and 100 grain weight recorded higher heritability estimates. Both the estimates of heritability and genetic advance were high for plant height, seeds/pod and 100 grain weight.

Kandaswamy *et al* (1989) reported that kharif was more advantageous for expression of a wider spectrum of variability. Selection for pods/plant, seeds/pod and 100 seed weight resulted in increased yield. The maximum range of variation was observed for pods/plant, clusters/plant and seed yield/plant.

and pendent. The pods are about 25 to 27 cm long and appear in two to three flushes.

Pusa Dofasli

Produced by crossing Pusa Phalguni with a cultivar from Philippines. Dwarf, bush type, suitable for spring, summer and rainy seasons. Pods thin, light green, 18 cm long, yield 7-7.5t/ha green pods.

Rituraj

A single plant selection from the cross Pusa Dofasli x EC 26410. The plant is bushy, pods light green, 25-30 cms. long, suitable for growing in both seasons.

Pusa Komal

It is a product of cowpea strains P-85-2 (high yield) and P 426 (resistant). Widely adaptable, photoinsensitive and resistant to bacterial blight, flowers in 40-45 days and produces green pods in 60-65 days. The bearing is almost synchronous and the pods can be harvested in three picking. A maximum yield of 172 q/ha was recorded at Delhi in a spring-sown crop.

Sel 61 B

It is an IIHR selection. Plants are bushy, vigorous can be grown throughout the year. Pods are green, thick stringless, fleshy Ready for harvest in 60-65 days. Yields 15 t/ha green pod.

Kanakamony

Evolved by Pureline selection at Pattambi. It is a dual purpose variety.

Variability and correlation studies

Hanchinal et al (1981) reported higher estimates of genotypic and phenotypic variation for days to maturity, pods/plant, 100 seed weight under different environments. According to Athwal and Singh

(1966) the season and soil factors are important in the study of quantitative variation and have the potential to influence the expression of variability. Schoo et al (1971) and Hanchinal et al (1981) reported high h^2 accompanied with relatively high genetic advance for pods/plant; pod length, seeds/pod, 100 seed weight and seed yield/plant.

The correlation and path coefficient studies in copea, by different workers also revealed that pods/plant, seeds/pod and 100 seed weight were important yield components in cowpea (Singh and Mehndiretta, 1970 and Dumbre et al (1982).

Jana et al (1982) reported that the characters like pods/plant, branches/plant, pod length and flowering should be considered by a plant breeder while selecting a plant type for getting maximum vegetable pod yield. Out of seven characters studied by them, 1000 grain weight had the highest heritability value on broad sense. Similar result was also reported by Bordia et al (1973), Bliss et al (1973) and Singh and Mehindiratta (1969). A path coefficient analysis also revealed that pods/plant exhibited the highest magnitude of direct effect towards yield (Jana et al (1983). They also reported that the genotypic correlation between vegetable pod yield and pods/plant was considerably high. Hence it is useful to select the genotype of cowpea on the basis of pods/plant for effective improvement in this crop.

Balakrishnan (1978), Pandita et al (1982) and Dharmalingam and Kadambavana Sundaram (1984) reported that pods/plant and seed yield had recorded high genetic variability in cowpea. The low value of genetic coefficient of variation for days to 50% flowering, days to maturity and pod length indicated their limited scope for improvement (Thiyagarajan, 1989). Similar results were reported by Radhakrishnan and Jebaraj (1982) in cowpea.

Angadis et al (1978) reported that among the 50 types of *V. unguiculata* with diverse geographical backgrounds, pod number, cluster number, seed yield and 100 seed weight had high heritability estimates coupled with high estimates of genetic advance.

Patil and Patil (1986) reported that the additive component was more important for all the characters in most of the crosses, except

The inclusion of subsp. dekinditiana may be utilised in breeding for resistance to different pathogens and insect pests (Steele, 1976). He further reported that the protein content of seeds can be increased (the range reported is 22-35%) and its nutritive value could be improved by increasing the proportion of sulphur containing amino acids.

Genetics of charcters

Genetic studies on cowpea, revealed that cowpea seed eye and seed coat colour are inherited independently (Calub, 1968). Smith (1956) and Calub (1968), from studies on eye colour, concluded that the seed coat eye patterns, such as watson, hostein, large eye and small eye, result from interaction between genes for Watson (ww) and ho'stein (hh), the genotypes for watson, hostein, and small eye being wwHH, WWhh and wwhh respectively. Saunders (1959) confirmed this work but suggested a third gene, the hilum ring gene (OC) which must be in a dominant condition for the expression of the eye patterns mentioned above. When this gene is in the homozygous recessive condition, a narrow eye pattern, called the hilum ring, is expressed. The hilum ring eye pattern varies from a type resembling the watson eye to a type where the eye can hardly be seen. Some modifier genes were reported by Franckowiak et al (1975). These include the Watson blotches modifier ($w^b w^b$) and the recessive modifier gene (dsds) which causes a dense spekling on the seed coat.

Saunders (1959), Ene (1973) and Franckowiak and Barker (1975) working on seed coat colour reported that the dominant allele R is the general colour factor that permits the eye pigmentation to be expressed over all or part of the seed, the flowers and other plant parts. Plants with the homozygous recessive 'rr' genotype have cream or white seeds with a hilum ring (a very narrow eye). Thus, the general colour factor R influences the eye pattern. All non-white colours involve one eye pattern expression which may extend over the whole seed (solid) or part of the seed as in Holstein and Watson, or may be confined to somewhere between a small eye or hilum ring pattern for which colour is often not reported (IITA, 1974). Saunders (1959) reported that all seed colours, except red, are determined by complementary gene action involving two or more genes which are unlinked. The expression of black

Table : Sources of disease resistance in cowpea

Diseases	Host resistance	Gene(s) involved	Reference
Cercospora leaf spot (*Cercospora cruenta*)	CR 17-1-34 and Ala. 963.8	Cls 1 dominant Cls 2 recessive	Frey *et al*, 1976
Anthracnose (*Colletotrichum lindemuthianum*)	-	Dominant gene(s)	Rogers *et al*, 1973.
Fusarium wilt *Fusarium oxysporum* f. *tracheiphilum*	Iron	-	Mackie, 1937
Phytophthora stem rot (*Phytophthora vignae*)	K_4-235 TVU 3861		Singh *et al*, 1982.
Powdery mildew *Erysiphe polygoni*	-	Single recessive	Fennell, J.L., 1948.
Target leaf spot (*Corynespora cassicola*)	VITA 3	a recessive gene	IITA, 1976.
Bacterial canker *Xanthomonas phaseoli* *X. vignicola*	Prima	Two gene pairs with epistasis	IITA, 1976.
		Single recessive gene.	Singh and Patel, 1977
		Single dominent gene.	Providentii, 1974.
Bean yellow mosaic BYMV	PI 297562	Single recessive gene	Reeder *et al*, 1972

(contd...)

Black eye cowpea mosaic (BCMV)	TVU 2480	bcm	Singh and Patel, 1977
Cowpea aphid-borne mosaic (CAMV)	TVu 410	One partially dominant gene	Patel, 1982.
Cowpea yellow mosaic (CYMV)	Ala bunch Dixielee	Three additive loci	Bliss and Robertson, 1971
Cowpea Chlorotic mottle (ccmv)	PI 255811	Single recessive (cc)	Rogers <u>et</u> <u>al</u>, 1973
		Single dominant gene (cm)	Khalf-Allah <u>et</u> <u>al</u>, 1973
Cowpea Severe mosaic (CSMV)	Macaibo FP 7733-2 (imm (immune	-	Rios, and Neves, 1982
Southern bean mosaic (SBM)	PI 186465	-	Hobbs <u>et</u> <u>al</u>, 1983

and mottling (possibly a seed coat pattern rather than colour) may be inhibited by other genes. The dominant B allele for black is epistatic over all other colours except purple which is determined by the genes P-R-. The following genotypes for the main solid colours of cowpea seed coat were suggested by Saunders (1959), purple, P-R; black, B-N-M-R-; B-N-mmR-, B-nnM-R- and B-nnmmR-; brown bbN-M-N-; buff or tan, bbN-mmR-; maroon, bbnnM-R-. White is determined by the recessive rr which masks the expression of the other colour genes.

Sreekantaradhya _et al_ (1977) reported pleiotropic nature of genes for pigment on six characters. Loka Prakash _et al_ (1983) detected differential expression of the gene for axil)Px) in the inheritance studies of six pigmented characters in cowpea. The ratio like 39 purple : 25 white for axil and flower; 117 purple : 139 green for calyx; 45 coloured : 19 non-coloured for pedicel, immature pod and seed (black : white) were reported for the first time by Lokaprakash _et al_ (1983). They designated the gene symbol for coloured pedicel as Pd.

Mode of inheritance of insect resistance in cowpea

Insects	Inheritance	Reference
Weevil (_Callosobruchus maculatus_	Resistance to cowpea weevils has additive, dominance and maternal components.	Fatunla and Badaru (1983)
Aphid (_Aphis craccivora_)	Resistance is a dominant trait and monogenically inherited	IITA (1984)
Bruchids and thrips	Resistance is a recessive trait and digenically inherited	IITA (1984)

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Genetics and breeding of winged bean

K.P. Prasanna*

Winged bean (Syn. Goa bean, Manila bean, Princess pea, Asparagus pea and Four angled bean) is a tropical legume vegetable cultivated for its protein rich pods and seeds, tender leaves, inflorescence and tubers, all of which are edible. It is also used as a forage crop (Ekpenyong and Borchers, 1978). It is called by different names in different languages as follows (Anon, 1969). Bengali - Chara-komi-sem or Lakar-sem, Marathi-Chavdhari ghevda, Tamil-Morisuavarai and Kannada - Shambe Kayi. Two other synonyms attributed to this crop are 'Soya's rival' and God-sent vegetable'. This is also known as a 'Supermarket on a stalk', because the plant combines the desirable characteristics of common bean, pea, spinach, mushroom, Soyabean and Potato. The crop is considered a saviour against protein malnutrition in the Third World countries.

Different opinions exist regarding origin of winged bean. It is considered a native of either India or Mauritius (Anon, 1969) Burkill, 1935 thought that it was originated in the African region, where all the other four or five species of *Psophocarpus* are found wild. According to Khan (1976) Papua New Guinea is a probable centre of origin since it has the largest variation for plant and pod characters. Matejka (1987) discussed Papua New Guinea, South East Asia or Upper Burma as possible centres of origin of winged bean. Erskine and Khan (1981) found wide variation within and between land races of winged bean in the high lends of Papua New Guinea. They concluded that strong local preferences and a low extent of cross pollination

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between adjacent land races could be the major factors for these variations. According to Harder et.al,(1990), eight of the nine species of *Psophocarpus* are native to Tropical Africa.

Winged bean is cultivated in Burma and South India. South India is considered as a secondary centre of origin by Gopalakrishnan et.al,(1981). The crop was introduced from Burma to Manipur, Tripura and Mizoram. (Haq and Smartt, 1973) opined that it was in cultivation for the past two centuries in Bengladesh. Now it is in cultivation in many of the Asian and African countries like India, Burma, Thailand, Vietnam, Malaysia, Indonesia, Ghana, Nigeria and Sri Lanka (Valicer et.al, 1987) In India, its cultivation is limited to states like Kerala, Tamil Nadu, Karnataka, Goa, Orissa, Maharashtra, West Bengal, Manipur, Tripura and Mizoram.

Germplasm resources

The following institutions are working on germplasm resources of winged bean.

i. Bengladesh Agricultural Research Institute, Joydebpur, Dacca.

ii. South East Asian Regional Gene Bank, University of Phillippines Los Banos College, Jaguna, Phillippines.

iii. Thai National Gene Bank, Thailand Institute of Scientific and Technological Research, Bangkok, 9, Thailand.

iv. University of Papua New Guinea, P.O. Box 4820, University P.O., Port Moresby, Papua New Guinea.

v. Kerala Agricultural University, Vellanikkara, Thrissur, Kerala, India.

vi. National Bureaux of Plant Genetic Resources, Pusa Complex, New Delhi.

vii. Faculty of Agriculture, University of Peradeniya, Sri Lanka.

Taxonomy

Psophocarpus tetragonolobus belongs to family Leguminosae. Psophocarpus is a small genus of climbing plants with tuberous roots. Stem is weak, twining, leaves three foliate with broad ovate leaflets, flowers light blue, pods 4 angled, 15-22 cm long, 2-3 cm broad, with each angle continued into a much crisped and toothed papery wing, seeds smooth and nearly globular (Parthasarathy 1986).

Related species of Psophocarpus

Psophocarpus Palustris (Syn: P. longepedunculatus)

This is a native of Tropical Africa and is similar to Psophocarpus tetragonolobus in many respects. It is cultivated in a few parts of the tropics for its edible pods and tuberous roots. It is of use as a ground cover for perennial crops and as a component of pastures (Anon, 1969).

Psophocarpus scandens

This is a vigorous perennial vine with mauve, blue, lilac or white flowers. The calyx and back of the standard petals are green and the keel and the wings have the colour of front of the standard. Leaves are usually trifoliate, but some with tetra and pentafoliate leaves were identified. Young shoots and pods of this species are eaten after boiling in water or milk. This is also used as a livestock feed, Harder *et al*, (1990).

Psophocarpus lancifolius

This is a perennial climbing herb with a distinct tuber. All parts of the plant including the bracteoles are covered with a yellow/brown pubescence (Harder *et al*, 1990).

Psophocarpus grandiflorus

Psophocarpus grandiflorus is a perennial vine attaining 5m. in length with an extensive root and shoot system. This species closely resembles the cultivated winged bean. The 4-9cm long pods are square in cross section and are prominently winged (Harder *et. al*, 1990).

Psophocarpus lecomtei

This is a prostrate plant with leaves adpressed to the ground. Slender non twining stems only occasionally branch. The entire plant including the small winged pods is covered with a white pubescence turning brown with age. This is reported to be used as a fish poison.(Harder *et.al*, 1990).

Floral Biology

Inflorescence is an axillary raceme upto 15 cm. long with 2-10 flowers; bracteoles ovate, persistent; calyx connate; corolla large, much exserted; standard broad, much reflexed, deeply emarginate, auricled at base, pale green at back, white or pale blue within, 2.5 to 4.0cm in diameter; wings are irregularly obovate; kneel incurved, obtuse; vexillary stamen free at base, connate with others from middle, anthers are uniform; ovary shortly stipulate; ovules many, style long, incurved and bearded lengthwise, stigma is terminal and globose with dense hairs around and below.(Pursglove, 1977).

Breeding objectives

Sastrapradja *et.al* (1980)studied the effect of different methods of pollination in winged bean namely natural open pollination, pollination by tripping and pollination by brushing. Of these, the maximum pod set was achieved under open pollination. In this case, the role of bumble bees is also effective. In another experiment, Erskine, (1980) observed that the rate of outcrossing was less than 1%, but in the wetseason, it reached 7.6% owing to the activity of bees (Xylocopa aruana). He also added that stem colour in winged bean is controlled by a single gene with purple dominant over the green.

Thompson and Haryono, (1980) observed wide genetic variability in the accessions of Psophocarpus tetragonolobus from Indonesia and Papua New Guinea. Muthukrishnan et al (1981) assessed the extent of variability in winged bean and observed that single podweight (g) expressed the highest phenotypic and genotypic variability followed by pod yield (g)/plant. Chundawat et al. (1981) observed wide range of phenotypic variation for most of the plant characters in a collection of winged bean introductions. They observed intermediate to semi spreading types with shorter internodal patterns among winged bean collections from different regions. Much variation was reported in leaf shape, which varies from deltoid, ovate to lanceolate and pod colour from pale green, green, dark green and purplish. Erskine and Khan, (1981) observed that the overall variability for days from sowing to the opening of first flower, mean pod length and weight of 100 seeds was partitioned between and within races. They evaluated the four loci controlling stem colour, pod specking, pod wing colour and pod shape and found that the average percentage of polymorphic loci was 80.4 over all the races.

Hildebrand et.al (1982) reported variation in storage root protein content in winged bean accessions ranging from 8.2 to 31.1%.

Philip, (1984) reported that phenotypic and genotypic coefficients of variation were maximum for weight of root tubers, followed by green pod yield and pods/plant. Crude protein was maximum in seeds (41.35%), followed by leaves (37.41%), Pods (31.28%), flowers (27.45%) and root tubers (25.89%). Prakash et.al, (1987) observed wide variation in total protein content of seeds, ranging from 38.1 to 45% in different accessions. Abe and Nakamura, (1987) noted variation in flowering time, flower colour, leaf shape, pod size, shape and colour of seed and tuber yield. In a set of winged bean varieties studied by Muthukrishnan et.al, (1981) it was observed that heritability, genetic advance and genetic advance as percentage of mean were high for pod weight, followed by pod length and pod yield/plant. It was also revealed that pod yield was positively correlated with number of fruits and single fruit weight. Chundawat et.al, (1981) also reported high genetic coefficient of variation and high expected genetic advance for pods/plant, weight/ pod and green pod yield/ plant. They also reported that pod yield was significantly and positively correlated with weight/pod, pod width and pods/plant. Path coefficient analysis conducted by them in winged bean, revealed that seed size has the highest direct effect followed by weight/pod, pod width and pods/plant.

Philip, (1984) estimated heritability and found it to be the highest for crude protein and crude fibre, but the genetic advance was low. The genetic advance was maximum for days to final harvest and pods/plant. Yield of pods/plant was highly and positively associated with days to final harvest, pods/plant and length and girth of pods. Seeds/pod exhibited significant negative correlation with pod yield. She found that the genetic advance through selection for pods/plant, days to final harvest and pod girth were superior by 2.95% over straight selection.

Erskine and Kesavan (1982) reported that the general combining ability effects were significant for all characters they studied except pods/plant and specific combining ability effects were significant for green pod yield, pod length and days to flower. General combining ability was strongly correlated with the parental means for pod weight, pod length and pod width. They opinioned that hybrid performance for pod length and weight could largely be predicted from the general combining ability. But pod yield in the hybrids could not be predicted from parental values. Silva and Omran, (1987) revealed that pod length and shelling percentage of winged bean are largely controlled by additive gene action. Heterosis was significant in only a few crosses. Shelling percentage was positively and significantly correlated with seed yield, an association thought potentially valuable for selection purposes. Veresh and Shivsankar, (1986) observed decrease in M_1 pollen and seed fertility with increase in dosage of rays when seeds were exposed to a range of 10 to 35 krad. In M_2, Chlorina followed by Xantha were the most frequent chlorophyll mutants, the highest frequency of such mutants occuring with 25 krad and the lowest with 30 krad. Viable mutants in M_2 included those with changes in stature and leaflet number and shape and early mutants. Veresh, (1987) observed in the M_2, from treatments with upto 35 krad, a non-liner relationship for chlorophyll mutation frequency. Chlorophyll mutations included albina, xantha, chlorina viridis and alboxantha types. Viable mutations included dwarf, bush and early maturing types. Savithramma (1987) reported 0.6% ethylmethane sulphonate as the optimum dose for inducing mutations in winged bean. Here, the M_2 mutants included dwarf, compressed internode and bushy, early and determinate types.

Iso-enzyme studies in winged bean revealed that 5 isoenzymes are useful in separating accessions, and a combination of these 5, identified 19 accessions, morphological and isoenzyme characteristics together seperated 24 accessions (Peiris, 1986).

Cultivars

Numerous cultivars are prevailing in winged bean in different countries where it is grown. Coming to India, IIHR, Bangalore has a few selections. IIHR Selections 21,60 and 71 are promising. Similarly WBC-2 from Meghalaya is also found good (Parthasarathy, 1986). A cultivar called WB 12-1 from Puerto Rico was resistant to bacterial wilt (Valdez and Almodovar, 1980).

Different characters, which are to be introduced to improve this crop, are photo insensitivity, earliness in home garden lines with extended harvest, plants having single leader with 40-50 nodes and suitable cultivars for tubers, seeds and green pods (Sathya narayanan et al, 1978).

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Genetics and breeding of Cucumber (*Cucumis sativus* L.)

Dr. M. Abdul Vahab*

Cucumber, a warm season vegetable is an important member of the cucurbitaceae. Treated once as a very seasonal crop, cucumber underwent many changes in the past years and now several crops are taken/year. This important change was brought about by changes in cultivar, maturity, adaptability, processing technology and consumer preference for the product.

Common names and synonyms

Cucumber has many synonym as given below.

Bengali - Sasha; Gujarati - kakdi, Hindi, Punjabi - khira; Kannada - soy, hekaiji; Kashmiri - Larr; Malayalam - Vellarikka; Oriya - kakadi; Tamil - kakkarikkai; Telugu - Dosakayi.

Origin and distribution

Cucumber is throught to have originated in India. (De Candolle 1982) and has been in cultivation here for 3000 years. *Cucumis hardwickii*, the probable progenitor of cucumber grows wild in the foot hills of Himalayas. Burma could be regarded as the secondary centre of origin. The plant was carried west ward to Asiaminor, Northern America, and Africa long before written history (Whitaker and Davis, 1962). At present, it is grown through out the world in tropical and subtropical regions.

Botany and floral biology

Cucumber is commonly a monoecious annual, trailing or climbing vine with stiff hairs throughout. Stem angle with small simple tendrils, leaves long petioled, lamina 4-9 cm long, deeply 3-5 lobed with rounded sinuses. Flowers small, yellow, 3-10 mm in diameter, staminate flowers in cluster, pistillate flowers solitary

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on long, slender, hirsute peduncles. Fruits oval to oblong variable in size, covered with long sharp glicening hairs on warty pimples, rind pale green, turning to ivory on ripening, flesh greenish, seeds many, small, white smooth, 3-5 mm long.

Choudhury and Pathak (1961) studied floral biology of cucumber under Delhi conditions. Anthesis takes place between 5.30-7.00 am. Anther dehiscence is between 4.30 - 5.00 am. Pollen fertility lasts for 14 hours after anthesis. Stigma becomes receptive 12 hrs. before to 7 hrs. after anthesis.

Taxonomy and cytogenetics

The genus *Cucumis* has over 40 spp. of which 8 are Indian (Chakravarthy, 1959) either in wild or in cultivated forms. All these species are generally monoecious. Cytological studies were carried out for seven species Viz. *C. callosus*, *C. hardwickii*, *C. melo*, *C. prophaterum*, *C. diapaceus* and 7 varieties viz. *C. s.* var *pickling* (Syn. *C. melo* var *pickling*) *C. melo* var *phut*, var *agrestis*, var *momordica*, var *muskmelon*, var *utilissimus* and var *ghurmi* (Trivedi and Roy, 1970; Singh and Roy, 1974). The studies revealed that the genus is dibasic with both 7 and 12 as the base chromosome numbers. The evolution of the genus with base number x = 7 and 12 is not clear. Bhaduri and Bose (1947) considered that the evolution of the base number 12 in the genus is from the base number 7 by fragmentation. This was supported by Ayyankar (1967) also. However, origin of base number 7 from 12 by fusion has also been suggested (Trivedi and Roy, 1970).

The three 14 chromosome spp. are *callosus*, *sativus*, and *hardwickii*. Karyomorphological studies revealed three pairs of chromosomes with secondary constriction in *sativus* and *hardwickii* indicating their closeness. The absence of such secondary constrictions suggested that *C. callosus* is the primitive taxon from which the other two derived. This indicates a trend towards asymmetry. However, studies based on chromatin length indicates the closeness of *C. hardwickii* and *callosus* (Trivedi and Roy, 1970; Singh and Roy, 1974). Studies of the taxon with 24 chromosomes showed that the cultivated varieties of *C. melo* have a tendency towards asymmetry (Singh and Roy, 1970).

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Genetic Resources of cucumber

The following institutes maintain cucumber germplasm as detailed below (Alcazar and Gulick, 1983).

SlNo.	Name of Institute	No. of accessions
1	Maritsa Institute for vegetable crops Bulgaria	71
2	Shandong, China	214
3	Dept. of genetic resources, Division of genetics and Plant Breeding method .Prague - Czechoslovakia	89
4	Zentralinstitute fur Genetik und kulfur pflanzenforschung, 4325 Gatersleben, Germany (GDR)	193 land races
5	Research centre for Agrobotany, National Institute for Agricultural variety Testing NIAVT, 2766 Tapioszele, Hungary	60
6	I.I.H.R., Bangalore, India	20
7	KAU Vellanikkara, Trichur	10
8	Vivekananda Parvathiya Krishi Anusandhan Shala, Almora, U.P.	10
9	NIAS Japan	121
10	Institute for Hort. plant Breeding (IVT) Wageningen, Netherlands	1930
11	National Hort. Res. Institute, (NIHORT) Idi, Ishin, Ibadan, Nigeria	9
12	PGRL, Pakistan	5
13	UNA, Lima, Peru	19
14	I.P.G., Laguna, Philippines	461
15	IHAR, Warsan, Poland	11
16	DPSC, Pretoria, South Africa	2
17	INIA, Madrid, Spain	11
18	ARARI, Izmir, Turkey	33
19	VIR, Leningrad, U.S.S.R.	2767
20	NSSL Colorado, USA	235
21	NCRPIS, Lowa, USA	662
22	NRPIS, New York, USA	260
23	IVRC, California	unknown number
24	Robinson's Geneva, N.Y.	110

Gene list of cucumber

Pierce (1989) gave an updated list of 105 genes for cucumber

Gene Symbol	Character	Gene Symbol	Character
a -	androecious	ap -	apetalous
Ar -	Anthracnose resistance	B -	Black or brown spines
B2 -	Blackspine - 2	B3 -	Blackspine - 3
B_4 -	Black spine - 4	bi -	bitter free
bl -	blind	bla -	blunt leaf
Bt -	Bitter fruit	bu -	bush
Bw -	Bacterial wilt resistance	C -	Cream fruit
Cca -	*Corynespora cassicola* resistance	Ccu -	*Cladosporium cucumerinum* resistance
cd -	chlorophyll deficient	cl -	closed flower
cla -	*Colletotrichum lagenarium* resistance	cm -	*Corynespora melonia* resistance
cmv -	Cucumber mosaic virus resistance	co -	green corolla
cor 1-	cordate leaves - 1	cor-2-	Cordate leaves - 2 (Syn: cor)
cp -	compact	cr -	crinkled leaf
cs -	carpel splitting	D (Syn: g)-	Dull fruit skin
de -	determinate	df -	delayed flowering
di -	*Diabrotica* resistance	dl -	delayed growth
dm (Syn: p)-	downy mildew resistance	dvl (Syn:dl)-	divided leaf
dw -	dwarf	Es-1 -	Empty chambers -
Es-2 -	Empty chambers - 2	F (Syn: Acr, acr F, D,St) -	Female
fa -	fasciated	Fba -	Flower bud abortion
Foc -	*Fusarium oxysporum* f.sp. *cucumerinum* resistance	g -	golden leaves
gb (Syn: n) -	Gooseberry fruit	gc -	golden cotyledon
gi -	ginko	gl -	glabrous
glb -	glabrate	gy -	gynoecious
H -	Heavy netting fruit	I -	Intensifier of P.
In-de (Syn Inlde) -	Intensifier of de	In F - (Syn. F) -	Intensifier of female sex expression

(Contd.....

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Ar -	Anthracnose resistance	B -	Black or brown spines
B2 -	Blackspine - 2	B3 -	Blackspine - 3
B_4 -	Black spine - 4	bi -	bitter free
bl -	blind	bla -	blunt leaf
Bt -	Bitter fruit	bu -	bush
Bw -	Bacterial wilt resistance	C -	Cream fruit
Cca -	Corynespora cassicola resistance	Ccu -	Cladosporium cucumerinum resistance
cd -	chlorophyll deficient	cl -	closed flower
cla -	Colletotrichum lagenarium resistance	cm -	Corynespora melonis resistance
cmv -	Cucumber mosaic virus resistance	co -	green corolla
cor 1-	cordate leaves - 1	cor-2-	Cordate leaves - 2 (Syn: cor)
cp -	compact	cr -	crinkled leaf
cs -	carpel splitting	D (Syn: g)-	Dull fruit skin
de -	determinate	df -	delayed flowering
di -	Diabrotica resistance	dl -	delayed growth
dm (Syn: p)-	downy mildew resistance	dvl (Syn:dl)-	divided leaf
dw -	dwarf	Es-1 -	Empty chambers -
Es-2 -	Empty chambers - 2	F (Syn: Acr, acr F, D,St) -	Female
fa -	fasciated	Fba -	Flower bud abortion
Foc -	Fusarium oxysporum f.sp. cucumerinum resistance	g -	golden leaves
gb (Syn: n) -	Gooseberry fruit	gc -	golden cotyledon
gi -	ginko	gl -	glabrous
glb -	glabrate	gy -	gynoecious
H -	Heavy netting fruit	I -	Intensifier of P.
In-de (Syn Inlde) -	Intensifier of de	In F - (Syn. F) -	Intensifier of female sex expression

(Contd.....

Genetic Resources of cucumber

The following institutes maintain cucumber germplasm as detailed below (Alcazar and Gulick, 1983).

SlNo.	Name of Institute	No. of accessions
1	Maritsa Institute for vegetable crops Bulgaria	71
2	Shandong, China	214
3	Dept. of genetic resources, Division of genetics and Plant Breeding method .Prague - Czechoslovakia	89
4	Zentralinstitute fur Genetik und kulfur pflanzenforschung, 4325 Gatersleben, Germany (GDR)	193 land races
5	Research centre for Agrobotany, National Institute for Agricultural variety Testing NIAVT, 2766 Tapioszele, Hungary	60
6	I.I.H.R., Bangalore, India	20
7	KAU Vellanikkara, Trichur	10
8	Vivekananda Parvathiya Krishi Anusandhan Shala, Almora, U.P.	10
9	NIAS Japan	121
10	Institute for Hort. plant Breeding (IVT) Wageningen, Netherlands	1930
11	National Hort. Res. Institute, (NIHORT) Idi, Ishin, Ibadan, Nigeria	9
12	PGRL, Pakistan	5
13	UNA, Lima, Peru	19
14	I.P.G., Laguna, Philippines	461
15	IHAR, Warsan, Poland	11
16	DPSC, Pretoria, South Africa	2
17	INIA, Madrid, Spain	11
18	ARARI, Izmir, Turkey	33
19	VIR, Leningrad, U.S.S.R.	2767
20	NSSL Colorado, USA	235
21	NCRPIS, Lowa, USA	662
22	NRPIS, New York, USA	260
23	IVRC, California	unknown number
24	Robinson's Geneva, N.Y.	110

Gene symbol	Character	Gene symbol	Character
l	- locule number	lh	- long hypocotyl
ll	- little leaf	ls	- light sensitive
m (Syn:a,g)	- andromonoecious	M-2 (Syn.b)	andromonoecious - 2
mp (Syn: pf⁺,pfd, pfp)	- multipistillate	mp-2	- multipistillate
ms-1	-male sterile -1	ms-2-	male sterile - 2
n	- negative geotropic peduncle response	ns	- numerous spines
O(y)	- Orange yellow corolla	opp	- opposite leaf arrangeme
P	- prominent tubercles	Pc(p)	- parthenocarpy
pl	- Pale lethal	pm-1	- powdery mildew resistance - 1
pm -2-	powdery mildew resistance - 2	pm-3	- powdery mildew resistance - 3
pm-h (s,pm)	- powdery mildew resistance expressed by hy hypotyl	pr	- protruding ovary
psl (Pl)	- *Pseudomonas lachrymans* resistance	R	- Red fruit
rc	- revolute cotyledon	ro	- rosette
s(f,a)-	spine size and frequency	s-2	- spine - 2
s-3	- spine -3	sc	- salt tolerance
sc(cm)-	stunted cotyledons	s'c(cm)-	stunted cotyledons
Sd	- SO_2 resistance	sp	- short petiole
ss	- small spines	T	- Tall plant
Ld	- tendrillers	te	- tender skin of fruit
Tr	- Trimonoecious	Tu	- Tuberculate fruit
u(M)	- Uniform immature fruit color	ul	- umbrella leaf
v	- virescent	vv-1	- Variegated virescent
w	- white immature fruit colour	wf	- white flesh
Wmv	- Watermelon mosaic virus resistance	Wmv-1-1-	Watermelon mosaic virus resistance-1
Yc-1	- Yellow cotyledon - 1	yc-2-	Yellow cotyledon-2
yf(v)	- yellow flesh	yg(gr)-	Yellow green immature fruit colour
Yp	- yellow plant	zymv	- Zucchini yellow mosaic virus

Breeding objectives and methods

The methods and objectives of breeding vary considerably with the region, purpose etc. In the survey on breeding objectives made in USA (Wehner, 1988), the primary objectives were yield, disease resistance, fruit quality and earliness/sex expression. Other traits were fruits/plant, fruit seed cell size, days to flower, branching habit, day length response, heat tolerance, drought resistance, cold vigour, cold shock resistance, salt tolerance, cold germination, air pollution resistance, parthenocarpic fruit, brine stock quality, nutritional value, fruit shape, resistance to diseases like gummy stem blight, rhizactonia fruit rot, anthracnose, pythium colony leak, downy mildew, CMV, WMV_2, angular leaf spot, target leaf spot, powdery mildew, scab, fusarium wilt, bacterial wilt, verticillium wilt and pests like prickle worm, spider mite, and root knot nematode.

Important breeding methods are pedigree (cross, select, self), back cross (cross, select, backcross), Inbred back cross (cross, Bc, self, select), single seed descent (cross, self, select), recurrent selection (Rs), half sib, full sib, S_1 line, S_2 line, Mass selection (single plant, Rs), pureline family cross (cross, bulk, self, select) and reciprocal recurrent selection.

Objectives for release of germplasm types are inbred lines, hybrids, inbred or line cultivars (from selfing), open pollinated cultivars (from mass selection), multiline cultivar (mixture of isolines) and synthetic cultivars. (73 inbreds intercrossed).

Breeding achievements

1. Considerable progress was made in evolving high yielding varieties/hybrids. They include Japanese Long Green, Straight Eight, Pusa Sanyog, Poinsette etc.

2. Resistant lines

Disease/disorder	Resistant varieties
a) Non parasitic	
1. Low temperature injury	Azerbarjan
2. Gummosis	Supert OE 48
3. Drought	Hanok 264

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yp	- yellow plant	zymv	- Zucchini yellow mosaic virus

Disease/disorder	Resistant varieties
b) 3. Fungal	
1. Downy mildew	Palmetto, Ashley
2. Powdery mildew	Polaris, Ambra
3. Sceb	Wisconsin SR 12, Bleanto
4. Anthracnose	Hybrid signal 235, Hybrid 517
5. Leaf spot	Hivergreen, Biveryel
c) Bacterial	
1. Wilt	PI 200816, PI 196477
2. Angular leaf spot	Poinsette, Gemini, Dixie
d) Viral	
2. Mosaic	Kyoto 3 Feet, Table Green Market More
e) Nematodal	
1. Meloidogyne incognita	West Indian Gherkhin

Prospects

The prospects in cucumber improvement are: bushy habit, lowernode to female flower, higher sex ratio, more flesh thickness, desirable fruit shape, size and flesh colour, bitterless fruits, uniform fruits, less seediness, better transportability and once over harvest.

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c) Bacterial	
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Genetics and breeding of Muskmelon (Cucumis melo L.)

Dr. Abdul Vahab*

The species Cucumis melo L. is a large taxon comprising of plants whose mature fruits are used as desserts, salads or cooked vegetables. In the case of muskmelon fresh flesh of fruit is eaten out of the rind after removal of seeds as dessert. The fruits of some cultivars are even preserved. Muskmelon is a warm season crop grown for the tropics to the temperate regions. The crop requires plenty of sunshine and heat and does well in the rot dry tropics. It does not do well in the humid tropics or in a damp atmosphere where the foliage diseases are serious and the fruits are of poor quality.

Common names and synonyms.

Assamese - Chiral; Bengali - Kharmuj; Telungu - Velapandu, Kasturi karabuja, Kharbuja, Velapandu; Tamil - Velapalom, kakkiri, kari; Malayalam - Thaikumbalom; Kannada - kakkarike; Marathi - kharbuj; Gujarati - Sakkartoli; Hindi - kharbooj; Punjabi - kharbuza; Sanskrit - kalinga; English - Sweet or muskmelon; French - cantaloup; German - Melonegurke ; Konken - Bachang ; American - cantaloupe or muskmelon

Origin and distribution

The place of origin of muskmelon is not known with certanity. Eastern region of tropical Africa is considered to be its centre of origin, since this area has great concentration of wild species showing phytogenetically older characteristics with good resistance to several pests and diseases (Leippik, 1966). Whitaker and Davis (1962) thought that Central Asia, comprising of Russia, Afghanistan, Pakistan and North West India as the secondary centre of origin. Russian botanists like Pangalo (1951) were of the opinion that, no African wild species coule be suspected as the ancestor of melons. Based on allozyme studies, Alcazar (1977) suggested India as the

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area of origin of cultivated melons. Dane et al (1980), from cytogenetical studies suggested South Africa as the primary gene centre of this genus. Now, it is distributed world wide.

Botany and floral biology

Muskmelon is trailing softy hairy annual. Vines are monoecious or andromonoecious. Root system large and superficial. Stem ridged or striate. Leaves orbicular or ovate to reniform, angled or shallowly 5-7 lobed, 8-15 cm in diameter, dendate base cordate, petioles 4-10 cm long, tendril simple. Flowers staminate and clustered, pistillate and solitary hermaphrodite 1.2-3 cm in diameter, yellow, on short stout pedicels, calyx 5 lobed, 6-8 mm long, corolla deeply 5 partite, petals round, 2 cm long, stamens three, free, connectives of anthers prolonged, pistil with 3-5 placentas and stigmas. Fruits very variable in size, shape and rind thickness, globular or oblong, smooth or furrowed, rind glabrous and smooth to rough and reticulate, pale to deep yellow, yellow-bfown or green, flesh yellow pink or green many seeded. Seeds whitish or buff, flat, smooth, 5-15 mm long.

Nandpuri and Brar (1966) studied the floral biology of muskmelon under Ludhiana conditions. Anthesis take place between 5.30-6.30 am and anther dehiscence is between 5.00 and 6.00 am. Pollen remains viable upto 14 hours. Stigma becomes receptive 2 hours before end 3 hours after anthesis.

Taxonomy and cytogenetics

Since the genus Cucumis is a large polymorphic taxon, the taxonomy is still in confusion. There are dessert, culinary and salad types in this taxon. Horticulturally, muskmelon and cantaloupe of USA differ slightly in physical characteristics and regional adaptation. The netted melon or muskmelon has a soft rind and netted markings on the surface. The flesh has stronger aroma, juicer flesh and larger seed cavity. Today cantaloupe refers to cultivars that are highly uniform in the overall netting (corky tissue on the rind) with relatively indistinct ribs or vein tracts. Internally the flesh is thick, salmon orange in colour with charaarea of origin of cultivatrd melons. Dane et al (1980), from cytogenetical studies suggested South Africa as the primary gene centre of this genus. Now, it is distributed world wide.

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C. melo var. agrestis - plants with slender vines small flowers and inedible fruits.

Var. cultura - Stout vines, large flowers and edible fruits

var. reticulatus - netted melons, most American cultivars and cantaloupes belong to this group.

var. cantaloupensis - cantaloupe melons, warty fruits, scaly, rough hard skin netting absent.

var. inodorus - wintermelons of USA, fruits with little musky order Eg: Honey Dew (green fleshed) Casata and Crenshaw.

var. flexuosus - snake on serpent or longmelon. Fruits upto 90 cm long (it is same as C. melo var. utili-utilissimus of India.

var. conomon - Pickling melon, fruit smooth, glabrous, without musky odour variously shaped.

var. chito - Mango lemon or lemon cucumber. Fruits small (orange sized). Also called vegetable orange or melon apple.

var. duadin - Fruits small like ehito, surface marbled with rich brown very fragrant, ornamental.

Anotner one, C. melo var.momordica is also recognised. This is also recognised. This is the phoot of India, whose fruitskin bursts or evacks on maturity.

Genetic Resources of muskmelon and other Cucumis spp.

Alcozar and Gulick (1983) listed the following institutes maintaining germplasm for muskmelon and other Cucumis spp.

SINo.	Name of Institute	No. of accessions	
		C. melo	C. spp.
1 .	IPIGR, Sadovo, Bulgaria	156	
2	CATIE, Tussialba, Côsta Rica	2	
3	RIPP, Prague, Czechoslovakia	2	
4	IRNA, Monfavet - Avignon, France	240	

cteristic flavour and the seed cavity is small and dry. The true cantaloupe is a European melon, not grown in America characterised by warty rind and dark yellow flesh. These are ideal for packing and long transport. The wintermelon of USA on the other hand require long growing season at relatively higher temperature under semi arid conditions and not suited to long storage and shipment after harvest. Most of central Asia varieties like those from Afghanistan and Uzbekistan of USSR are long duration types grown during dry period from April-May to October. These are generally oblong, round, netted or smooth skinned, green, orange or white fleshed. Eg: Sardamelon available in North India. In the Persian group persian large and small are recognised. There are also melons grown in glasshouses in Europe and Japan.

Deakin _et al_ (1975) grouped _Cucumis spp._ into five. _C. sativus_ and other 14 chromosome species in one, and cultivated melon in the second, _Anguria_ group is third consisting of _C. longipes_, _C. africanus_, _C. dipsaceus_, _C. leptodermis_, _C. myriocarpus_, _C. propheta-run_, _C. zyhesi_, _C. ficifolius_ and _C. leptadactylus_. The fourth group had _C. dinteri_, _C. sagittatus_ and _C. humifractus_. The fifth group had only _C. metuliferus_. The later cytological investigations by Dane _et al_ (1980) confirmed conspecificity between _C. dintesi_ and _C. sagittatus_ and between _C. myriocarpus_ and _C. leptodermis_. The annual cross compatible species are _C. africanus_, _C. anguria_, _C. dispaceus_, _C. leptodermis_ and _C. myriocaprus_. The perennial cross compatible species are _C. ficifolius_, _C. zeyhesi_, perennial tetra-ploids, _C. auleatus_, _C. heptadactylus_ and _C. zeyhesi_ and perennial hexaploid _C. figarei_.

There exists huge diversity of the polymorphic species _C. melo_. Russian botanists like Pangalo (1951) and Zhukosvsky (1962) have raised C. melo even to generic status of _Melo_ sp. retaining cucumber under _Cucumis_. The West Indian Gherkin _C. anguria_ found in semiwild state in West India is now considered conspecific with _C. longipes_. The wild form was retained as var. _longipes_ and the cultivated as var. anguina (Meeuse, 1958, Deakin _et al_ 1971).

Naudin (1859) divided the species into several botanical varieties adopting trinomial nomenelature as given below.

cteristic flavour and the seed cavity is small and dry. The true cantaloupe is a European melon, not grown in America characterised by warty rind and dark yellow flesh. These are ideal for packing and long transport. The wintermelon of USA on the other hand require long growing season at relatively higher temperature under semi arid conditions and not suited to long storage and shipment after harvest. Most of central Asia varieties like those from Afghanistan and Uzbekistan of USSR are long duration types grown during dry period from April-May to October. These are generally oblong, round, netted or smooth skinned, green, orange or white fleshed. Eg: Sardamelon available in North India. In the Persian group persian large and small are recognised. There are also melons grown in glasshouses in Europe and Japan.

Deakin et al (1975) grouped Cucumis spp. into five. C. sativus and other 14 chromosome species in one, and cultivated melon in the second, Anguria group is third consisting of C. longipes, C. africanus, C. dipsaceus, C. leptodermis, C. myriocarpus, C. prophetarun, C. zyhesi, C. ficifolius and C. leptadactylus. The fourth group had C. dinteri, C. sagittatus and C. humifractus. The fifth group had only C. metuliferus. The later cytological investigations by Dane et al (1980) confirmed conspecificity between C. dintesi and C. sagittatus and between C. myriocarpus and C. leptodermis. The annual cross compatible species are C. africanus, C. anguria, C. dispaceus, C. leptodermis and C. myriocaprus. The perennial cross compatible species are C. ficifolius, C. zeyhesi, perennial tetraploids, C. auleatus, C. heptadactylus and C. zeyhesi and perennial hexaploid C. figarei.

There exists huge diversity of the polymorphic species C. melo. Russian botanists like Pangalo (1951) and Zhukosvsky (1962) have raised C. melo even to generic status of Melo sp. retaining cucumber under Cucumis. The West Indian Gherkin C. anguria found in semiwild state in West India is now considered conspecific with C. longipes. The wild form was retained as var. longipes and the cultivated as var. anguina (Meeuse, 1958, Deakin et al 1971).

Naudin (1859) divided the species into several botanical varieties adopting trinomial nomenelature as given below.

C. melo var. *agrestis* - plants with slender vines small flowers and inedible fruits.

Var. *cultura* - Stout vines, large flowers and edible fruits

var. *reticulatus* - netted melons, most American cultivars and cantaloupes belong to this group.

var. *cantaloupensis* - cantaloupe melons, warty fruits, scaly, rough hard skin netting absent.

var. *inodorus* - wintermelons of USA, fruits with little musky order Eg: Honey Dew (green fleshed) Casata and Crenshaw.

var. *flexuosus* - snake on serpent or longmelon. Fruits upto 90 cm long (it is same as *C. melo* var. utili- *utilissimus* of India.

var. *conomon* - Pickling melon, fruit smooth, glabrous, without musky odour variously shaped.

var. *chito* - Mango lemon or lemon cucumber. Fruits small (orange sized). Also called vegetable orange or melon apple.

var. *duadin* - Fruits small like ehito, surface marbled with rich brown very fragrant, ornamental.

Another one, *C. melo* var.*momordica* is also recognised. This is also recognised. This is the phoot of India, whose fruitskin bursts or evacks on maturity.

Genetic Resdurces of muskmelon and other *Cucumis spp*.

Alcozar and Gulick (1983) listed the following institutes maintaining germplasm for muskmelon and other *Cucumis spp*.

SlNo.	Name of Institute	No. of accessions	
		C. melo	*C. spp.*
1	IPIGR, Sadovo, Bulgaria	156	
2	CATIE, Tussialba, Costa Rica	2	
3	RIPP, Prague, Czechoslovakia	2	
4	IRNA, Monfavet - Avignon, France	240	

Sl No.	Name of institute	No, of accessions C. melo	C. spp.
5	Ziguk, Gaterleben, GDR	133	Unknown No.
6	NIAVT, Tapioszele, Hungary	98	60
7	VCRI, Budapest Hungary	50	
8	IIHR, Bangalore, India	430	20
9	NBPGR, Phalgi		32
10	ARC, Abu Ghraib, Iraq		17
11	I.G., Bari, Italy		69
12	NIAS, Ibaraki, Japan	122	
13	PGI, Kyoto, Japan		11
14	IVT, Wageningen, Netherlands	325	136
15	BIHORT, Ibadan, Nigeria	11	17
16	ARC, Islamabad, Pakistan	5	5
17	UNA, Lima, Peru	22	
18	IPG, Laguna, Philippines	177	252
19	IHAR, Warsaw, Poland	unknown	
20	DPSC, Pretoria, South Africa	31	46
21	INIA, Madrid, Spain	568	76
22	ARHRI, Izmir, Turkey	92	21
23	VIR, Leningrad, USSR	3776	
24	NBL, Colorado, USA	1024	26
25	NCPIS, Lowa, USA		662
26	SRPIS, Georgia, USA	2099	
27	NRPIS, New York	353	24
28	UA Arizona		
29	IVCRC, Californea	unknown	unknown
30	Robinson's, Geneva, New York	15	111

Gene list of muskmelon

An updated list of 74 known genes were reported for muskmelon (CGC, 1986).

Gene symbol		Character	Gene symbol		Character
a (syn: M)	-	andromonoecious	ab	-	abrachiate
Af	-	*Aulacophora* resistance	Ag	-	*Aphis gossypii* tolerance

Gene symbol Character	Gene symbol Character
Al-1 (Al$_1$)-Absission layer-1	Al-2(Al2)- Abscission layer - 2
Ap-1^1 (Aps-1^1) - Acid phosphatase - 1	Ap-1^2(APS-1^2)- Acid phosphatase-2
Bi - Bitter	dc - 1- *Dacus cucurbitae* - 1 resistance
dc - 2- Dacus cucurbitae -2 resistance	Fn - *Flaccida necrosis*
	Fom-1 (Fom$_1$) - *Fusarium oxysporum* f. *melonis* resistance
Fom-2 (Fom$_{1-2}$) *Fusarium oxysporum* f. *melonis* resistance	Fom-3 " "
g - gynomonoecious	gf - greenflesh colour
gl - glabrous	gp - green petals
gyc - greenish yellow corolla	h - halo cotyledons
jf - juicy flesh	lmi - long mainstem internode
Mc - *Mycosphaerella citrullina* resistance	MC-2 (Mc^1) *Mycosphaerella citrullina* resistance
ms-1(ms^1) male sterile - 1	ms-2 (ms^2) male sterile - 2
ms-3 (MSL) male sterile - 3	ms-4 - male sterile - 4
n - nectarless	nsv - necrotic spotvirus resistance
O - Oval fruit	p - pentamerous
Pa - Pale green foliage	Pc - 1 - *Pseudomonas cubensis* resistance
Pc-2 - *Pseudomonas cubensis* resistance	Pgd - 2^1 (6-PGDH-2^1)-Phospho glucodehydrogenase 2^1
Pgd-2^2(6 PGDH-2^2)-phosphogluco-dehydrogenase 2^2	Pgi-1^1 (PGI-1^1)-phosphogluco isomerase 1^1
Pgi - 1^2(PGI-1^2) - phosphogluco-isomerase $_1{}^1$	Pgi - 1^2(PGI-1^2) - phosphogluco-isomerase $_1{}^1$
Pgi - 1^2 (PGI-1^2) - phosphogluco isomerase$_1{}^2$	Pgi - 2^1 (PGI-2^1) - phosphogluco isomerase $_2{}^1$
Pgi-2^2(PGI-2^2) - phosphogluco isomerase $_2{}^2$	Pgm - 2^1(PGM-2^1)-phosphogluco-mutase $_2{}^1$
Pgm-2^2 (PGM-2^2)- phosphogluco-mutase $_2{}^2$	Pm-1 (Pm^1)-Powdery mildew resistance
Pm-2 (pm^2) - powdery mildew . resistance - 2	Pm-3 (pm^3)- powdery mildew resistance - 3
Pm-4 (PM^4) - Powdery mildew resistance	Pm-5 (pm^5) - powdery mildew resistance - 5

Gene symbol Character	Gene symbol Character
Al-1 (Al_1)-Absission layer-1	Al-2(Al2)- Abscission layer - 2
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Bi - Bitter	dc - 1- *Dacus cucurbitae* - 1 resistance
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Pgi - 1^2(PGI-1^2) - phosphogluco-isomerase 1^1	Pgi - 1^2(PGI-1^2) - phosphogluco-isomerase 1^1
Pgi - 1^2 (PGI-1^2) - phosphogluco isomerase 1^2	Pgi - 2^1 (PGI-2^1) - phosphogluco isomerase 2^1
Pgi-2^2(PGI-2^2) - phosphogluco isomerase 2^2	Pgm - 2^1(PGM-2^1)-phosphoglucomutase 2^1
Pgm-2^2 (PGM-2^2)- phosphoglucomutase 2^2	Pm-1 (Pm^1)-Powdery mildew resistance
Pm-2 (pm^2) - powdery mildew resistance - 2	Pm-3 (pm^3)- powdery mildew resistance - 3
Pm-4 (PM^4) - Powdery mildew resistance	Pm-5 (pm^5) - powdery mildew resistance - 5

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Prv^{1} (Wmv) - Papaya ring spot virus resistance	Prv^{2} (Wmv)-papaya ring spot virus resistance
$Px\text{-}1^{1}$ ($PRX\text{-}1^{1}$)-peroxidase-1^{1}	$Px\text{-}1^{2}$ ($PR\text{-}1^{2}$)- peroxidase-1^{2}
$Px\text{-}2^{1}$ (px_{2A}) - peroxidase 2^{1}	$Px\text{-}2^{2}$ (px_{2B})-peroxidase - 2^{2}
r -, red stem	ri - ridge
s - sutures	si - 1)b) short internode - 1
si-2 -short internode - 2	So - Sour
sp - spherical fruit	st - striped pericarp
v - virscent	v - 2 virscent - 2
Vat - virus aphid transmission resistance	w - white fruit (mature)
wf - white flesh	Wi - white fruits (immature)
Wt - White testa	Y - Yellow epicarp
yg (y) - yellow green	Yr - yellow virescence
Zym - Zucchini Yellow mosaic virus resistance	

Breeding objectives and methods

The important objectives of muskmelon breeding are (1) development of cultivars with superior consumer qualities such as improved clesh colour, texture, T.S.S. and fruits which withstand transportation stress; (2) identification of varieties resistant to powdery mildew and downy mildew; (3) exploitation of heterosis for economic characters and (4) resistance to cucumber mosaic virus, squash mosaic virus, cucumber green mottle virus and aphids.

The important breeding methods are (1) mass selection (2) pedigree method (3) bulk population (4) back cross (5) heterosis and (6) mutation breeding (to maintain variability) Polyplidy, intergeneric and interspecific hybridisation are not of much use in muskmelon.

Breeding achievements

In muskmelon, the gene action of important characters have been studied and 74 genes have been listed. Studies in variability, combining ability and heterosis have been carried out. The salient breeding achievements are:

1. Improved cultivars like Arka Rajhans, Arkajeet, Pusa Sarbati, Pusa Madhuras, Hara Madhu, Punjab Sunehri, Durgapura Madhu, Pusa Hybrid etc.

2. Utilization of male sterility from American male sterile lines MS-1 and MS-2 using carls Facourite and Pear as pollen parent.

3. Resistant lines

Disease/pests	Resistant varieties
Powdery mildew	Campo, Jacumba, Georgia 47, Planter's Jumbo, PMR 45 and Seminole
Downy mildew	Seminole, PI 124112, Georgia 47, Ealisto, Home Garden, Gulf stream Planters Jumbo.
Fusarium oxysporum	Perlita
Squash Mosaic virus	PI 157080 (from China)
Cucumber Green Motcle virus	Phoot, kachri, 83-27-6R (Non dessert)
Muskmelon Mosaic virus	Oriental pickling melon (non dessert)
Aphids	Aristo, Invernizo, Escrito

Prospects

Prospects of muskmelon inprovement is mainly on development of varieties suitable for high density planting which is associated with thick flesh and small seed cavity, induction of variability theough mutation, interpscific and int·rgeneric hybrid isolation

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$Px\text{-}2^1$ (px_{2A})	- peroxidase 2^1	$Px\text{-}2^2$ (px_{2B})	-peroxidase - 2^2
r	-. red stem	ri	- ridge
s	- sutures	si - 1)b)	short internode - 1
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Genetics and breeding of pumpkin

Mini Raj*

Introduced to India from the South American Centre of Crop origin by foreign navigators and emissaries, pumpkin is grown throughout India. The archeological and botanical records lead inescapably to the conclusion that *Cucurbita moschata* is of new world origin. Secondary centres of diversity for Cucurbita exists in Europe and were originated following the introduction of it's culture to the old world. The premature land races were formerly abundant in both hemispheres.(Aguinagalde *et al* 1990).

Botany and cytogenetics

There is a lot of confusion in the common epithets like squash, pumpkin, marrow etc, and more than one common name is ascribed to any one botanical species. Horticulturally, however, squash cultivars are commonly divided into two classes, 'bush' and 'vining'. The bush squashes do not store well and are commonly called as Summer Squash under the species *cucurbita pepo*. The vining group includes winter squashes (*Cucurbita maxima*) and pumpkin (*Cucurbita moschata*),(Sheshadri, 1986). All the pumpkin cultivars are vining types.

The genus *Cucurbita* consists of about 13 species or species groups. However, there are only 5 domesticated species of *Cucurbita* and they are separated by sterility barriers as well as a convincing number of morphological features of the trichomes, leaves, calyces, corollas, stamens, pedicels and seeds. They are *Cucurbita maxima,*

*Assistant Professor, Kerala Agricultural University, Vellanikkara.

Cucurbita pepo, *Cucurbita moschata*, *Cucurbita ficifolia* and the current addition *Cucurbita argyrosperma* (recently shown to be the correct name for what has generally been called *Cucurbita mixta*, (Nee, 1990).

No obvious candidate for a wild ancestor of *C. moschata* is known at this time. None of the wild species now known match the vegetative or floral characters of *C. moschata* very closely. *C. moschata* is characterised by soft pubescence on the leaves and young plants, calyx lobes which are often expanded and foliose and a hard, smoothly angled pedicel which flares at the fruit attachment and then abruptly contracts. The seeds are variable but always have a prominant border differentiated in colour from the body, (Nee 1990). The most popular cultivar in *C. moschata* is the Butternut squash with fruits relatively small, cylindrical with pronounced bulb surrounding the seed cavity and bright orange flesh.

Isozyme studies

Flavanoids, proteins and isozymes are selected as phytochemical compounds to be studied in the genus *Cucurbita* and cultivars to compare their inter and intra specific variability. These compounds are currently considered as useful taxonomic markers to clarify phylogenetic relationships in Cucurbita species. (Aguinagalde *et al* 1990). Isozyme studies by Weeden, 1984 in which genetic analysis of 8 isoenzyme systems were carried out, revealed that at least 28 loci condition the isoenzymic phenotypes in *C. moschata*. The result of the analysis together with the high chromosome number in the genus (2n = 40) and the cytological evidence given by other authors are taken as evidence for the allotetraploid origin of *Cucurbita*.

Mutschler and Bush,(1987) identified two series of 2-4 plasmids in *Cucurbita moschata* cultivars with Crookneck and stable or unstable Butternut fruit morphology.

Genetic resources of *C. moschata*

Cultivated *Cucurbits* originated in two centres in the New World Central Mexico is the centre of origin for *C. pepo*, *C. moschata*, *C. mixta* and possibly *C. ficifolia* and Southern Peru, Bolivia and Northern Argentine are the centres of origin for *C. maxima*.

According to the global report of genetic resources of Cucurbitaceae by IBPGR, (Alcazear and Gulick, 1983), the following institutes collect and maintain germplasm of *C. moschata*.

Sl. No.		Name of the Institute	No. of accessions in possession
1	INTA	(Institute Nacional de Tecnologia Agropecuaria) Argentina	20
2	IPGR	(Institute of Plant introduction and genetic resources) Sadovo, Bulgaria	7
3	ICA	(institute Colombiano Agropecuaria) Palmira, Colombia	14
4	CATIE	(Centro Agronomico Tropical de Investigacion Y Ensenanza), Costa Rica	330
5	NIAVT	(National Institute for Agricultural variety Testing) Hungary	2
6	NIAS	(National Institute of Agricultural science), Ibaraki, Japan	37
7	NBPGR	(National Board for plant Genetic Resources), Vellanikkara, India	39
8	INIA	(Instituto Nacional de Investigaciones Agricolas) Mexico	77

(contd.)

(cont..)

Sl. No.		Name of Institute	No. of accessions in possession
9	UNA	(Universidad Nacional Agraria) Peru	5
10	DPSC	(Division of plant and seed control) South Africa	8
11	ARARI	(Aegean Regional Agricultural Research Institute), Turkey	12
12	NSSL	(National Seed Storage Laboratory) USA	141
13	NCRPIS	(North Central Regional Plant Introduction Station) USA	8
14	SRPIS	(Southern Regional Plant Introduction Station) USA	268
15	NRPIS	(Northeast Regional Plant Introduction Station) USA	62
16	IVCRC	(Imperial Valley Conservation Research Centre) USA	59

Genetics of characters

Estimates of gene effects indicated the relative importance of additive, dominance and epistasis for fruit and cavity size indices (Doijode and Sulladmath, 1981) with the implication that recurrent selection may prove profitable to bring genetic improvement in this crop. (Doijode *et al*, 1982) studied the genetic components of variance of rind thickness in the parental, F_1, F_2, BC_1 and BC_2 generations of a 9 x 9 half diallel. Additive, dominance, additive x additive and dominance x dominance gene effects were important. (Doijode and Sulladmath, 1982) observed that, in general, additive x additive gene interaction was predominant for the inheritance of the trait, days to fruit maturity. Inheritance of B - carotene in pumpkin was studied in a diallel analysis ,(Doijode, 1983). Partial dominance was observed for this trait. Predominance of additive gene action was noted which was further confirmed by high narrow sense heritability. Graphic analysis of data on six yield related and quality traits from a 7 x 7 complete diallel cross revealed that complementary gene action conditioned days to fruit maturity, content of total soluble solids and fruit weight, while duplicate gene action conditioned fruit size index, cavity size index and flesh thickness,(Doijode and Sulladmath, 1984). Sirohi et al, 1986 observed overdominance for stem length, days to opening of the first male and female flower, fruits/plant and yield/plant and dominance for days to fruit harvest, fruit weight, fruit index and flesh thickness. Epistasis was pronounced for all the traits. Recessive alleles were predominant for days to first harvest and dominant alleles for all other traits. Mode of inheritance of seed characters in pumpkin revealed predominance of non-additive genetic effect for number of seeds, seed weight, 100 seed weight and seed size index,(Doijode et al 1987). Over dominance was observed for number of seeds, seed weight and 100 seed weight and complete dominance for seed size index. The heritability estimate was high for seed size index. (Mutschler and Pearson, 1987) opined that butternut shape of fruit was monogenic and dominant, in crosses between Crookneck and stable Butternut varieties. But in crosses between Crookneck and unstable Butternut lines, inheritance of fruit shape was not monogenic and in some cases were strongly affected by the maternal phenotype.

Variability and correlation studies

In a study of 18 diverse genotypes,(Gopalakrishnan, 1979) found that fruit yield/plant was positively correlated with main vine length, average fruit weight and weight of first mature fruit. Female flowers/plant and fruits/plant had no correlation with fruit yield/plant. Carotene content was observed rather independant of fruit yield/plant. He suggested that selection of plants considering yield *per se* was efficient than selection of component characters.

High estimates of heritability and genetic advance were observed for vine length and fruit set (%),(Rana, 1982). A highly significant positive association with yield/plant was found for female flowers/plant, fruit number, fruit weight and flesh thickness. Path coefficient analysis showed that the magnitude of direct effects of the characters studied on yield depended on environment. (Sirohi *et al* 1986)reported high heritability and low genetic advance for days to first harvest, fruit weight, fruit shape index and flesh thickness. Extent of variability and divergence among 50 selected genotypes were assessed by(Suresh Babu, 1989). He grouped them into five clusters based on Mahalanobis D^2 statistic. In genetic variability studies of 20 genotypes of pumpkin, (Borthakur and Shadeque, 1990) found that heritability estimates were higher for internodal length of main Creeper, total leaf area/plant, fruit weight, fruit size index and flesh thickness indicating that selection based on phenotypic performance would be effective for these characters.

Heterosis

(Doijode *et al* 1982)studied heterosis of 9 yield related traits in 21 F_1's derived from a 7 x 7 half diallel. Fruit weight, fruit size, cavity size and flesh thickness exhibited the highest positive heterosis. CM 12 in combination with Arka Chandan or IHR 8 gave significant positive heterosis over the better parent for fruit weight. Heterotic performance for TSS and B - carotene were studied by Doijode 1983. Maximum heterosis over the mid parental value for TSS content was 52.7% and maximum heterosis over the better parent was 43.1%. Content of B - carotene was generally intermediate between the parental values and there was no significant heterosis over the better parent nor over the mid parental value. (Doijode et al 1982) reported heterosis for seed number, seed weight/fruit, 100 seed weight and seed size index in a 7 x 7 diallel excluding reciprocals.

Nine agronomic characters were studied in a diallel cross of 10 lines, (Sirohi et al 1986). Specific combining ability (SCA) variance components exceeded general combining ability (GCA) variance components for all characters except vine length. The cross S 93 x CM 12 had the greatest SCA for yield/plant and the next greatest SCA for fruits/plant and fruit weight.

Interspecific hybridisation

Breeders have long been interested in interspecific crosses among major Cucurbita spp. (Whitaker and Davis 1962) concluded that Cucurbita moschata occupies a central position among the annual species and can be crossed with difficulty with C. pepo, C. maxima, and C. mixta. Embryo culture and/or amphidiploidy were suggested to overcome poorly developed embryos and F_1 sterility usually encountered in these crosses. They also indicated that the likelihood of success varied with cultivars of the 'Butternut' group of C. moschata with C. pepo 'Delicata'. Both natural field crossing and controlled pollinations were involved. Natural cross between C. pepo and C. moschata never occurred. Failure of 181 hand pollinations to produce seeds suggested that (there was parthenocarpic development of fruits) "Butternut" strains and 'Delicata' may be less promising as parents to achieve this interspecific cross than some cultivars previously used such as 'Large Cheese' and 'Connectcu Field' . (Sharashenidze and Ramishvili 1979) reported about the natural hybrids of C. pepo, C. maxima and C. moschata from Georgia, which exhibited both paternal and maternal characters. Pollination of C. moschata 'Karotinnaya' with a mixture of pollen from two varieties of C. maxima produced viable hybrids, Savchanko, 1979. Selection in the F_2-F_4 gave useful forms with high values for yield and contents of dry matter and carotene. (Paris et al 1980) attemped interspecific hybridisation among C. moschata and C. pepo. They could successfully transfer a gene (B) affecting fruit characteristics from C. pepo to C. moschata. (Kwack and Fujieda, 1985) obtained high female lines through inter specific hybridisation of Cucurbita. In crosses of PM 143 (from C. pepo x C. moschata) with C. maxima variety 'Kuri', the F_1 hybrids differed from both parents in sex expression; the first female flower was borne at a lower node than in either parents and they bore more female flowers upto the first 20 nodes than either parents. Seed abortion and techniques for obtaining hybrids in inter specific crosses of Cucurbita was studied by (Kwack and Fujieda, 1987). Endosperm growth in the hybrids was similar to that in the parental species, but embryo growth was retarded. There were varietal effects on the success of interspecific hybridisation. (Munger 1990) maintained interspecific population obtained through embryo culture from 'Yankee Hybrid', a yellow straight neck Summer Squash, (C. pepo) pollinated by 'Butternut' (C. moschata).

Resistance breeding

Providenti *et al* (1978) reported that *C. ecuadorensis* was immune or resistant to four viruses infecting cucurbits and it was compatible with *C. maxima* which would be a good source of resistance in breeding programme. They also found that *C. foetidissima* is a good source of resistance to three viruses infecting cucurbits and that *C. martinezzi* was resistant only to two viruses but could be used to transfer resistance to CMV to *C. moschata*. Three varieties of pumpkin namely CM-14, King of the Mammottis and Large Red were reported by (Jayasree 1984) to be resistant to yellow vein Mosaic.

Umamaheswaran (1985) screened nine varieties of *C. moschata* for resistance to pumpkin mosaic virus and reported that none of the varieties were suceptible to pumpkin mosaic virus.

Munger and Providenti (1987) studied inheritance of resistance to Zucchini Yellow Mosaic Virus in *C. moschata* and found that a single gene when homozygous in *C. moschata* confers a high level of resistance to Yellow Mosaic Virus. Balakrishnan (1988) also found that all the 9 varieties he tried were susceptible to pumpkin mosaic virus, but the degree of infection varied. Paris *et al* (1988) reported that resistance to Zucchini Yellow Mosaic Virus was controlled by a single dominant gene designated ZYM. Screening 71 genotypes for resistance/tolerance to pumpkin mosaic and yellow vein mosaic disease revealed that all genotypes except CM-214 were susceptible. (Suresh Babu, 1989). Artificial inoculation studies confirmed immunity of CM 214 (Nigeriah Local) to pumpkin mosaic virus and yellow vein mossic virus.

Improved varieties

Arka Chandan

A selection from Rajastan collection, medium sized flat fruits weighing 2-3kg with depressed polar ends, rind colour, light brown with creamy patches at maturity, fruits mature in 125 days, it is released from IIHR, Hessarghata.

CO-I

A local collection, early maturing in 135 days, each produces 10 to 12 fruits and yield ranges from 23 to 25t/ha, released by Tamil Nadu Agricultural University, Coimbatore.

CO-II

Fruits are small weighing 1.5 to 2/kg. It is highly suitable for dense planting and kitchen garden. Flesh is reddish with high sugar content, released by Tamil Nadu Agricultural University.

Pusa Viswas

This variety released by IARI, New Delhi is suitable for growing in spring/summer season in northern plains. It yields 40t/ha. Fruits are produced in 120 days, weigh 5 kg. and have a thick golden yellow flesh.

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Genetic improvement of bottlegourd (*Lagenaria siceraria* (Mol. standl)

Dr. Arumugam*

Origin and distribution

Lagenaria siceraria is found at the present time, throughout the tropics and subtropics of theWorld either as a cultivated plant or 'Camp follower'. Archaeological evidences proved that it originated from Africa and distributed to the new world.

Taxonomy

Vigorous, annual vine, having smooth, viscidi foliage, musky scented, with branched tendrils, corolla white, staminate and pistillate flowers solitary, fruit 15 cm to 130 cm in length, being disk-like, globular, club-shaped, or bottle-shaped, seeds 10-25 mm long, a few are broad, flat and corky, others narrow and two pronged.

Cytogenetics

Very little cytological or genetical work is reported in this species. There are eleven pairs of comparitively small chromosomes.

Inheritance

Pathak and Singh (1980) studied the inheritance of fruit shape, colour and taste in *L. siceraria*. They used inbred lines

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in their crosses and obtained segregations for fruit shape, colour and taste in the F_2 generation as shown below:

Fruit shape

Conical	x	tumari	Mono-hybrid	3 tumari : 1 conical
Round	x	Club	Mono-hybrid	1 round : 2 inter mediate : 1 club
Club	x	tumari	Dihybrid	9 bottle : 3 club:4 tumari

Fruit colour

Patchy	x	white	Monohybrid	3 patchy : 1 white

Fruit taste

bitter	1	sweet	Mono-hybrid	3 bitter : 1 sweet

There was no evidence of the existence of linkage between any of the above characters. Additional observations indicated that fruit maturity and seed-size inherited polygenically.

Breeding strategy

In the past, a little breeding work for the evolution of high yeilding and better quality varieties are done on this group of crops.

At the Indian Agricultural Research Institute, New Delhi, studies carried out in 1962 showed that crosses among six varieties (three long and three round) exhibited heterosis in 22 F_1 progenies selected in respect of earliness and total yield. The mean increase in yield of hybrids over the mean of all the parents was 100.6%. The hybrid between IC. 2416 (from Hosiarpur) and Summer Prolific Long (Standard variety) outyielded the better parent by 266.61%.

At the same Institute, 18 F_1 combinations were studied for their hybrid vigour. Heterosis for early and total yield was recorded. The best two hybrids, 41 x 6 and 11 x 41 outyielded, their respective better parents by 81-42% and 78.60% respectively, forty five per cent of hybrids showed increase in number of fruits also. Majority of the hybrids showed an increase in weight and length of fruits. In combining ability, the parent No. 11 was superior to all.

In punjab, a variety of bottlegourd, Early long was developed by selection.

At the Indian Agricultural Research Institute, New Delhi, a variety called Summer Prolific Round is listed among the improved varieties.

Genetic Improvement of Ribbed gourd (*Luffa acutangula*) and Spongegourd (*Luffa cylindrica*)

Dr. Arumugam*

Origin and distribution

The *Luffa acutangula* and *L. cylindrica* are cultivated in all of the tropical regions of the World. *Luffa* species are originated from tropical portions of Asia and *L. cylindrica* is indigenous to tropical Asia - probably India.

Taxonomy

Monoecious, annual vines, with branched tendrils and five to seven lobed, nearly glabrous leaves, flowers yellow, showy, with the corolla of five free petals, staminate flowers in racemes, the pistillate flowers solitary and short - or long - pedunculate, anthers free, pistil with three placentae and many ovules, sigmas three, bilobate, fruit oblong or cylindrical and rind becoming dry at maturity, the interior fibrous, seeds numerous - a tropical genus of about eight species of Asiatic origin.

Cytogenetics

The early cytological work with *Luffa sp.* has not been very enlightening, except in enabling us to record that all members of the genus have thirteen pairs of chromosomes.

Inheritance

Singh *et al* (1948) investigated the inheritance of sex forms

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in *Luffa acutangula*. In this species, there are four sex forms; monoecious, andromonoecious, gynoecious and perfect (hermaphrodite). All except the gynoecious type are true - breeding when self-pollinated.

Mudaliar (1940) reported of an interspecific cross between *Luffa acutangula* and *Luffa aegyptiaca* (wild), where the F_1 progenies were intermediate in character and gave two flushes in a season and stood hot weather well.

Pathak and Singh (1949) succeeded in making reciprocal crosses between these species. The morphological features of the F_1 plants are generally intermediate between those of the parents.

Saito (1953) successfully induced tetraploids of *Luffa cylindrica* and established triploid lines from inter-crossing diploid and tetraploid lines. Shinohara *et al* (1955) developed tetraploids resistant to Fusarium wilt. Tetraploids were induced in two cultivars of *L. cylindrica* and one of *L. acutangula*. Fusarium resistance in the tetraploids was random in nature.

Agathi (*Sesbania grandiflora* Pers)

Dr. I. Irulappan, Ph.D.*

Agathi is a tropical, quick growing and soft wooded tree which has ornamental, food and fodder values. Agathi is valued for its Vitamin A (25.56 iu/100g) rich leaves. The flowers are also eaten as vegetable. From one or two tees in the kitchen garden, a regular supply of leaves for greens all through the year can be obtained. The tree can be used as a standard for pepper and betelvins, as shade tree for coconut seedlings and as wind break for banana plantations.

Agathi is one of the few vegetables which provides iodine, (2 mg/100 g of the edible portion). The bark yields good fibre and a gum and the juice of the flowers is said to improve the sight, when squeezed into the eyes.

Table 1. Nutritive value (per 100 g edible portion)

Components	leaves	Flowers
Moisture (g)	73.1	87.40
Protein (g)	8.4	1.80
Fat (g)	1.4	0.60
Fibre (g)	2.2	1.00
Calcium (mg)	1130	-
Phosphorus (mg)	80	-
Iron (mg)	3.9	-

(Contd.)

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Table 1 contd.

Components	leaves	Flowers
Vitamin A (iu)	9000	-
Thiamine (mg)	0.21	0.13
Nicotinic acid (mg)	1.20	2.80
Ascorbic acid (vitc) (mg)	169.00	41.00
Riboflavin (mg)	0.90	-
Iodine (mg)	2.30	-

Leaves and flowers of agathi are much valued for their nutritional and medicinal properties.

It is a native of Malaysia and is grown in parts of Punjab, Delhi, Bihar, Orissa, Assam, Bengal, Tamil Nadu and Kerala. There are two forms of Agathi, one with red flowers and the other with white flowers. The white flowered Agathi is suitable for kitchen garden.

Agathi can grow up to a height of 12 m and nearly 30 cm in girth with straight stem and spreading branches.

The roots of the Sesbanias are copiously covered with large root tubercles which should make them a good green manure.

The cotyledons are large, epigeal, the first leaf is simple ovate or sub-ovate, three-lobed.

The leaves are odd even pinnate with very numerous narrow leaflets and narrow stipules. Leaves are 15-30 cm long with 10-20 pairs of leaflets and an odd one. Leaflets are linear-oblong about 2.5cm long.

Flowers are very large; 7.5-10 cm long, white or in one variety red, in lax 2-4 flowered racemes. Calyx teeth short, sub-equal, corolla exserted, petals long clawed, keel petals sub-rostrate; stamens 9+1 with uniform anthers. Ovary linear stipulate, many ovuled. Style filiform, incurved glabrous.

Pods are long measuring 30-45 cm. They are linearly septate, deliscent and many seeded.

Agathi is often cultivated in gardens but rarely lives more than 3 years. It grows best in black cotton soils and comes up quickly when the surface soil is loose and uneven. It is resistant to drought.

The seeds are first sown in the nursery and later transplanted at a distance of 90 cm giving a population of 12,345 plants per hectare.

In Tamil Nadu, two months after sowing/transplanting ammonium sulphate is applied to the seedlings. A tree yields 4.5 - 9.1kg of leaves per year. The plants come to flower by September-December and to fruiting during summer.

In the early stages of crop growth it suffers severe attack by seedling blight caused by Colletotrichum capsici. The disease can be effectively controlled by 1 per cent bordeaux mixture spray.

Chekurmanis (*Sauropus androgynous* Merr.)

Dr. I. Irulappan, Ph.D.

Chekurmanis (*Sauropus androgynous* Merr.) (Syn. *S. albicans* Blume, *S. gardnerianes* Wight., *S. sumatrans* Mig.) is a perennial leafy vegetable. It also called as multi vitamin green/multi mineral packed vegetable. It has an unique position in the list of leafy vegetables because of its high nutritive value and multivarious uses. Its leaves are very rich in protein, minerals and vitamins A, B and C. The crop is being grown in Southern India, Indonesia and Singapore. The leaves can be cooked like other greens.

Nutritional composition in 100 g of edible leaf

Contents	
Moisture (%)	73.6
Carbohydrate (g)	11.6
Protein (g)	7.4/6.8
Fat (g)	3.2
Vitamin A (IU)	9510/47,500
Vitamin B (IU)	51
Vitamin C (mg)	110/247
Riboflavin (mg)	0.32
Calcium (mg)	570
Phosphorus (mg)	200
Magnesium (mg)	61
Iron (mg)	28
Calorific value	54

Origin and distribution

The plant is originated in the Indo Burma Centre of crop

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origin. It is found in the Sikkin Himalayas, Khasi, Abor and Arka Hills at 1220 m elevation and in the Western Ghats of Kerala from Wynad Northwards at altitude of 300 to 1200 m. It is believed to have been introduced into Kerala from Malaya in the year 1953. In Malayalam it is known as 'Madhura Kheera". The plant grows wild in the evergreen forests of the Western Ghats and in the southern parts of Kerala. It was introduced in to Tamil Nadu through the Agricultural Research Stations of the state during 1955-56 where it become popular as "Thavasi Murungai".

Botany

Saurapnus androgynus Merr. belongs to the family Euphorbiauae. The genus sauropus consists several other species of which the following species are related to androgynus. These are (1) Sauropus assimilis Thw. (2) S. netroversus wight. (3) S. rigidus Thw. and (4) S. quadrangularis Muell.

The plant is an erect and glabrous perennial shrub. It grows upto 1.5 meter in height. The branches are tesete and and flaccid.

The leaves are alternate membraneous, entire, sesile ovate-oblong and 3.5 cm in length.

Flowers small, greenish red, monoecious, minute, axillary, pedicelled and clustered. Fruits sessile, white or pinkish, 0.2 cm in diameter with a fleshy epicarp.

Mode of Pollination

The crop in highly cross pollinated and entomophilous. Plants being monoecious and protogynous, cross pollination in the rule.

Soil and climate

The plant grows well in all types of soils. A warm humid climate with good rainfall is best suited for the luxuriant, succulent growth of leaves and twigs. It can tolerate shade to some extent. The crop has been observed to come up in mild humid locations with equable temperature like Coimbatore, Kallar, certain parts of Kanyakumari district and Kerala state.

It is propagated by stem cuttings which root easily and also through fresh seeds. Both hardwood and semihard-wood cuttings of 20-30 cm length after trimming the leaves are used as planting materials. They are planted in shallow furrows spaced 30 cm and at a distance of 10-15 cm in 2-3 rows. Rooted cuttings can be made in nursery beds also or in pots and then transplanted around the kitchen garden.

Cultivation

The land is ploughed and levelled well. Well rotton FYM is added @ 2 kg/sq.m. The cuttings are planted in shallow furrows atleast 15 days earlier to the onset of monsoon during April-May. Subsequently frequent irrigations are given until root initiation takes place.

After the onset of monsoon it does not require much irrigation. The cuttings come up very well and would be ready for harvest within 3 or 4 months of planting, when the plants are about 90 cm high. The apex is nipped off which enables the plants in putting forth new branches. The tender shoots and leaves can be harvested intermittently for several subsequent year as.

An application of urea as top dressing or foliar spray would be sufficient to overcome initial retardness of the cuttings. Further, application of organic manure or nitrogenous fertilizer after every picking gives more yield.

Eventhough it can withstand the hot dry weather for a long period, watering of plants in such condition is desirable for getting constant appearance and growth of new leaves.

Pests and diseases

Scale insects and aphids infest the plant and control of these pests is easily secured by spraying Parathion at 0.2%. The crop is otherwise free from pests and diseases.

Uses

Tender shoots and leaves are used for culinary purposes, and as salad. The leaves are also said to be used to give a light green colour to pastry and to fermented rice in the Dutch East Indies and in Java for preparation of soup. The plant is also useful for growing as a hedge around home gardens where because of its perennial nature, provides an evergreen lush to the garden. It has also been observed that it could be trained on pandals, arches and on trellises. In Java, it is often planted in live fences and in the midst of garden beds to provide light shade for the other vegetables planted in the beds.

Besides other uses, the leaves are used as cattle and poultry feed in certain parts of the country. In some other places, the plants are planted as a soil binder to prevent soil erosion.

Medicinal uses

Chekurmanis has several medicinal properties. The juice of leaves pounded with roots of pomegranate (*Punica granaum*) and leaves of jasmine (*Jassminum sambac*) is used against eye troubles. A decoction of its roots is often recommended for fever in rural areas. Pounded roots and leaves are used as poultice for Ulcers in the nose.

Crop Improvement

There are no distinct type or cultivar in this crop. As the crop is cross pollinated and clonal propagation is possible, breeding methods like single plant selection and mass selection can be successfully adopted. Exploitation and maintenance of heterosis is also a possibility. Information on cytogenetical studies of the crop is not available. Being a potent and highly nutritious vegetable it needs the attention of the scientists for its upgradation.

Curry leaf (*Murraya koenigii* (L) spreng) - Rutaceae

Dr. I. Irulappan, Ph.D.

Curry leaf is an important perennial tree vegetable and the leaves are widely used in Indian cookery for flavouring foodstuff. The leaves have a slightly cungent, bitter and feebly acidic taste and they retain their flavour and other qualities even after drying. Ground curry leaf with mature coconut kernel and spices forms an excellent preserve. Curry leaf is also used in many of the Indian ayurvedic and unani prescriptions. It has many medicinal values and industrial uses.

The leaves contain moisture (63.8%), protein (6.1%), fat (1.0%), carbohydrate (16%), fibre (6.4%), minerals (4.2%), Vitamin A (12600 iu/100 g), nicotinic acid (2.3 mg/100g) and vit. C(4 mg/100g). Besides these, 18 free amino acids are present in the leaves.

History, origin and distribution

Curry leaf is found to grow wild along the foot hills and plains of Himalayas from Kumaon to Sikkim. It is cultivated in Bengal, Assam, Deccan platean, Western Ghate, Tamil Nadu and Kerala.

Originated in the 'Tarai' tract of Uttar Pradesh, gorws upto an elevation of 1500 m and is widely distributed in India, Burma,

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Ceylon, China, Pakistan, Australia and the Pacific Islands.

Systematics and Botany

Murraya is a member of Rutaceae and is an unarmed, semideciduous, aromatic pubescent shrub. The genus *Murraya* has four species of which 3 may be found in cultivation.

Chromosome number

The curry leaf tree is a true diploid with 2n = =8, n = 9 (Raghavan 1957). Its high seeded nature, viability of seed and fertile progenies indicate the true diploid nature of the tree.

Related species

Two species *Murraya paniculata* (L) Jack (indigenous to Burma) and Murraya exotica L. (Syn. *Chalcas paniculata* Mant., *Caminum sinense* *Rumph,* *Marsana buxijolia* Sonnerat) (indigenous to India, Ceylon and China) are most closely related to *Murraya Koenigii*. The wood of *M. paniculata*, sometimes referred to as chinese box w wood or Andaman Salin wood, is popular in the trade. *Murraya exotica* is a popular hedge and is well adapted for topiary. It is also used sometimes as a rootstock for citrus.

Curry leaf tree

Murraya koenigii is a shrub or a small tree, 3-5 m high with slender but strong woody stem. The branches are covered with dark grey bark. The woody stem has a closely crowded, shady crown. The roots are woody and widely spread, occasionally send up suckers.

The leaves are alternate, exstipulate, imparipinnate, 15-20 cm long, usually glabrous, sometimes slightly pubescent when

Drumstick (*Moringa oleifora* Lem.) Syn. *Moringa pterigosperma*

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Drumstick (Moringa Oleifera Lem.) is a vitamin rich, mineral packed and nutritious tree vegetable. It is considered as a delicacy in the South Indian households and is the most popular for the distinct appealing flavour of its fruits. The fruits, leaves and flowers are used in culinary preparations. The roots are said to be used in Ceylon as a substitute for horse radish. The roots, the bark and its exudation and seeds are also utilised. An oil from the seeds (oil of Ben) is reported to be used as a lubricant in watch making and in the preparation of cosmetics. The seeds are also reported to be fried and eaten.

The composition of nutritive value of drumstick leaves and pods per 100g of edible portion is given in Tables 1 and 2.

Table 1. Nutritive value of leaves and pods (per 100 g of edible portion)

	Leaves	pods
Moisture (%)	75.0	86.9
Protein (g)	6.7	2.5
Fat (g)	1.7	0.1
Carbohydrates (g)	13.4	3.7
Mineral (g)	2.3	2.0
Fibre (g)	0.9	4.8
Calories	92	26

(contd.)

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Table 1 contd.

	Leaves	Pods
Calcium (mg)	440	30
Megnesium (mg)	24	24
Phosphorous (mg)	70	110
Potassium (mg)	259	259
Copper (mg)	1.1	3.1
Iron (mg)	7	5.3
Sulphur (mg)	137	137
Vitamin A (iu)	11300	184
Chlorine (mg)	423	423
Thiaxine (mg)	0.06	0.05
Riboflavin (mg)	0.05	0.07
Nicotinic acid (mg)	0.8	0.2
Vitamin C (mg)	220	120
Oxalic acid (mg)	101	101

Table 2. Protein fractions of leaves and fruits (G/16 GN)

	Leaves	Fruits
Arginine	6.0	3.6
Histidine	2.1	1.1
Lysine	4.3	1.5
Tryptophan	1.9	0.8
Phenylalanine	6.4	4.3
Methionine	2.0	1.4
Threonine	4.9	3.9
Leucine	9.3	6.5
Isoleucine	6.3	4.4
Valine	7.1	5.4

young and very strongly aromatic. Rachis is slender, tertee and pubescent, often with a light reddish tinge above. Leaflets number 9-25 or more short stalked and alternate., ovate to ovate lanceolate, gland dotted and strongly aromatic. The leaves have a slightly pungent, bitter and feebly acidulous taste. They retain their flavour and maintain it even when moderately dried.

The inflorescence is a terminal, pedunculate, many flowered, compact, corymbiform, cymose panicle. The peduncle and pedicels are pubescent.

The flowers are small, white, fragrant, about 1 cm long subcompanulate, ebractiate or with minute bracts. Calyx is deeply 5 cleft and pubescent. Petals number 5, free and spreading. Stamens are 10 and are attached around or outside the disc. Filaments are free, alternately short and long, linear, subulate and bear small and short anthers. Ovary is hypogynous and is seated on the disc, 2-celled with 1 or rarely 2 ovules in each cell. The style is elongate, cylindrical, thick and articulate. The stigma is capitate or grooved. It is self pollinated and variability is much limited.

Fruits occur in close clusters. They are succulent, ovoid or subglobose, apiculate and glandular. The berries are 1-2cm in diameter with a thin pericarp and mucilaginous pulp enclosing 1 or 2 seeds. Seeds are large with small embryo. Fruits turn green to red and ultimately black on ripening. Seeds are non-endospermic with membraneous and glabrous taste.

Climate and soil

Curry leaf is well grown in **warm climate.** A loamy soil with good organic matter is best suited for its cultivation.

Propagation and cultivation

Curry leaf is usually propagated by seeds and seed suckers. It can also be propagated by leafy cuttings of ripe wood. Air layering also can be tried for its propagation.

Planting is done during the monsoon. A spacing of 1.5-3m is given in the main field. A basal dose of farm yard manure at the rate of 5 kg per pit is given. It is possible to harvest leaves 15 months after planting with judicious pickings. Once the plant attains three years of age it can be put for commercial harvest and a fully grown up tree is likely to yield about 100 kg. of leaves per year.

Diseases and pests

The crop is vulnerable to only a few diseases and pests, such as saprot (*Fomes* pectinatius), collar rot of seedlings (*Rhizoctonia solani*) and a leaf spot (*Phyllosticdina murrayae*). The economic losses due to the above diseases are minimal.

The composition of seed kernel and cake left after extraction of oil is given in Table 3.

Table 3. Composition of Kernels and cake after extraction of oil

	Kernel (%)	Cake (%)
Moisture	4.0	-
Crude protein	38.4	58.93
Fatty oil	34.7	-
N-free extract	16.4	-
Fibre	3.5	-
Minerals	3.2	-
Lime (CaO)	-	0.40
Phosphoric acid (P_2O_5)	-	1.09
Potash (K_2O)	-	0.80

The oil from the seeds of _M. oleifera_ is known in the trade as Ben or Behn oil. The oil is edible and used for illumination. The oil is highly valued by watch makers as a lubricant. It has also use in cosmetic industry and also has some value as a constituent of non-yellowing, non-drying plasticising alkyde. The characteristics of seed oil are presented in Table 4.

Table 4 : Characteristic of seed oil

Specific gravity	0.8984
Acid value	3.5
Sapponification value	182.2
Iodine value	64.2
Reichert Miessel value	0.44

(Contd..)

Table 4. contd..

Acetyle value	11.5
Hehner value	91.6
Unsaponified matter (%)	3.05
Fatty acid compenents (%)	
Palmitic acid (%)	9.3
Stearic acid (%)	7.4
Behnic acid (%)	8.6
Oleic acid (%)	65.7

Origin, History and Distribution

The use of moringa leaves as greens has been highly esteemed in India since time immemorial, and its importance has been mentioned in "Rigveda".

Drumstick is indigenous to northwestern India. In its wild form, it is found in the sub-Himalayan region from the east of river Chenab to the Sarda and in the tarai tracts of Uttar Pradesh in India.

The tree is widely distributed in India, Egypt Phillippines, Ceylon, Thailand, Malaysia, Burma, Pakistan, Singapore, West Indies, Cuba, Jamaica and Nigeria.

Botany and Nomenclature

Systematics:

The plant is a medium-sized, tree belonging to the family Moringaceae which has a single genus *Moringa*. There are two common species viz., *M. oleifera* and *M. concanensis*, the former being the vegetable species. *M. oleifera* is distinguished by leaves usually tripinnate, leaflets 12-18 mm long, petioles yellow or white without red streaks, and the tree is medium sized. *M. concanensis* is characterised by bipinnate leaves, leaflets 15-30 mm long, petals with red streaks or reddish at base and a large tree.

Based on morphological characters of the plant and the fruit characters other than the length of fruit it was found that the several types could be broadly classified based on the branching habit of the tree and the pigmentation of the floral parts and the fruits. In regard to the branching habit, tye types could be broadly classified into two groups viz., i) types having profuse branching habit and in which the branches are straggly and drooping and (ii) types having only a few branches and in which branches are errect. Of the two, the former is preferred by growers on account of their larger yields.

Based on the pigmentation of the plant, floral part and the fruit, three broad groups could be distinguished.

I Group:

The tender twigs are dirty brown, leaf stalk and peduncle of panicles tinged purple; stamens and ovary completely purple; fruits in tender stages reddish, turning green with reddish streaks running from base to tip at full maturity.

II Group:

Twigs dirty brown, leaf stalk, nodes, peduncle, pedicel and their point of attachment deep purple; basal portions of sepals and petals tinged purple; stamens and ovary completely purple;

fruits at tender stages deep reddish turning to black purplish on full maturity.

III Group:

The plant parts are green except the basal portions of the leaf stalk which are sometimes tinged purple; sepals whitish; petals either white or light yellow; stamens and pistill light yellow; fruits at tender stages light green with or without purple tinge turning to darker green on maturity.

The types that are under cultivation generally fall into the first or the third group. The second group is not found under large scale cultivation persumably because of the comparatively lower yields and the poorer quality of fruits.

Apart from the above mentioned characters, the types are also found to differ in several other minor characters such as the size, thickness and texture of the leaflets, the aroma of the flowers, the smoothness or otherwise of the fruit surface and the thickness of inner flesh, its taste, flavour etc. In some places in Madurai district, a distinct/type of drumstick in which the fruits have small tubercular protruberances over their surface was also met with.

Varnacular Names

In Burmese it is called dandalottin; Sanskrit: Sobhonjana; Hindi: Shajmah, Shajna, Segra; Bengalese: Sajna; Oriya : Minigha, Sajina; Punjabese: Sanjna; Marathi: Sujna; Tamil: Murungai Malayalam: Moringa, Muriga and Assamese: Sajina.

Cytology

The tree is a true diploid with 2n = 28 (Patel and Narayana, 1937).

Structure

A small or medium sized tree; bark corky, soft, fissured, glabrous, tuberous root.

Leaves are spirally arranged, 25-48 cm long, crowded at the distal end of the branches, long-petioled, incompletely tripinnate in the rachises, with glands between the pinnate and the leaflets; leaflets stalked, ovate or obovate, base acute obtuse or rounded, often oblique, apex obtuse, rounded or emarginate, entirse, dull green on both sides, lighter coloured abaxial (Beneath), pinnately nerved, at first shortly grey, pubescent, soon glabrous, 0.9-1.8 x 0.5-12 cm.

Flowers are fragrant, bisexual, oblique, stalked, united into erect, axillary, many-flowered panicles, densely pubescent, jointed beneath into apex, 0.7-1.0 cm long. Calyx deeply 5 - partite, tube somewhat angular, cupular-cyathiform, oblique, green, densely shortly pubescent on both sides, sepals unequal in size 0.7-1.4 x 0.25-0.5 cm. Petals 5, unequal, yellowish, white with a greenish base with thin veins, the 2 hindmost and the two lateral ones reflexed, ovate or obovate, obtuse, with a canaliculate base, on the innerside hairy at the base otherwise glabrous. 1-1.7 x 0.5-0.6 cm; the foremost petal erect, obovate, obtuse, glabrous on the inside, on the outside with longitudinal rows of hairs; 1.4-1.6 x 0.6-0.8 cm.

Stamens 5, alternating with 5 stabulate staminodes, denselypilose at the base, the hindmost stamen the longest, 0.8-0.9cm the other ones much shorter.

Ovary stalked, densely clothed with rather long, oppressed hairs, terete, with 3 longitudinal furrow, 1-celled;placentae 3, bearing a double row of ovules, style thin, curved white shortly pubescent hollowed at the apex.

Capsules are pendulous, linear, acuminate, obtusely bigonous, ribbed, usually 20-45 cm long, sometimes upto 120 cm long, 3-valved, valves spongy and thick; impressions of the seeds, half globose.

Seeds are numerous, globular, about 1 cm diameter, 3 winged; wings produced at the base and the apex 2-2.5 cm long, 0.4-0.7cm wide, scarious, the cuter walls of the epidermis of testa thick. Below the epidermis is a parenchyma zone where the cell walls have numerous pits, thus presenting a reticulate appearenace. There follows a region of fibres, upto 150cm in length, containing orystals. The rest of the testa consists of parenchyma similar in structure to the outer zone, althogh they are longer in longitudinal section and have longer intercellular spaces.

The endosperm is a single layer with oil drops and tiny alenrone grains. Associated with the aleurone layer are 2 or 3 layers of flattened cells. The cotyledons parenchyma cells contain oil drops, alenrone grains and sometimes cluster crystals. The inner cells of the cotyledons are stellate.

Ecology

Climate and soil:

It is strictly a tropical plant and grows well in the plains. However, it is found growing in the subtropical climate also. It is predominantly a crop of dry and arid tract where it has been found to perform well and give profitable yields.

Drumstick is not very exacting in soil requirements. It grows well in almost all types of soils except stiff clays, but sandy loam soils containing a good amount of lime are the best suited for its cultivation. The crop is more or less confined to sandy soils as seen in the coastal areas.

Cultivation:

Propagation:

The tree can be propagated by seeds or through limb cuttings. The latter being usually preferred to ensure earlier production and better productivity. Limb cuttings of 1 to 1.35m length and 14 to 16 cm in circumference, obtained from selected trees are planted *in situ* during June-October.

The limb cuttings are planted in well prepared pits of 60 x 60 x 60 cm. at a spacing of 2.4 to 3.0 m in the square system. The cuttings root easily.

In some areas, old uneconomic trees are out down leaving a stump. From this, a number of shoots arise subsequently of which only one is allowed to grow. From this branch, cuttings of 2m length and 4-6 cm in diameter are taken and used for planting.

The crop is grown purely as dry crop. Hand watering is done at the initial stages, if necessary, till the plants are well established. Regular irrigation and manuring are rarely practised. In the homesteads of Kerala, ring trenches are taken around the tree and filled with green leaves, farmyard manure and ash during rainy season. Application of 7.5 kg. farmyard manure and 0.37 kg. ammonium sulphate per tree, during the month of December gave three fold increase in yield over the unmanured trees, in a research programme conducted at Coimbatore.

In places which are exposed to heavy winds, slender branches are liable to be damaged and break easily at the joints especially when fully loaded with fruits. In such situations, mounds are formed around the tree trunks upto a height of 30 to 45 cm from the groundlevel.

Harvesting and yield

In South India, the drumstick generally bears in two seasons, viz. July-September and March-April. Pods are also found sometimes on the tree almost throughout the year. The seasons of bearing and yield however, vary from place to place possibly due to local soil and climatic conditions.

The plants raised from cuttings bear in 6-8 months of planting. The yield is generally low in the first two years (about 80 to 90 pods per tree per year). The normal yield starts from third year onwards and a single tree can yield as high as 500 to 600 pods per year. The yield of pods progressively increases over the years. Under north Indian conditions, the tree sheds its leaves in December-January and new leaves appear in February-March. This is followed by flowering and fruiting which is harvestable during May-June.

Old trees will become ill shaped with straggly as well as high branches. To give a good shape to such trees, pollarding (Heading back the main branches) is practised. This ensures a desirable shape to the trees, confines its growth within limits, promotes new growth on which pods will be produced in plenty and facilities easy harvesting. This practice of pollarding has to be repeated as and when necessary. The longevity of the tree is said to be about 15-20 years.

Crop improvement

There are only a few named varieties of drumstick. 1) 'Jaffna' is a popular drumstick type in South India. This variety bears long pods (60-90 cm in length) and with a soft flesh of good taste. This type of moringa can yield 400 pods from the second year of planting which increases to 600 pods per tree per year from the third year of planting.

ii) 'Chavakacheri murungai': This is an ecotype of Jaffna moringa, which bears pods as long as 90-120 cm.

iii) 'Chemmurungai' : This is also another ecotype of Jaffna moringa. This type is said to flower and fruit through out the year and also yields heavy crops. The tip of the pod is red in colour. The tree is medium sized and bears long pods.

iv) 'Palmurungai' is preferred for its thicker pulp and better taste of the pods.

v) 'Punamurungai' is another variety grown in the home gardens of Tirunelveli-Kattabomman and Kanyakumari districts.

vi) 'Kodikalmurungai' is cultivated predominantly in the betel vine gardens of Tiruchirapalli district of Tamil Nadu. The pods are shorter (20-25cm in length) and thick fleshed. The pods and leaves are very tastier. The trees are short statured and the leaves are smaller. This is a distinct type propagated by seeds.

vii) '<u>Kattumurungai</u>' : This is a wild type producing small and inferior quality pods. The trees are larger and leaves are bigger. The pods are 30-60 cm in length and fleshy but used as cattle feed.

There are some other types of moringa also.

viii) Thavittu murungai

ix) Kodi murungai

x) Nalla Murungai

xi) Bitter murungai

It is reported that in West Indies there are certain types which rarely flower and bear pod and are principally cultivated for their foliage and others are cultivated for pods (Osche 1977).

Considerable genetic variability has been reported to be available in the tarai tract of Uttar Pradesh.

In the germplasm pool consisting of 122 accessions, which are maintained vegetatively at the College of Horticulture, Vellanikkara, a large variability has been reported. Nine of the accessions namely, MO1, MO2, MO5, MO 10, MO 12, MO 20, MO 32, MO 40 and MO 107 exhibited earliness. The number of fruits/tree/year ranged from 3 to 541 and MO 65, MO 70 and MO 52 were rated as the best for yielding more number of pods/tree/year. For commercial cultivation, the ideal pod length is 45 to 60 cm and 7 accession, viz. MO 70, MO 65, MO 95, MO 7, MO 25, MO 78 and MO 52 were selected with mean yield of more than 10 kg/tree/year with fruit length of 45-60 cm. Among the accessions, the highest yield was recorded in MO 70 (26.25 kg/tree) followed by MO 65

(25.73 kg/tree) and MO 107 (23.52 kg (tree).

Though moringa is grown over vast areas as a pure crop, little attention was given earlier to culture of manuring.

In recent years, moringa is grown as a commercial crop with improved package of practices and the productivity has increased considerably under such situations.

The ecolution of seed moringa types has brought out a revolution in moringa cultivation. Seed moringa is grown as a pure crop or intercrop or as shade crop.

The package of practices for the cultivation of seed moringa are as follows:-

Seed Moringa - Package of Practices

Season	-	July - December
spacing	-	2.5m x 2.5m
Seed rate	-	600 g/ha

Preparatory cultivation

Dig pits at the spacing of 2.5 meter either way to a size of 45 x 45 x 45 cm. Add 15 kg of compost or FYM/pit and mix it with top soil.

Sowing:

Sow one seed per pit at a depth of 2.5 to 3.0 cm. About 50 seedlings may be raised in polythene bags for gap filling.

After cultivation

Gap filling may be done within a month. When the seedlings are about 75 cm. in height the tip may be pinched to facilitate branching.

Manuring:

The following doses of fertilizers may be applied per plant 3 months after planting.

Urea : 100 g

Super phosphate: 100 g

Muriate of Potash : 50 g.

Again apply 100 g of urea per plant after six months when the plants are in bearing.

Irrigation

Irrigate before sowing and on the 3rd day after sowing. Keep sufficient moisture until germination. Irrigate at the interval of 10-15 days according to soil types. Irrigate sufficiently after every application of fertilizers. Enough moisture should be there during summer which will prevent flower shedding and increase the yield.

Plant protection:

Drench the soil around the plant with any cropper fungicide (2 g/litre) to prevent wilting of plants. Spray Duspan (3 ml/litre) against hairy caterpillars, To control Leaf eating caterpillar spray Endosulfan (2 ml/litre) or monocrotophos (1.5 ml/litre). Spray Dichlorovos (0.5 ml/litre) or Monocrotophos (1.5ml/litre) of Fenthion (0.5 ml/litre) against fruit flies. Avoid spraying one week before harvest.

Ratoon crop:

Cut back the trees to 90 cm from ground level after the harvest is over in about 14 months. In another 4 to 5 months the plants will come to harvest. Similarly ratoon crops can be taken for 3-4 years. Within a week after cutting back the fertilizer dose given above has to be applied along with 25 kg. of FYM or compost every year.

Intercrop:

Short duration vegetable crops like Tomato, Cowpea, Bhindi can be grown as an inter crop in Moringa field. Moringa can be grown as an intercrop in orchards and coconut plantations during the pre-bearing age.

Crop Improvement

There is a wide variability among seed moringa progenies. In a variability study conducted at Periyakulam consisting a population of 184, yield for inflorescence, fruit weight, and yield by number of fruits/plant exhibited wide variability.

In an another study carried out at Coimbatore, variation of larger magnitude was reported for number of fruits, weight of fruits, and number of branches. The variation was moderate for stem girth and height of emergence of first branch. A low variation was recorded for length and girth of pods.

Two varieties have been released in seed moringa so far.

1. K.M.1. Pods are short (32-37 cm in length and 5.5 to 6.0 cm in girth), pod weight is 65 to 82 g, number of pods per tree/year 226 to 328, pod yield is 14.690 to 26.900 kg/tree/year and seeds per pod 10 to 13.

2. P.K.M.1. This variety was released in 1988 from the Horticultural Research Station, Periyakulam. It is very popular in the Southern States. The salient characters of this variety are:

No. of flowers/inflorescence 52

No. of primary rachis/inflorescence 7

No. of secondary rachis/inflorescence 15

No. of pods set/inflorescence 2

Pod length (cm) - 61 to 78

Pod girth (cm) - 6.3 to 6.6

Pod weight (g) -140-170

No. of seeds/pod - 19 - 20

No. of pods/plant - 186 to 215

Pod yield/plant(kg) - 29.68 to 34.68

Plant Protection	Control
1. Seedling damage by painted bug	- Spray BHC 50% or carbaryl @ 2g/1 - Clean cultivation
2. Leaf eating caterpillar	- Spray endo sulfon 2 ml/1 or Methyl parathion 1.5 ml/1
3. Bud worm	- -do-
4. Fruit fly	- This is the most serious pest causing economic losses to the growers - Remove the affected fruits and destroy - Spray parathion or - Dichlorovos @ 1 ml/1 or Monocrotophos 1.5 ml/1
5. Hairy caterpiller	- Spray methyl parathion 1.5 ml/1
6. Aphids	- Spray Methyl Demeton or Dimethodate 1 ml/1
7. Fruit rot	- Spray Mancozeb 2 g/1 or Carbandazim 1 g/1
8. Wilt	- Drenching with copper-oxy chloride @ 2 g/1

Waterleaf

Ceylon spinach/Water spinach/Swamp cabbage

Talinum triangulare (Jacq.) Willd.

Dr. I. Irulappan, Ph.D.*

Water leaf is a soft mucilaginous leafy vegetable grown in the tropics. Being a shade loving species, it is suitable for cultivation under other crop canopy. The leaves and tender shoots are used as vegetables. The edible parts contain protein (1.9%), fat (0.7%), carbohydrates (4.3%) and minerals like calcium (120 mg) and phosphorus in traces. It also contains iron (8.9mg).

Origin and distribution

The origin of the crop is traced to Brazil. Later it was introduced from Brazil to Java in 1915. At present it is being cultivated as a minor leafy vegetable in India, Malaysia, Indonesia, Arabian countries, USA and West Indies.

Botany

It belongs to the family Portulacaceae, genus *Talinum* which has neary 50 other species of annual or perennial herbs, more or less succulent, sometimes woody at base. The related species in which leaves are eaten as vegetable are *T. arnotti*, *T. caffrum*, *T. patens*, *T. portulecefolium*, *T. crassifolium*, *T. cuneifolium* and *T. indicum*.

Chromosome number

The chromosome number is 2n-48 and 72. The higher chromosome number indicates polyploid nature of the crop.

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The plant:

The plant is a herbaceous perennial, erect or decumbent at base, 35 to 90 cm in height.

The stem in stout, succulent and fleshy. The leaves are light green, shining, triangular in shape and fleshy, obovate or narrower. Leaves are about 7.5 cm long.

Flowers are large, pink in racemes. Seeds are black, small, smooth and matures rapidly after flowering. Short day condition favour flowering and fruiting. The purple flower colour is partially dominant over white flower colour. The crop is highly self pollinated.

Soil and climate

The crop prefers well drained soil rich in organic matter. It grows upto an altitude of 1000 m. Most humid conditions favour optimum growth and development of the crop.

Propagation

Water leaf is propagated through seeds or cuttings. Seedlings raised in containers are transplanted to raised beds when 5.8cm tall. They are planted at a distance of 30 cm apart. As a basal dose, farmyard manure is applied at the rate of 5 kg. per 10 sq. meters. Foliar application of urea (1.5%) is also beneficial.

Harvesting:

The tender shoots are harvested 6 to 8 weeks after planting. During short day condition, flowering occurs and seeds develop very rapidly impairing the cooking quality of the vegetable.

Shoots of about 15 to 20 cm length are cut when leaves are fully developed. Terminal shoots are removed at first harvest to encourage lateral shoot development for subsequent harvests. When the branches form a dense mass, it is better to replace the old plants with new planting.

Pests and diseases

Pests and diseases are rearely serious in this crop which makes its cultivation easier.

Uses

Besides its use as a leafy vegetable and in soups and stews, it can find its use as a succulent in ornamental gardens.

Crop Improvement

No cultivars have been developed through organised breeding programmes. The high oxalate content of the leaves limits its consumption. Therefore, breeding programme may be directed towards evolving varieties or types with low exalate content.

Management of soil acidity and salinity for vegetable cultivation

Dr. A.I. Jose*

1. Soil acidity and its management

Soil becomes acidic mainly due to the loss of bases by excessive rainfall and soil acidity is common in all regions where the precipitation is high. Removal of nutrients by higher plants and microorganisms, production of carbondioxide and organic acids by the decomposition of organic matter, improper use of commercial fertilizers and the production of mineral acids such as sulphuric acid in acid sulphate soils are other factors which make soil acid.

Negative charges on clay minerals originate from the isomorphous substitution in the crystall lattice of a cation of lower valence for a cation of higher valence and also from the dissociation of hydrogen ions from hydroxyl groups which are structural components of the crystal lattice. In region of high rainfall where the bases are easily lost from the soil due to heavy leaching, the cation adsorptive sites (negative charges) of the clay minerals get saturated with hydrogen ions making the soil acid.

Under strongly acid conditions, avidity is mainly a function of aluminium ions released from the soil. Under these conditions, much aluminium becomes soluble and is present in the form of Al^{3+} ions or aluminium hydroxy cations. Presence of these ions or the clay surface is considered to be acid forming since these ions when released into soil solution have a tendency to hydrolyse giving rise to H^+ ions in solution, causing acidity.

$$Al^{3+} + H_2O \longrightarrow AlOH^{++} + H^+$$
$$AlOH^{++} + H_2O \longrightarrow Al(OH)_2^+ + H^+$$
$$Al(OH)_2^+ + H_2O \longrightarrow Al(OH)_3 + H^+$$

Soils behave like a buffered weak acid and that it will resist sharp changes in pH accordingly. This is because there exists an

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equilibrium between the ions in soil solution and that adsorbed at the colloidal surface. Consequently, a change in the concentration of H^+ ions in solution (active acidity) will be counteracted by changes in the concentration of adsorbed H^+ ions (potential acidity) either by the adsorption of ions on to the surface or by its release into the soil solution so as to maintain the equilibrium. Thus, the buffering capacity of the soil will be proportional to its cation exchange capacity. Evidently to neutralise the acidity of soil, both the active acidity and potential acidity are to be taken into account. A clayey acid soil will require much a larger quantity of lime as compared to a sandy soil of the same pH. This is because, the pH measures only the active acidity (H^+ ions in solution) of the soil while the clayey soil with its high CEC will possess high potential acidity due to adsorbed H^+ ions.

The lime requirement of soil refers to the amount of lime required to neutralise the soil to a desired pH value (usually 6.5). It can be found out by neutralising a known weight of soil with a known volume of standard KOH solution and calculating the lime required on per hectare basis (15 cm depth).

The liming materials commonly used are the oxides, hydroxides and carbonates of calcium or calcium and magnesium. The reaction of liming materials with the acid soils can be represented as

$$CaCO_3 + \text{heat} \longrightarrow CaO + CO_2$$

Calcite

$$CaMg(CO_3) + \text{heat} \longrightarrow CaO + MgO + 2CO_2$$

Dolomite

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

Burned or quicklime — Slaked lime

$$\underline{/soil/}{}^{H}_{H} + Ca(OH)_2 \quad \underline{/soil/}\ Ca + 2H_2O$$

(Magnesium oxide reacts similar to calcium oxide)

The quality of the liming material will be usually expressed in terms of calcium oxide equivalent or by calcium carbonate equivalent. The $CaCO_3$ equivalent is also known as the neutralising power of the material. The efficiency of the material also depends on the degree of finess; assuming 100% efficiency for a 60 mesh material.

Liming is done to provide a soil reaction that is favourable for the growth of plants and for the adsorption of mineral nutrients from the soil. Perhaps the greatest single direct benefit of liming acid laterite soils is the reduction in the solubility of Fe, Al and Mn where the concentration of these ions in soil solution approaches toxic levels. The liming materials also provide Ca and Mg which are often limiting nutrient elements in these soils. The indirect benefits include increased availability of phosphate and micronutrients, improved microbial activity and soil physical conditions. Thus liming of acid soil will relieve the Fe and Al toxicity, reduce P fixation and improve physical conditions of soil as indirect effects.

In liming the acid soils, it should be borne in mind that these soils are developed and continue to be under warm humid climate with high rain fall, congenial for the development of acid soil. Therefore, it will be impossible to maintain the soil reaction neutral or at near neutral point, permanently. On economic considerations, liming programmes should be oriented to the judicious application of lime to maintain a favourable range of soil pH at the sensitive period of crop growth. Though liming soil to a pH value of 6.5 is considered ideal, it is a controversial point whether liming the avid soils to a pH value above 5.5 will be economical in terms of crop yield.

The effects of liming with and without fertilizers on tomatoes, maize, snap beans (<u>Phaseolus vulgaris</u> and cabbage were evaluated by Smith <u>et al</u>. (1986) at 22 production centres. Calcite, calcite with 3% Mg and dolomitic lime types at rates of 4.5 - 15.7 t/ha were compared with unlimed controls. High lime rates increased yields in all crops and had no deleterious effects. Substantial changes in soil pH and Ca and Mg saturation took place within a year of application. The concentration of leaf Mn and to a lesser extend leaf Zn and B was decreased by liming. Calcite lime increased leaf Ca but depressed leaf Mg especially at 13.4 - 15.7 t/ha. Comparable dolomitic treatments enhanced leaf Mg substantially but did not increase leaf Ca. Within 2-3 months of lime application, leaf analysis showed that the calcite type usually supplied reasonable amounts of Ca, the dolomitic type consistently supplied substantial quantities of Mg and both the types reduced leaf Mn in all crops.

Increase in yield of vegetables due to application of lime has been reported by various workers (Manrique, 1985; Nuoham, 1986; Genenchova et al., 1987; Laughlin et al., 1987; Tapper et al., 1987; Cutcliffe, 1988; Parker et al., 1988.

2. Management of salinity and alkalinity

2.1 Saline soils

They contain a concentration of neutral soluble salts sufficient to seriously interfere with the growth of most plants. The electrical conductivity of a saturated extract (ECe) is greater than 4 dS/m. Less than 15% of the CEC of these soils is occupied by sodium ions and the pH usually is below 8.5. This is because the soluble salts present are mostly neutral and because of their domination, only a small amount of exchangeable sodium is present. Such soils are sometimes called white alkali soils because of surface encrustation, if present, is light in colour. The excess soluble salts, which are mostly chlorides and sulphates of sodium, calcium and magnesium can readily be leached out of these soils with no appreciable rise in pH. This is a very important practical consideration in the management of these soils. The acid saline soils (Pokkali and Kaipad soils of Ernakulam and Cannanore district in Kerala) are acidic as well as saline. They are saline because of the intrusion of sea water. The soluble salts, chlorides and sulphates vary with season and locality. Maximum salinity is observed during summer. These soils are cultivated using salt resistant varieties and adopting special agronomic practices. The kari soils of Kuttanad in Kerala are extremely acidic, waterlogged and saline in certain patches.

2.2. Saline sodic soil

They contain appreciable quantities of neutral soluble salts and enough adsorbed sodium ions to seriously affect most plants. More than 15% of the CEC of these soils is occupied by sodium and the pH may or may not be below 8.5. The pH is more likely to be below 8.5 because of the depressive influence of the neutral soluble salts as in the case of saline soils. The electrical conductivity of a saturated extract will be more than 4 dS/m. Unlike the saline soils, leaching will markedly rise the pH of saline sodic soils unless Ca or Mg salt concentrations are high in the soils or in the irrigation water. This is because, the exchangeable Na, once the neutral salts are removed, readily hydrolyze and thereby sharply increases the hydroxyl ion concentration of the soil solution. In practice, this is detrimental since the sodium ions disperse the mineral colloids, which then develop a tight, impervious soil structure. At the same time, sodium toxicity to plants is increased. It is there fore necessary to convert toxic sodium carbonate and bicarbonate to sodium sulphate by first treating the soil with heavy applications of gypsum or sulphur. Leaching will then render the soil more satisfactory for crops.

2.3 Sodic soils

They do not contain any great amount of neutral soluble salts, detrimental effects on plants being largely due to the toxicity of the sodium as well as the hydroxyl ions. The high pH is largely due to the hydrolysis of sodium carbonate.

$$2Na^{+} + CO_3^{--} + 2H_2O \longrightarrow 2Na^{+} + 2OH^{-} + H_2CO_3$$

The resulting hydroxyl ions give pH values of 10 and above. Also, the sodium complex undergoes hydrolysis.

$$\boxed{\text{Soil}}\,Na \quad + \quad H_2O \qquad \boxed{\text{Soil}}\,H \quad + Na^{+} + OH^{-}$$

The exchangeable sodium which occupies morethan 15% of the CEC of these soils, is free to hydrolyse because the concentration of neutral salts is rather low. The E.C. of saturated extract is less than 4 dS/m. Consequently the pH is above 8.5, often rising as high as 10.0. Owing to the deflecculating influence of the sodium, such soils usually are in an unsatisfactory physical condition. Because of extreme alkalinity resulting from the Na_2CO_3 present, the surface of the sodic soils is usually discoloured by the dispersed humus carried upward by the capillary water and hence the name black alkali soil. These soils are often located in small areas called slick spots sorrounded by soils that are relatively productive. As in the case of saline sodic soil, the soil should be treated with gypsum or sulphur before leaching.

Reclamation

Providing under-drainage and leaching or flushing work well with saline soils. But in the case of sodic soils the caustic alkali carbonates should be first converted to sulphates by treatment with gypsum or sulphur. The soil must be kept moist to hasten the reaction and the gypsum must be cultivated into the surface. The soil is then throughly leached with irrigation water to free it of some of its sodium sulphate. The gypsum reacts with both the Na_2CO_3 and the adsorbed sodium as follows.

$$Na_2CO_3 + CaSO_4 \longrightarrow CaCO_3 + \underset{\text{leachable}}{Na_2SO_4}$$

$$\text{Soil}\ \begin{matrix}Na\\Na\end{matrix} + CaSO_4 \longrightarrow \boxed{\text{Soil}}\,Ca + Na_2SO_4$$

Sulphur upon oxidation yields sulphuric acid which not only changes the sodium carbonate to the less harmful sulphate but also tends to reduce the intense alkalinity.

$$Na_2CO_3 + H_2SO_4 \longrightarrow CO_2 + H_2O + Na_2SO_4$$

$$\boxed{\text{Soil}}\begin{matrix}Na\\Na\end{matrix} + H_2SO_4 \longrightarrow \boxed{\text{Soil}}\begin{matrix}H\\H\end{matrix} + Na_2SO_4$$

When sulphur is used, the carbonate radical is entirely eliminated as CO_2 while gypsum retains it as $CaCO_3$.

Saline and saline-sodic soils with their relatively low pH (usually less than 8.5) detrimently influence plants largely because of their high soluble salt concentration, leading to the plasmolysis of the plant cells. Sodic soils, dominated by active sodium, exert a detrimental effect on plants by caustic influence of high alkalinity, toxicity of the bicarbonate and other anions and the adverse effects of sodium on plant metabolism and nutrition.

2.4 Tolerance of vegetable crops to saline-alkali conditions

Among the vegetable crops, garden beet, asparagus, spinach, cabbage and tomato are the high salt tolerant crops, whereas radish, celery and green beans are salt sensitive crops (U.S.D.A., 1954). Generally tuber crops are sensitive to salts. The values of relative tolerance of vegetable crops to salinity for 50% reduction in yield and 10% reduction in yield have been given by USDA (1954) and Branson (1960) respectively.

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Shade response of a few tropical vegetable crops

R. Vikraman Nair*

Cultivation of short duration, seasonal crops including vegetable crops in the interspaces of coconut is a common practice in the coconut belt of the country. A variety of crops are grown with varying levels of success.

The success of an intercrop depends mainly on the level of light infiltration through the coconut canopy and the ability of the intercrop to come up in the shaded situation. The former depends on spacing given to coconut and the age of palms. Estimates made at the Central Plantation Crops Research Institute, Kasaragod have shown that percentage light transmission through coconut canopy in a space-planted coconut plantation can range from as low as about 10 per cent in a ten-year old plantation to as much as about 70 per cent in a 70 year old plantation, there being a near proportionate increase with advancing age. During the period before the 10th year, the values fall sharply with advancing age they being very close to 100 to start with.

With such a large variation in light intensity in the interspaces of coconut, crop performance will vary depending on situations and there is, thus, necessity for choice of crops and crop varieties. The general recommendations are the following.

(i) From 10th to 20th year of planting of coconut when light infiltration is less than about 20 percent, it may not, perhaps, be possible to raise any crop in the interspaces of coconut economically.

(ii) From 20th year onwards, intercropping can be done with shade-loving and shade-tolerant crops upto the 50th year when light infiltration will be between about 20 and 50 per cent.

(iii) From 50th year onwards when light intensity will be more

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than about 50 per cent, shade-loving, shade tolerant and shade intolerant crops may be used as intercrops.

(iv) Shade sensitive species will be generally unsuitable for intercropping.

In order to assess the shade response of some of the common short duration tropical crops, trials were conducted by raising these experimentally at shade levels of about 0, 25, 50 and 75 per cent at the College of Horticulture, Vellanikkara during the period from 1980 to 1982. Some of these crops included colocasia, coleus, cowpea, brinjal, amaranthus, cluster beans, bhindi and sweet potato. The responses of these crops to shade were markedly different. In all these crops, yields were the highest in the open and they declined with increasing levels of shade. The rates of decrease were, however, different. In colocasia, the yields under shade expressed as percentages of that in the open were substantially higher than the percentages of illumination. These percentage values at 25, 50 and 75 per cent shade levels were 56, 50 and 42 percent, respectively. These two crops were, therefore, classed as shade-tolerant. In coleus and brinjal, percentages of yield were almost comparable to the percentages of illumination and these were classed as shade-intolerant. The percentage values were 78, 59 and 39 for coleus and 72, 45 and 23 for brinjal. In all the other three crops, the trend inyield was one of substantial decline with shading. This trend qualifies these crops to be classified as shade-sensitive. Data on the yield of these crops at various shade levels are given in Table 1. In all these trials, only one variety each of the crops was used.

In order to assess the extent of intervarietal variations in shade response of crops, trials were taken up since 1988 by including nearly all the available varieties of the crops. Colocasia was one of these crops tried. Results of this trial showed substantial differences in shade response between morphotypes some of them giving higher yields under 25 per cent shade than in the open. These varieties thus, qualify themselves to be grouped as shade-loving. Most of the morphotypes, however, were brought under the categories of shade tolerant and shade-intolerant crops. Data on the yield of 11 morphotypes of colocasia are given in Table 2.

To summarise, it is established that light infiltration through coconut canopy varies widely and hence, the quantity of light available to the intercrops. These intercrops also show large inter-species and inter-varietal differences in shade response, thus, making choices of crops and crop varieties meaningful.

Table 1. Shade response of vegetable crops in terms of yield and dry matter production

Percentages of shade	Colocasia	Coleus	Brinjal	Sweet potato	Bhindi	Amaranthus	Cluster beans	Cowpea
				YIELD				
0	100 (17.5)	100 (34.1)	100 (32.7)	100 (7.7)	100 (10.1)	100 (25.1)	100 (5.6)	100 (5.9)
25	56	78	72	21	38	44	32	40
50	90	59	45	2	11	22	11	20
75	42	29	23	0	6	10	4	14
				DRY MATTER YIELD				
0	Similar	Similar	100	100	Similar	Similar	100	100
25			113	49			82	75
50			93	44			51	36
75			65	13			22	30

Figures in brackets indicate yield in tonnes ha^{-1}

Table 2. Effect of shade on total tuber yield, cormerl yield and corm yield of colocasia morphotypes

Treatments	Cormel yield t ha $^{-1}$	Corm yield t ha $^{-1}$	Total tuber yield t ha $^{-1}$
Shade levels (%)			
T_1 (0)	23.5	5.0	28.5
T_2 (25)	22.6	6.6	29.1
T_3 (50)	19.4	6.6	25.3
T_4 (75)	15.5	6.7	22.1
SEM$\pm$	1.3	0.9	0.7
CD (0.05)	4.0	NS	2.1
Morphotypes			
M_1	24.0	2.8	26.8
M_2	32.6	6.3	38.8
M_7	14.7	3.2	17.9
M_8	16.3	3.4	17.9
M_9	17.4	2.7	20.5
M_{10}	22.6	8.4	31.0
M_{12}	14.6	6.0	20.3
M_{17}	21.1	4.4	25.8
M_{15}	16.4	12.7	29.1
M_{16}	18.4	13.2	31.6
Sree Rashmi	24.6	5.3	29.2
SEm$\pm$	3.7	1.5	4.5
CD (0.05)	7.4	3.1	9.0

Crop management of solanaceous vegetables - Tomato, brinjal and chillies

S.K. Tikoo*

India is the second largest producer of vegetables next to China. Estimated production is 45 million tonnes annually, which is less than half of our annual requirement presently. The family Solanaceae, which includes five economically important vegetable crops viz., Potato, Tomato, Brinjal, Chillies and Bell (green) peppers contributes substantially to the annual production in India. After potato, tomato is the most widely grown vegetable crop in the world. It is the second largest crop to be processed as it lends itself to several products like ketchup, juice, puree, paste etc. It is estimated that 20 million tonnes of processed tomatoes are produced in the world today, which is 40-45% of the total vegetable production, Portas et al (1991). Area, production, and productivity of these three crops is presented in Table 1.

Table : 1. Production statistics of tomato, chillies and brinjal

Crop	World			India		
	Area*	Prodn.	Yield	Area	Prodn.	Yield
Tomatoes	2669	63988	23.98	83**	790	9.58
Chillies#	1925	9610	8.51	904	877	0.9
Brinjal	431	5644	13.11	372 ASIA	4432	11.92
				(Not available for India)		

SOURCE : F A O Year Book 1988

* - Area = 1000 ha ; Prodn. = 1000 t ; Yield = t/ha

** - FAO Estimate. Actual Area may be above 100,000 ha

\# - FAO does not include India. Hence, Indian figures have been added to FAO data.

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Although India is the 2nd largest populous country in the world we produce tomatoes in just 3.15 percent of world's area and total production is even lesser at 1.23 percent of the world. Out average yields of 9 to 10 t/ha compare most unfavourably with the averages of above 60 t/ha in USA during the year 1990. Chillies, are grown over an area of 46.96 percent of the world's acreage, but - if the available statistics are right - our total production is just 9.12% of the world. This is due to the fact that our average yields are reported as 0.97 t/ha compared to 11.2 t/ha in China, 14.12 t/ha in Turkey, 35.336 t/ha in Yugoslavia, Raju & Luckose (1991).

In brinjal the situation is not clear as India's statistics are not available. However, in Karnataka alone 25000 hectares of brinjal are grown annually and average yields are reported to be 20 t/ha. This compares very favourably with the world's average yields of 13.11 (FAO Year book, 1988). Asia grows 85.7 percent of the world's brinjal.

The inevitable conclusion is that a huge gap in production exists mainly due to low productivity. In order to meet the required per capita consumption there is a need to (a) improve productivity in all these crops and (b) even increase area in tomato. The reasons for lower productivity can be traced to following:

1. Inadequate input management due to
   a. lack of resources to buy inputs
   b. poor transfer of available technology.
2. Non availability of inputs uniformly all over the country e.g., a. inadequate quantity of quality seeds
   b. fertilizers and pesticides
3. Lack of varieties suitable for the consumer, industry and the producer. Eg., in tomato the producer needs high yield, disease resistance and transportability; the consumer wants good appearance, taste, and shelf life; the industry needs uniform size, good colour, high solids and viscosity.

The need of the hour is to narrow down these gaps. An excellent co-ordination between science & technology, governmental agencies, private and public sector is required to allow for widespread increases in output.

Economic importance

The three crops under discussion are highly remunerative to the grower. Cost of cultivation of open pollinated and hybrids is presented in tables 2 and 2A. A cost benefit analysis on current market rates prevailing in Karnataka is presented in table 3. It clearly reflects the benefits to the grower, especially, the higher returns incase of hybrid varieties of tomato and brinjal. The estimates are conservative and hence an experienced and well informed grower can not only help realise potential yields, but also increase his own profits substantially. One important factor linked to these is the post harvest handling, packaging and price support that the grower gets. Discussing that would, of course, be outside the purview of this paper.

Table 2. Cost of cultivation of open pollinated tomato, brinjal, abd chillies

Inputs	Costs per acre (Rs.) Tomato	Brinjal	Chillies
Seed cost	40	25	120
Nursery raising	150	150	150
Ploughing (4 times) @ Rs. 90/acre	360	360	360
FYM @ 10 t/acre	500	500	500
Labour costs			
a. Land preparation Basal - 4 men	96	96	96
b. Fertilizer Application Basal - 4 men	64	64	64
c. Top dressing & Earthing up (8 men)	128	128	128
d. Irrigation - 1/2 man day/i irrigation 30 irrigations in 12 days = 15 men	240	120*	120*
e. Weeding (Twice) 8 men/weeding	254	254	254
f. Sprays (8 sprays x 1 man)	128	128	128
g. Fruit pickking and packing (8 to 12 times)	400	400	300

(contd...)

(Table contd..)

Fertilizers	540	500	300
Insecticides + Fungicides	600	500	250
Total cost	3500	3200	2770

* - Irrigation requirement is much less as more drought tolerant

Table : 2A. Cost of cultivation of hybrid varieties per acre of tomato and brinjal*

Inputs	Cost per Acre (Rs.) Tomato	Brinjal
Seed costs	900	300
Nursery raising	150	150
Ploughing @ Rs. 90/acre	360	360
F Y M @ 10 t/acre	500	500
Labour costs (in O P variety)	1310	1190
Additional labour for picking**	300	300
Additional labour costs (Staking, Pruning & Tying of Plants - 8 men x 2 days)	1280	-
Stakes***	3000	-
Fertilizers (as in O P)	540	500
Addtnl. fertilizer costs for Additional Top dressings	300	300
Insecticides + fungicides	600	500
Total costs	9,240	4,100

* - Hybrids not available in Chillies as yet.

** - For extra yield, extra labour required for picking and packaging

*** - Initial Investment Rs. 24000/8 seasons = Rs. 3000

Table 3. Cost benefit ratio for open pollinated and hybrid varieties to the grower for tomato, brinjal and chillies

	Tomato		Brinjal		Chillies
	OP	HYB	OP	HYB	OP
1. Cost of cultivation per acre (Rs.) A	3500	9240	3200	4100	2770
2. Average sale price/kg	1.00	2.00	1.0	1.5	1.5
3. Average marketable yield-t/ha	10	25	8	12	0.5** (Dry chillies)
4. Total income B	10000	50000	8000	18000	7500
5. Transportation costs C*	3000	7500	2400	3600	150
6. Net income (4-5)	7000	42500	5600	14400	7350
7. Net profit (6-1)	3500	33260	2400	10300	4580
8. Net cost benefit	1:1	1:3:6	1:0.75	1:2.5	1:1.65

A - @ the rate of labour costs in Karnataka

B - Wholesale rates - Tomato : OP @ Rs. 1/kg, HYB @ Rs. 2/kg Brinjal : OP @ Rs. 1/kg, HYB @ Rs. 1.5/kg & Chillies @ Rs. 15/kg.

* - @ Rs. 300/- per tonne for a distance of 50 km from farm to market

** - Yields can be upto 1.2 t/acre in improved varieties under irrigated conditions

Production management

In order to bridge the yield gap and increase cost benefit ratios to the grower, available production techniques have to be meticulously followed. Hence, following parameters of crop production need to be efficiently managed.

a. Soil and climate
b. Raising seedlings
c. Land preparation
d. Transplanting and spacing
e. Fertilizers and manures
f. Irrigation

g. Soil mulching
h. Training/staking
i. Use of growth regulators if any
j. Physiological disorders
k. Harvesting

a. Soil and climate

Ideal temperature regimes, soil types and pH required for these crops are presented in table 4.

Table : 4. Ideal climatic requirements of tomatoes, chillies, brinjal and green pepper

Crop	Ideal Mean Min	Ideal Mean Max	Soil types	Ideal pH
Tomato	16 c	30 c	Well drained, deep loamy soil with good moisture holding capacity are ideal	6.0 to 6.5
Brinjal	22 c	30 c	Clay Loam or Silt Loam	5.5 to 6.0
Chillies	18 c	32 c	Light loamy soil rich in lime for rainfed - well drained black soils	6.5 to 7.0

Source : Atherton and Rudich, 1986, Bose and Som, 1986

High temperature accelerates both crop growth rate and the ripening process (Geisenberg ' Stewart, 1986). Temperature is the main factor that determines how fast a plant grows. Growth occurs only when temperature is above a minimum level called the <u>developmental threshold</u>. As the temperature increase beyond this threshold. As the temperature increases beyond this threshold, growth rate increases first, then plateau's off, and finally declines if temperatures approach an upper limit (Anon, 1985), e.g., the developmental threshold in tomatoes is about 10 C; the upper limit for growth is 43 C to 44 C. This basic relationship governs the development of most organisms except warm blooded vertebrates. Due to warmer night temperatures in rainy season tomatoes in Karnataka reach harvestable maturity one week earlier than in the rabi season. Such information and the per se varietal maturity characteristics can be very useful to plan planting schedules so that the harvesting and movement of the produce could be regulated as is done in most of the developed countries.

The seasons for South, North and Hilly areas are identified in table 5. The first season mentioned in each region is the optimum season for ideal production of the crop. Off season cultivation brings in related problems of crop management. Eg., high temperatures of above 35 C during summer reduce fruit set in all three crops because of ovary dessication and inability of pollen to germinate at that temperature. Summers also mean high incidence of viruses transmitted by vectors eg., leaf curl virus in tomato and chillies. The rainy season brings the fungal problems viz., Leaf Spots and Fruit Rot in tomato, chillies and brinjal because of the congenial conditions for their growth. During the rabi season, fruit borer remains one of the main problems in tomato, as the weather favours borer activity. In order to manage these problems, crop protection schedules have to be suitably altered. These schedules will depend on local situations. Comprehensive knowledge has been acquired over the years on the role of environmental factors on the germination, growth, flowering, fruit development, fruit ripening and quality of tomato. For a review on these, suggested readings are Picken et al (1986), Atherton & Harris (1986), Ho & Hewitt (1986), Grierson & Kader (1986), Giesenberg and Stewart (1986) have indicated optimum temperature required for various stages of crop growth in tomato. However, such detailed information on chillies and brinjal is lacking.

b. Raising seedlings

There are two methods for raising healthy seedlings

(a) Bare root transplants and
(b) Block transplants.

The former are obtained by sowing directly in rows in raised nursery beds. The latter are raised in seedling flats having honeycomb like cubicles of appropriate size. These honeycombs are filled with an excellent, light weight, presterilized rooting media like peat moss - perlite - vermiculite mix. Seeds are sown in each of these and uniform seedlings produced. Rabi season transplants, irrespective of seedlings produced. Rabi season transplants, irrespective of being bare root - the only practice following in India - or blocks, are ready for transplanting in about 30 days. In the rainy season it takes only 25 days because of relatively higher temperatures. Following is a check list for raising tomato seedlings per acre:

*Prepare 10 raised beds (8" to 1" high) of 2.5' width & 15' length for each acre of planted crop

*Mix 5 baskets (10 kg each) of well decomposed compost (FYM) red soil and sand in a ratio of 1:1:1 per bed, to form flat levelled tops.

*Spread & mix 10g of Furadon granules and 1/2 kg Suphala fertilizer mix per bed uniformly

*Drench the beds thoroughly with Captaf (2g/a) solution one week before sowing & cover with a plastic sheet. Remove the sheet one day before sowing.

*Sow the seeds in shallow furrows 3" apart. Close the furrows with FYM-SOIL mix and cover with dry grass

*Water the beds every morning with a rose water can. During summer additional watering and shade for the first 15-20 days needed.

*Immediately on germination (6/7 days after sowing) drench the beds with Captaf solution again

*Spray the seedlings with a mixture of Nuvacron 1.5 ml/1 + Dithane M45 2g/1 on 15th and 25th day after sowing.

*Harden the seedlings by reducing watering during the 4th week after sowing. Plant by 30th day after sowing. During warmer season seedlings will be ready by 25th day.

The process of hardening is especially important to obtain woody seedlings with an excellent root:shoot ratio. Hardening means exposing the plants to water stress which promotes root growth and development of woody tissue - a natural stress response. Such seedlings establish well in the field allowing good plant stands, because the transplanting shock is reduced. Block transplants do not face such a shock and hence establish a uniform plant stand much faster. By using the block transplant method, it is possible to raise an ere of tomato nursery with just 30 to 40 g of seeds. A very useful system followed in most developed countries to reduce expenses on hybrid seed costs.

Number of seed beds required per acre would be the same for Brinjal but would have to be 15 in case of Chillies when following 60 cm x 30 cm spacing. Since the rainfed crop is planted at longer spacing (table - 5), the number of seed beds required are 7 only.

In order to increase quality of transplants Melton and Dufault (1991) have shown that nutrient solutions of 225 mg/N, 45 mg P and 25 mg K per litre should be used to water the seedlings, especially the block transplants. **Priming** ie., pre-sowing salt treatments and osmo conditioning, has been shown to increase uniformity and speed of germination, especially under low temperature conditions, Geisenberg and Stewart (1986). The most commonly used chemicals are K No.3+ K3Po4; NaCl, Mannitol or PEG (Polyethylene glycol). Priming could help advance the season during cooler temperatures.

c. Land preparation

Levelled and deep lands and ideal for crop growth as these ensure even distribution and penetration of water. Ideally, a well prepared field is that which allows satisfactory water infilteration and retention, provides enough air space to allow for a ready exchange of soil air with the atmosphere, Hegarty (1978). Johanssen (1989) emphasised the role of deep ploughing for ideal root growth in tomato, without which, he claims, tomatoes in the open field could not realise the present yields. From an average of 50 to 55 t/ha in early 80's in California, the present averages are 70 t/ha. Excellent lan preparation and pre planting management has contributed substantially to this increased productivity.

d. Transplanting and spacing

Except tomatoes, which are direct seeded in many countries like U.S.A. - especially the processing types - the three crops are transplanted. Irrespective of the crop, the best method of transplanting is to irrigate the field one day prior to planting. Appropriate equipment (can be designed locally) should be used to make 3-4" holes on the sides of the ridges at recommended spacings (table - 5). Transplanting should be carried out in the evenings to avoid dessication due to higher day temperatures. Uproot the seedlings and plant one per hole. Ensure that the soil is firmly pressed around the root zone to remove air pockets which can deter fresh root growth. Follow the planting with a light irrigation. After top dressing the seedlings are brought to the centre of the ridge by earthing up.

Crop density can be decided upon several considerations. Knowing the canopy size of the variety/hybrid under cultivation is important. Determinate tomatoes have a smaller canopy than the semi-determinate and indeterminate types. Canopy size is greately influenced further by the soil, fertility, irrigation, temperature and growing season. Varieties meant for concentrated fruit ripening like those meant for processing are planted closer than varieties which are expected to yield over a longer period. Early yields in tomato are promoted by higher plant density as the number of early flowers per cluster are increased, but this may not result into higher total yields, Fery and Janik (1971). Geisenberg and Stewart (1986), have reported that in processing tomatoes under ground culture optimum plant population under irrigated conditions is 50-60000 plants compared to only 30-40000 plants under arid conditions. At lower population density the fruit size is increased and so is per plant yield but not higher yields per unit area, Tikoo (Unpublished data).

In Brinjal there is a wide range of spacings reported in literature, a few of which are presented here. Choudhary (1979) recommended 50-60 cms spacing between rows as well as plants for bushy varieties. 75-90 cms between rows and 60-70 cms between plants for spreading varieties. Chauhan (1981) observed long fruited varieties to yield best at 45 x 60 cms spacing and round ones at 60 x 75 cms.

Gupta et al (1978) recorded highest yield of Brinjal at 75 x 50 cms on sandy loam soil at Bangalore. Shukla and Prabhakar (1987) obtained highest yield of brinjal hybrid Arka Navneet at 50 x 40cms spacing. From the above it is obvious that the spacing decision will have to be taken as per recommendations given for a particular variety as well as on the soil type.

Factors like variety, soil fertility, irrigated or dry-land cultivation, are the parameters for the choice of plant spacing in chillies. In Karnataka and Maharashtra, spacing of 75 x 75 cms and 90 x 90 cms is generally followed whereas in Andhra Pradesh and Tamil Nadu, narrow spacing of 45 x 45 cms or even closer is practiced, Shukla (in press). Wider spacing of 90 x 90 cms is followed in rainfed cropping especially in tall varieties like Byadgi and Sankeshwar in Karnataka and Maharashtra. Chilli varieties NP46A, Jwale, K-1 are short statured and 60 x 60 cms spacing is followed. For concentrated dry red chillies bush varieties should be grown in 60 x 30 cms only. Again, no single spacing can be recommended.

e. Fertilizers and manures :

Well decomposed farm yard manure at the rate of 25 tonnes per hectare is a standard requirement of all the three vegetables under discussion. The fertilizer dosages are discussed below - crop wise.

Tomato

Soil type, its water holding capacity, relative maturity of the cultivars being planted will hold the key to fertilizer dosage as well as the method and frequency of application. In general a long duration cultivar will recessive one basal application followed by at least two top dressing at 20 day intervals after transplanting. Hybrid cultivars, especially indeterminate ones, require extra top dressing as well as higher dosage of total fertilizer per unit area. In medium and heavy soils, phosphorus, Potash and most of the nitrogen is applied as basal fertilizer before planting followed by the remaining nitrogen as a top dressing.

There are several ways of applying fertilizer in tomatoes. In

U.S.A. and Israel the processing tomatoes receive 50 percent of the basal dose through broadcast which is ploughed in and followed by seedbed preparation. Rest of the basal dose is rotovated on the individual beds. Mixed fertilizers are also applied in bands 3-5 cms below and beside the seeds when direct seeded. However, in case of transplanted crop the fertilizer band is placed 7-10 cms below and 5 cms beside the rows to prevent high salt concentration in the proximity of the seedlings (Geisenberg and Stewart). As per Feigin and Shakib (1971), 2.5 kg of nitrogen is required for every tonne of tomato produced. If tomatoes are produced in sandy soils and under low soil temperature, the ratio of ammonia to nitrate should be 1:1 because higher ammonia can adversely influence root growth, Ganmore-Neumann and Kafkafi (1980). Under warm soil conditions application of nitrogen as ammonia or urea would be suitable. A long term continuous usage of ammonium form of Nitrogen can also make the soils more acidic. Pill et al (1978), reported that high level of ammonia could cause blossom - end rot. In general, 60 kg of N per hectare is recommended as preplanting basal dose. For open pollinated cultivars another 60 kg of N is recommended as a top dress. For hybrid cultivars 60 kg. N as a second top dress is advised. Some even recommend a third top dress of 60 kg N. A comprehensive study on fertilizer requirement of hybrids vs. open pollinated cultivars in India needs to be carried out.

Varietal differences in response to nitrogen have been reported by Tikoo et al (1990). Such studies should be extensively conducted to evolve varieties which are efficient in usage of available fertilizers. It would help reduce cost of inputs. Adequate levels of phosphorus during establishment and initial crop stage ensures helathy root growth. In developed countries they use a starter solution containing 8:24 (N:P), at about 10 cm per metre row. The rates for drip irrigation are phosphoric acid at 30-100 cm per m of water during the whole growing season, Geisenberg and Stewart (1986). For adequate levels of pottassium 500 to 1000 kg of KCI K2So4 would be necessary per ha, Sagiv et al (1973). They suggest a proportion of 1:3 or 2:3 N:K in drip lines for firm and high-quality fruit. Mizrachi (1978) observed improved total soluble solids in the fruit by using high potassium fertilization. In a study on use of fossil shell fertilizer and its efficiency, Hasegawa (1989) reported the following:

a. fruit water content and average fruit weight was highest with inorganic fertilizers

b. sugar and amino acid levels were highest with organic fertilizers and

c. vitamin C content was highest with fossil shell fertilizers.

Among the micro-nutrients, boron, manganese and zinc are the most important. Boron deficiency causes reduced root growth, very dark burn on leaf margins and spots between leaf veins. Symptoms resemble salt damage, Anon (1986) and Tiwari and Choudhury (1986). Boron deficiency also enhances fruit cracking. Soil application of Borax @ 20 to 30 kg per hectare, is recommended. Zinc deficiency is seen by yellowing of leaves between veins, Anon (1986). It will occur in high pH soils like Boron. Increases in sugar/acid ratio by use of manganese at 10 ppm have been reported, Tiwari and Choudhury (1986). In order to avoid these deficiencies two prophylactic sprays, one at flowering and the other a fortnight later is suggested.

Brinjal

The status on fertilizer application has been nicely reviewed by Som and Maity (1986) and Shukla (in press). A crop yielding about 60 t/ha removes about 190-25-159 kg of N, P_2O_5 and K_2O per hectare, Gnanakumari and Styanarayan (1971). The recommended range of N:P:K is 56:56:28 kg to 280:280:280 of N:P:K as per various studies (Shukla, in press). The soil type, varietal characteristics and climate are the variables that have to be kept in mind before making a choice. The most commonly applied dosage is given in table - 5.

Although, micronutrient deficiencies are seldom a problem in brinjal, adequate supply of minor elements ensures good flowering, fruiting and earliness, Som and Maity (1986). In water and sand culture experiments, Mehrotra et al (1973) recorded the type of deficiency symptoms of N,P,K, CA, Mg, S, Fe and B in Brinjal. Since, practically most farmers in out country would neither carry out soil analysis nor be aware of the deficiency symptoms, it would probably be a good idea to undertake prophylactic sprays as suggested in tomato.

Chillies

The recommended dosage of N:P:K: is given in table - 5. Deshpande (1985) recommended 1/3 N, 1/2 P_2O_5 and 1/2 K_2O as basal dose. A wide array of fertilizer recommendations have been reported, Bose and Som (1986). Again, the choice will be based on soil type, irrigated or rainfed cultivation and the variety to be grown.

f. Irrigation

Adequate moisture supply at the right time ensures excellent crop growth and hence yield. The frequency of irrigation will depend on the moisture retention capacity of the soil, water table and weather conditions. Extensive work has been done on irrigation systems in tomato. Rudich et al (1977) adequately demonstrated how irrigation schedules can be manipulated to improve processing tomato fruit quality viz., increased soluble solids. A growing season which ends in a relatively dry period with favourable temperatures for fruit ripening and harvest would be ideal for manipulating irrigation schedules to enhance fruit quality. If the soil has high water retention ability and the wetted soil layer during rainy season has 150 cm depth, experiments in Israel have proved that economic yields of high quality can be achieved with one auxillary irrigation 7 days after first fruit-set. Such systems of cultivation need to be adopted in India in suitable environments. Three main types of irrigation are followed:

a. The traditional furrow system
b. Overhead sprinkler and
c. Drip irrigation.

Furrow irrigation is the oldest system and is most suited to India due to negligible initial investment costs. It is highly suited to medium andheavy soils where excellent horizontal distribution of water can be achieved. In light soils furrow irrigation can be successfully employed if furrows are close enough to the plants. Overhead sprinkler irrigation is expensive to install and may not be suitable throughout the crop growth as it stimulates fungal growth when the plant canopy is large.

Drip irrigation is the ideal system to realise the potential yield in tomato. Phene (1989) has shown in experimental trials on a large scale that open field yields of 170 t/ha have been obtained using a sub soil drip. In Israel yields of 120-140 t/ha are routinely obtained these days. The reasons for the success of drip irrigation have been summerised by Stevens (1986) as follows:

1. Improved water-use efficiency as it helps cut water requirement by 30 to 50 percent.

2. Careful control of soil moisture allows excellent root growth, plant canopy, high fruit set, healthy development of all the set fruits to potential size, low incidence of fungal diseases and excellent fruit solids. The last of which is a prime requisite of tomatoes for processing.

3. Direct application of fertilizers and chemicals so that optimum quantities are available to root zone. This means less losses due to leaching.

Initial cost of setting up a drip irrigation system is Rs. 35000/- per acre presently in India. This system can operate for several seasons. The recurrent costs would be fertilizers and chemicals, beside repair and renewal of drip lines periodically. Since the yield increase would be phenomenal large scale trials on this system are essential. Tomato roots are known to develop in a depth of 150cm and in a radius of 80cm in medium and heavy soils. In light soils they penetrate 60-80cm only. A well developed root system reduces stress conditions in case of high temperatures or dry winds (Portas and Dordio, 1980). This spread of the roots and soil type can be used as a guideline for frequency of irrigation to be followed.

In brinjal and chillies, exhaustive studies on water requirement and irrigation system are lacking. However, the parameters mentioned in tomato will hold good. Chilli being essentially a rainfed crop would require much less water than Tomato and Brinjal. Also, the marketable product in chillies is the dried fruits and hence heavy watering to form the bulk of the fruit weight as in tomato and brinjal is not required.

g. Soil mulching

Soil mulching can be beneficial in the following ways:

a. Uniform moisture distribution in upper layer of soil
b. Better root development in upper layers for better utilization of nutrients
c. Weed control
d. Moisture conservation

Transparent, yellow and black polythene mulches are most commonly used abroad. In Israel the yellow plastic mulch is used to reduce infection by yellow leaf curl virus of tomato because the vector Bemesia tabaci gets more attracted to the yellow plastic, Cohen (1982). The heat of the plastic due to exposure to sun kills the flies. Plastic mulch is also known to affect fruit yield and quality, Geisenberg and Stewart (1986). The suggested thickness of the clear and black poly ethylene films is 0.03 mm, while the yellow film should be 0.04-0.05mm. The film should be 120 cm wide. During cool season clear plastics are prefered but black plastic is used during warm season as it radiates back the heat and hence keeps soil temperature within tolerable limits.

h. Training/staking

In tomatoes grown under supported culture, especially for taller varieties and where several harvests have to be carried out, the plants need to be staked or trellissed. The most common form of stakes are thick (2" dia) to 6' poles to be fixed vertically in between planting rows at 2 m intervals. Long thin (1" dia) poles are then horizontally tied on to these poles at 2 or 3 levels at 1.5' intervals from the ground. 20 days old plants are then loosely tied on to these horizontal stakes. If the lands are quite levelled and can have long planting rows, the horizontal stakes can be replaced by mild steel wire strung across each row. Varietal growth habit and the growers preference of fruit size helps decide on how many stems per plant can be maintained. Lower the number of stems better the fruit size. Care has to be taken to remove all side shoots from young plants except the axillary shoot below the first flowering cluster. This helps in increasing stem girth and also in training the plant properly. The axillary shoot below the first flowering cluster is the most vigorous and is hence retained. In addition one may maintain one or more stems for training.

When grown under environmentally controlled structures - like green houses in scandinavian countries - the plants are grown with single stems. The hybrids used in such conditions are indeterminate in growth habit. Koming (1989) has shown that a harvest index of 84% is achieved in such conditions. Against a fresh growth of 24.5 kg per plant the fruit yield was 20.6 kg per plant. The number of trusses per plant in this experiment was 30.5 trusses. Such training conditions and controlled environments can mean yields of 468 t per ha in tomato.

i. Growth regulators

In tomato fruit-set can be severely hampered if the night temperature go below 10-12 c or above 20-22 c. Under high temperatures the stigma becomes exserted and prevents normal pollination, while low temperatures render pollen non viable, Levy (1972). Low temperature fruit set also results into fruit deformation like catfacing etc. Literature is full of references on several compounds that can be used for improving fruit set, Atherton and Rudich (1986), Bose and Som (1986), Shukla (in press). While these treatments can certainly improve matters the relative success will depend on the commercial formulation and how closely the recommended guidelines for a particular product have been followed. Ethrel is used extensively in countries where the post harvest packaging and movement of the fresh produce is regulated. In USA the mature green tomato fruits are held in cold storage after treating with ethylene at 400 ppm. The fruits then ripen to an even colour by the time they are transported to the retail stores.

In processing tomatoes harvested once over, commercial ethepon treatment at 200-400 ppm is carried out when about 15 percent of the fruits are red. But once the treatment is carried out the fruits have to be harvested within 15 days or else there can be a very heavy loss of fruits. Any mistakes in concentrations can mean scorching of leaves prematurely and thereby heavy sun scalds.

In Brinjals treatment with 2,4-D at 2-5 ppm and 4-CPA at 20ppm at the flowering stage caused earlier and more uniform ripened fruits. Som & Maiti (1986), have reviwed this work.

Application of mixtalol, a mixture of long chain aliphatic alchohols, at the rate of 4 ppm, 6-8 weeks after transplanting is reported to increase brinjal yields by 35 tp 52 percent, Shykla and Prabhakar (1986). The ultimate choice of growth regulators will depend on the commercial formulation and its dosage recommended. Suffice it to say that such sprays are beneficial to the crop if used judiciously.

Similarly several growth regulators have been tried in chillies to reduce flower drop eg., NAA at 50 ppm, Muthkrishnan et al (1986). They also quote that (i) malic hydrazide and ethrel at 3000 and 200 ppm, respectively, were observed by Kim & Ho, (1978), to suppress flowering in chilli and (ii) 400 ppm ethrel improved fruit setting in both winter and summer crops, Nagdy et al (1979).

Type of growth regulator, genetic make up of the crop, environment under which the crop is grown are the important factors that will govern the choice. However, exhaustive studies under varied environmental conditions in India need to be carried out to help arrive at ideal dosages.

j. Physiological disorders

Several physiological disorders are known in tomato. Based on an extensive review, Grierson and Kader (1986), have described these as follows:

a. Blossom-end rot

Beginning as small water-soaked lesions at or near the blossom scar of green tomatoes, the spots enlarge into light or dark brown sunken leathery tissues. Inadequate calcium supply in the soil is related to this malady. Varietal differences are well known, indicating genetic control. Use of calcium ammonium nitrate as a source of nitrogen is recommended. Concentration of calcium in fruits below 0.8% (dry weight basis) markedly increases this problem.

b. Blotchy ripening

Green, greenish-yellow areas on normal red fruits is a characteristic symptom of blotchy ripening. Such areas contain less organic acids, dry matter, total solids, starch, sugars and nitrogenous compounds. Higher potassium and inorganic nitrogen seem to reduce the incidence of blotchy ripening. Exact causes are not yet known.

i. Green back

A genetically related disorder caused by the presence of the green shoulder in immature fruits, which does not ripen properly. Can be removed by genetically incorporating the uniform ripening gene 'u' in the varieties.

ii. Sunscald or sunscorch

On exposure of fruits to direct sun radiation for a long duration, especially if temperature of fruits exceeds 30 c, the affected parts become yellowish and remain so during ripening. The skin gets shrivelled when temperature of exposed fruit exceeds 40c, it becomes white and sunken which is a typical symptom of sunscald. Cultivars with very good foliar cover escape such injury.

iii. Cracking

Tomato fruits tend to exhibit radial or concentric cracks on its skin especially following extreme fluctuations in water supply. It is under genetic control and is related to the thickness and resilience of the skin. The splits on fruits reduce their appearance, transportability and make them more susceptible to pathogen attack. Use of crack resistant cultivars is a remedy, besides ensuring adequate water supply.

iv. Puffiness

Existence of open cavities between the outer pericarp and the locular contents is called puffiness. Percentage incidence is related to the genotype and growing conditions which can cause improper pollination, fertilization or seed development.

v. Gold fleck/pox syndrome

Irregular or round green specks appearing on the green and immature green fruits causes the ripe fruits to look poxed with gold flecks. These reduces the fruit's market value. Genetically resistant varieties are the only remedy.

Such detailed information on Brinjal and Chilli disorders are lacking.

k. Harvesting

Tomato

The harvesting schedules for a particular variety or hybrid will depend mainly on the season, its maturity and growth habit. It will also depend on if the produce is meant for fresh consumption or processing and also if the tomatoes are direct seeded or transplanted. Transplants take approximately 14 to 20 days less from planting to harvest than direct seeded (ds) tomatoes. Harvest dates for both ds & transplanted tomatoes can be further advanced by 7 to 14 days using clear polythene mulch. Low Nitrogen availability and water stress at this time can also shorten ripening time (Griesenbach and Stewart, 1986).

Fresh market

Since the fresh market fruit will require a gap of a few to several days from the growers field to retail shop, the climactric nature of the tomato fruit helps in planning stages of harvest. Tomato fruit has the following maturity stages (table 6).

Table 6. Maturity stages in tomato

Maturity stage	Description	Av. No. of days to reach red ripe maturity*
Immature Green (IMG)	No jelly like material in the locules, seeds get cut when fruit sliced by knife	15
Mature green (M G)	Jelly-like matrix in all locules; seeds are not cut by a sharp knife upon slicing the fruit	7 - 8
Breaker (B)	Slight break of colour at blossom end; Internal red coloration	4 - 5
Turning (T)	Break of colour all over the fruit More yellowish tinge	2 - 3

(contd...)

Pink (P)	Whole fruit almost pinkish red	1 - 2
Rep ripe (RR)	Firm fully red ripe fruits	0

* - in firm fruited cultivars

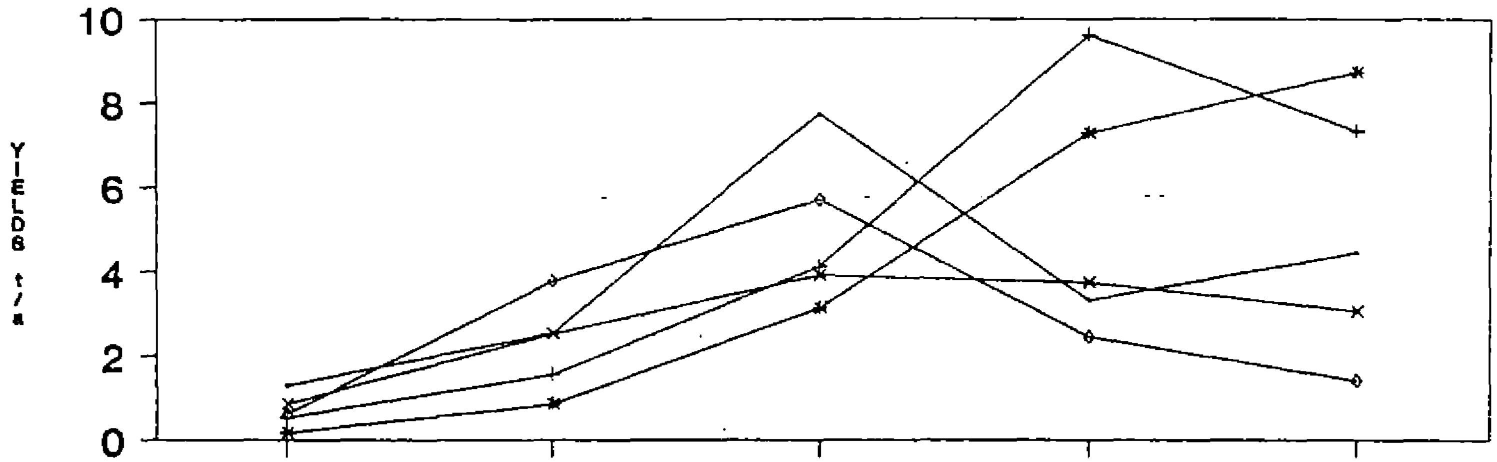
Depending on the distance of the market the choice of stage of harvest is made. In India fruits are picked only at breaker stage as fruits picked at mature green stage would require treatment with ethylene to bring uniform ripening. Firmer the fruit, better is the transportability. This factor is also important to decide harvesting schedules. Besides these factors, maturity of the variety and growth habit is to be kept in mind to decide planting and harvesting schedules (Fig 1). It shows comparitive yield data on 5 tomato hybrids over 5 weekly pickings. While most hybrid show a peak at PICK 3, HYB 2 and HYB 3 peak at pick 4 & 5, indicating their relative lateness. CHK 2 is the earliest and its pickings are almost over by PICK 5. Such information on varieties/hybrids is essential to help the farmer extend his growing season by staggered planting of early type followed by a late type.

Growth habit would be another factor for harvesting schedules. An indeterminate (I) cultivar would have the maximum harvesting period, followed by the semideterminate (SD) and the determinate (D) varieties. This is so because the flowering in the I types is gradual - three leaves separating two flowering trusses. In SD types the flowering is intermediate, two leaves separating two flowering trusses. In D types there is a concentrated fruit ripening, only one leaf separating two flower trusses. Open field yields of tomatoes range between 25 to 170 t per hectare depending on variety, growing conditions, season and type of cultivation. Indeterminate varieties in open fields have a harvest index (HI) of 45 per cent - source exceeding the sink. Semi-determinates have a HI of 55 to 60 percent and determinates have upto 70 percent HI. Under green house, Hasegawa (1989) reports 84 percent HI.

Processing tomatoes

Determinate cultivars have been very well exploited for the processing industry as these allow complete harvesting once over or

FIG.1.RELATIVE YIELDS(t/a) OF PROMISING TOMATO HYBRIDS OVER 5 PICKINGS



	PICK1	PICK2	PICK3	PICK4	PICK5
HYB1	1.29	2.54	7.75	3.32	4.44
HYB2	0.53	1.56	4.11	9.62	7.33
HYB3	0.17	0.85	3.12	7.28	8.73
CHK1	0.85	2.53	3.91	3.74	3.06
CHK2	0.62	3.78	5.7	2.44	1.41

PICKINGS

HYB1 HYB2 HYB3 CHK1 CHK2

Source: S.K.TIKoo(unpublished data)

in few pickings. Since the fruits have to be harvested red-ripe proper estimates of the quantity to be harvested can be made and utilised to schedule supplies to the processor. An area where the whole strategy has been fine tuned in countries like USA, Italy, France, Turkey etc., but still in a primitive phase in India. One hopes that such vast fund of information can be duly put to applied use. Yields of processed tomatoes can be between 25 to 70 t/ha.

Brinjal

In brinjals, edible fruits are harvested at mature green, when the skin is very glossy and seeds have not been formed. At harvesting, the fruit is picked along with the calyx which gives it the fresh appearance. Green calyx and purple fruit is the typical colour combination. Shukla (in press) reports that heavier crop can be produced if fruits are picked before they reach full size. Average yields vary between 20 to50 tonnes per hectare. The frequency and duration of picking is related to growth habit as in tomato. The choice of variety can be made on the ultimate need of the grower, market demand and pricing.

Chillies

Chillies can be harvested at green stage or dried-red stage. Majority of the harvest is of course in the latter form. In several case the growers prefer to pick the first harvest as green chillies which stimulates further flush of flowering and fruit set. Green fruits are ready to pick within 2 months of transplanting. The number of pickings will depend on season, cultivar and cultural practices. Yields per hectate are as follows in general.

	Yield (t/ha) Rainfed	Irrigated
Green chillies	7 to 10	20 to 25
Dry chillies	0.75 to 1.0	2.0 to 2.5

(Source : Deshpande, 1985)

All these three crops have a very promising possibility of growth in India in the next few years, especially tomato and chillies. The key for higher productivity is harnessing of available technology. Awareness of the exonomically important diseases and their timely control measures will go a long way in sustaining yield potentials. Massive efforts are required to transfer the technology in the quickest possible time to the vegetable growers so that the gap in productivity is narrowed down. Future will see further improvements in the varietal characteristics, especially the value added qualities like multiple disease resistance, better fruit quality etc. A co-ordinated effort to improve post harvest management would help in allowing the higher yields to reach the consumer without the losses in transit.

TABLE - 5 : A PRODUCTION GUIDE FOR TOMATO, BRINJAL AND CHILLIES

INPUTS	CROP TOMATO	BRINJAL	CHILLIES
SEED RATE/ACRE			
O P	125g	125g	250g
Hybrid	60g	60g	150g
SEASON	S-Oct-Nov,Jun-Jul Feb-Mar N-Nov-Dec,Feb-Mar July-Aug H-Feb-Mar*	S-Oct-Nov,Jun-Jul Feb-Mar N-Nov-Dec,Feb-Mar July-Aug H-Feb-Mar*	S-Oct-Nov,Jun-Jul Feb-Mar N-Nov-Dec,Feb-Mar July-Aug H-Feb-Mar*
METHOD OF PLANTING	T & DS	T	T
SPACING	90cm x 30cm (Single Row) 150cm x 30cm (Twin Row)	90cm x 30cm (Single Row)	60cm x 30cm** (IRR) 90cm x 90cm (RF)
F Y M	10t	10t	10t
BASAL FERTILIZER PER ACRE (N : P : K)	24kg:40kg:24kg	24kg:40kg:14kg	8kg:8kg:8kg (IRR) 12kg:12kg:12kg (RF)
TOP DRESSING PER ACRE ***	24kg:-:-	24kg:-:-	RF - 8kg:-:- IRR - 12kg:-:-

* - T = Transplanted DS = Direct Sowing

*** - For hybrid cultivars one or two additional top dresses of Nitrogen are recommended depending on the type of hybrid (See text).

S - SOUTH N - NORTH H - HILLY REGIONS NORTH RF - RAINFED IRR - IRRIGATED

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Management of leguminous vegetables

Indira, P*

Leguminosae (Syn. Fabaceae), one of the three largest families of flowering plants, includes pulses, vegetables green manure crops, oil seed crops, cover crops and timber plants. Among these, vegetable legumes are important from nutrition point of view as they supply proteins to the diet. Having root nodules, they fix nitrogen from the air and thereby enhance soil fertility. Both the pods and seeds are rich in protein and are excellent sources of vitamins and minerals. The important tropical leguminous vegetables are cowpea (Vigna unguiculata), Field bean (Lablab purpureus), winged bean (Psophocarpus tetragonolobus) and cluster bean (Cyamopsis tetragonoloba).

Cowpea

Cowpea (Syn. asparagus bean, snake bean, yard long bean, southern pea) is grown throughout the country for its long green pods as vegetable, seeds as pulse and foliage as vegetable and as fodder (Chakraborthy, 1986). It is cultivated over an area of 0.57 million hectares with an estimated production of 0.12 million tonnes of grains in India. The largest area is in Rajastan (31%) followed by Tamil Nadu (20%), Karnataka (17.18%) and Orissa (9%) (Henry and Daulay, 1988). In Kerala, Tamil Nadu, Andhra Pradesh and West Bengal, long, thick podded varieties, mostly trailing types are grown; where as in Haryana, U.P., Bihar and M.P. dry seeds are eaten. While Punjab, Gujarat and Maharashtra prefer short, thin pods of Pusa - do-fasli type (Mohan, 1988).

Soil

Well drained, humus rich, sandy loam soils are the best suited for growing cowpea. It thrives under vide range of soils if proper drainage is provided.

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Physiological factors :

Cowpea is a warm season crop and thrives the best between 21-35°C. It can be grown successfully both in spring-summer and rainy season in the plains. It cannot withstand heavy rainfall and water logging. Different cultivars respond differently to temperature and day length and thus there are distinct cultivars for spring-summer and rainy seasons. High light intensity delays flowering but increases flower and pod numbers. George and Nair (1987) conducted a field trial to test the feasibility of growing cowpea under coconuts. The cowpea Cv. Kanakamani was artificially shaded by 0, 25%, 50% or 75%. Yields under 0, 25%, 50% & 75% shading were 1.58, 0.66, 0.40 and 0.15 t/ha respectively. Dry matter production was less affected by shading. LAI was not affected upto 60 days after sowing after which it rapidly declined. It was concluded that cowpea for vegetable purpose would not be suitable for growing under coconuts.

Season

Cowpea is grown throught the year under Kerala conditions. It can be grown as a cover crop in coconut gardens and as an intercrop in tapioca during May-September. It can be grown as a pure crop in single crop and double crop rice fallows during rabi and summer seasons. It can be grown throughout the year in homestead gardens. Generally it is sown in June-July for rainy season crop. In places like Bangalore where climate is mild, it can be grown almost throughout the year. Proper time of sowing in Northern India starts from February and may be continued till september (Singh and Patel, 1990). Damodaran et al (1988) studied performance of cowpea lines under different rates of sowing during kharif. Five cowpea cultivars sown on 15th and 30th July gave 2 year average seed yields of 832 and 862 kg/ha respectively compared with 446-565 kg, When sown on 30th June or 15th August. The cultivars NPRC 3 and CO_4 gave the highest yields of 718 and 797 kg. compared with 580-677 kg for other Cvs.

Seed rate and sowing

Cowpea is a direct sown crop. There are two methods for sowing - broadcasting and dibbling. Under Kerala conditions, for grain and dual purpose types of cowpea a seed rate of 60-65 kg/ha is recommended for broadcasting and 50-60 kg/ha for dibbling. For vegetable type it is 20-25 kg/ha (KAU, 1989). The seedrate recommended for the cultivar Pusa Komal is 15-20 kg/ha (Singh & Patel, 1990). Hooda and Singh (1989) reported that a seed rate of 20-25 kg/ha is sufficient for grain and green pods. But for mixed cropping, its seed should be mixed proportionately with seed of other crops. There is no definite proportion for a mixed crop of fodder cowpea. For a mixed grain crop, about 10 kg. cowpea seed is mixed with the seeds of other crops and 35-40 kg/ha is enough for fodder purpose. Seed treatment with Thiram at 3 g/kg of seed is advisable before sowing. The seed should be sown at a depth of 6-7 cm. There should be sufficient moisture in the field at the time of sowing.

Spacing

For grain and dual purpose types, if dibbling is adopted, a spacing of 25 cm between rows and 15 cm between plants is recommended with 2 seeds/hole. If broadcasting is adopted, the seeds can be sown broadcast over the field and channels drawn after sowing. For vegetable type, a spacing of 45 cm between rows and 15 cm between plants is suitable (KAU, 1989). Under Bangalore conditions a spacing of 60 cm (row to row) and 15 cm (seed to seed) is recommended (Mohan, 1988). A spacing of 30-45 cm x 10 cm is recommended for the cv. pusa komal in N. India. During summer, spacing is usually reduced.

Manures and fertilisers

In Kerala, a fertilizer dose of lime, 250 kg/ha or Dolomite 400 kg/ha N 20 kg/ha, P_2O_5 30 kg/ha and K_2O 10 kg/ha is recommended. Among these, lime is applied at the time of first ploughing. Half the quantity of N, whole of P_2O_5 and K_2O are applied at the time of final ploughing. The ramaining N may be applied 15-20 days after sowing.

According to Singh and Patel (1990) Cowpea requires only a starter dose of fertilizer comprising 10-20 kg nitrogen and 50-75kg phosphorus, to be incorporated/hectare of land before sowing.

Since cowpea is highly susceptible to Zn deficiency, especially in paddy-and wheat rotated soils, incorporation of 10-15 kg. Zinc Sulphate/heactare would be beneficial.

Adehayo (1985) reported the effect of applying 0,2,5 or 10% (on DM basis) of cowdung, poultry manure or house hold waste to an Alfisol soil collected at 0-15 cm depth in Nigeria on DM yields of cowpea Cv. Ife Brown. The greatest drymatter accumulations of 15.6, 13.8 and 10.5 g. were obtained at the highest rate of poultry manure, cowdung and household waste respectively. Poultry manure gave the highest overall dry matter yields.

Irrigation and interculture

Cowpea is a shallow-rooted crop and requires less moisture for its growth. It is sensitive to water logging. Therefore light irrigation should be given. Irrigation prior to flowering helps in pod setting and another irrigation should be given after the pods have set. After harvesting of green pods of the first flush, another irrigation improves yield. This will help in initiation of second flush of flower.(Chakraborty, 1986). For the Cv. Pusa komal, in normal weather the first irrigation is required at flowering and another at pod formation. However the summer crop should be irrigated every 20 days (Singh and Patel, 1990).

In Kerala during the second crop season, ie. September to December cowpea is grown as a fringe crop along the rice field bunds. During summer season, it is grown as a pure crop in rice fallows after the harvest of first or second crop paddy. Only these two crops requires any irrigation.

The plot is to be kept free of weeds for the first 45 days after sowing. One hoeing should be done about 4 weeks after sowing for controlling weeds and helping in root aeration. Earthing up is done at first flowering stage and again after the second harvest.

Chauhan et al (1985) reported the efficiency of herbicides and other cultural practises on cowpea. They compared nitrofen, fluchloralin, alachlor and pendimethalin each at 2 rates for weed control in cowpea, with 3 cultural practises (hoeing or hand-weeding 30 days after sowing and weed free conditions) and unweeded control in 30,45 and 60 cm apart. Amongst weed control treatments the highest vegetable production of crop and yield were under weed free conditions.

For grain and dual purpose varieties of cowpea, decapitation is found to be advantageous as the crop shows trailing tendency. Rafique-Uddin (1983) studied the effect of some defoliation treatments on the yield components in cowpea. Two erect, non-vigourous and determinate cowpea Cvs. were grown at 3 plants/bag upto 50% flowering. Thereafter they were grown at 3,2, or 1 plant/kg bag without defoliation and with 20,40, 60 or 80% defoliation. The decrease in number of plants/bag increased the number of pods/plant and had no effect on 100 seed and number of seeds/pod. The number of pods/plant and 100 seed weight decreased with increase in the defoliation level.

Among the different growth regulators spraying of maleic hydrazide at 50-200 ppm just before flowering is found to increase the yield of pod in cowpea.

Harvesting and yield

Green pods for vegetable are usually ready within 50 days after sowing depending upon the variety. The green pods should be picked in tender condition otherwise they become fibrous. Marketable pods are available in about 45 days in case of an early cultivar and may continue upto 100 days in flushes. It produces about 50-80 quintals of green pod/hectare.

Economic of cultivation

The cost of cultivation of cowpea was worked out by Motilal Nehru and Thampi (1987). They found that by investing about Rs. 12,300/ha. farmers are getting a net profit of Rs. 15,400/ha excluding cost of family labour.

Field bean

The lablab bean or Dolichos bean (sem) is one of the most ancient among the cultivated plants. In the west, it is known as 'Bonavist' or the 'Hyacinth bean'. It is grown throughout the tropical regions of Asia, Africa and America. The crop is multi-purpose - a pulse, vegetable and forage. Although the crop is indigenous and grown all over the country, compact large areas of commercial production are uncommon. The perennial type (*typicus*) and annual type (*lignosus*) are grown in India. It is a field crop in Tamil Nadu, Andhra Pradesh, Karnataka, Madhya Pradesh and Maharashtra. Despite the many good attributes, the crop remained unexploited owing to low productivity, long duration, photo-sensitivity and an indeterminate growth habit. The consumer preference also varies with pod size, shape, colour and aroma. (Shivasankar and Kulkarni, 1989).

Soil and climate

Dolichos bean grows on a wide range of soil with average fertility. Premnath (1976) reported that field bean is relatively a cool season crop. It is adapted to the tropical and sub tropical regions. There are some drought resistant strains, grown as a dryland crop in regions with 630 to 890 mm/annual rainfall. Fruiting starts by winter and declines during summer.

Sowing and season

Dolichos bean is a direct sown crop. It is mostly grown as a homestead vegetable in Kerala, commonly near houses. It is trailed over pandals or allowed to climb on roof tops. The seeds are sown in July-August with the onset of monsoon.

In south and central India, it is usually grown as a mixed crop with ragi or sorghum. It is drilled at a spacing of 1 metre between ragi or sorghum. Ragi or sorghum, earheads are harvested first leaving the stalks for giving support to the vines of dolichos bean. The vines grow profusely on them and flower in November-December, giving a continuous crop of green pods and dry seeds throughout the winter and spring. The vines when cut with sorghum straw give a mixed fodder with high nutritive value. If it is grown as a pure crop it can be sown at a spacing of 1mx0.75m. Three to four seeds are sown/hill and later thinning is done to allow two plants to grow/hill. About 20-30 kg seed is required for sowing one hectare. In a kitchen garden, plants can be retained for 2-3 years (Chakraborthy, 1986).

Fertilizers and manures

A manure and fertiliser dose of FYM - 20t/ha, N-50 kg/ha, P-kg/ha and K-50 kg/ha is recommended in Kerala (KAU, 1989). When grown as a mixed crop with fingermillet it is fertilized with 20 kg ammonium sulphate and 40 kg superphosphate/hectare after the first weeding. Recent studies at UAS, Bangalore, showed a 11.4% increase in yield when the rhizobium was inoculated and only 6.4% enhanced yields, with an application of 25 kg/ha of nitrogen over the control (Shivasankar and Kulkarni, 1989).

Weeding

Inter-cultivation can be done to check weeds from growing in the field types but in garden types such a practice is not possible once the vines spread.

Irrigation

Dolichos bean is mostly grown as a rainfed crop. During summer, frequent irrigation should be avoided since it is sensitive to waterlogging.

Flower drop

A high rate of flower shedding is a major factor limiting productivity in dolichos. Only 10 to 20% flowers produced mature into pods. Soil application of nitrogen 20kg/ha at flowering increases the yield parameters. Also, application of Calcium Chloride 0.1% and NAA (100 ppm) when the first inflorescence comes to flower increases fruit set and productivity (Shivasankar and Kulkarni, 1989).

Harvesting and yield

Dolichos pods at their early stage of development, although highly tender, do not attain proper size and weight while at later stages of development, the pods become hard and fibrous and lose consumer's acceptance. They are harvested when green and secculent. Jana and Chathopadhyay (1977) observed that maturity index depended on pod-weight which in turn depended on pod breadth. The process of pod development differed in varieties and hence they were grouped as early pod-maturing and late pod-maturing which could be harvested at 20 and 25 days after anthesis respectively for fresh market. The rate of dry matter production, grain development, pod development and grain : pod ratio varied in all the varieties at various stages of maturity. The varieties like Kalyanpur T_1, Deshi and Rajani were found to be early pod maturity for fresh market with respect to tenderness and maximum weight.

The average yield varies from 50 to 80 quintals of green pods per hectare.

Winged bean

Winged bean offers an exceptional promise and shows a great potential for overcoming the protein malnutrition problem throughout the humid tropics. In addition to high protein, its seeds contain sizeable amount of oil, dry matter, potassium, Calcium, Sodium and phosphorus.

Soil and climate

The crop can be grown in any soil with good soil texture. It can also be grown in heavy soils with poor drainage. Sandy and well drained soils are good for tuber production. The crop does not grow well in very alkaline or very acid soils.

The winged bean has traditionally been cultivated between latitudes of 20°N and 10°S. In recent years the plant is successfully introduced to subtropical and warm, temperate latitudes. The crop withstand, high temperature but never survives frost. It is sensitive to photoperiod, humidity and rainfall. Continuous day temperatures higher than 32°C or lower than 18°C inhibit flowering even under otherwise suitable short-day conditions.

The plants require short day conditions for flowering. Planting during short days would result in flowering within 8 weeks. Rainfall, which is detrimental to many legumes, is good for winged bean eventhough a short period of drought will not affect the crop. It is traditionally cultivated in areas with annual rainfall of 700 to 4,000 mm. It thrives in hot humid areas with 2,500 mm or more annual rainfall. This crop also displays some drought tolerance (Shanmugavelu, 1989).

Seed rate, sowing and spacing

A seed rate of 15-20 kg/ha is recommended in Kerala. Pre-soaking of the seeds for 2 days before planting would give a good germination percentage. The seeds are sown in flat beds or ridges. The spacing varies depending on the cultivar and location. In Kerala the recommended spacing is 75 x 50 cm.

Season

The time of planting has a significant effect on yield. Winged bean is mainly grown in small plots in backyard gardens, edges of fields or against fences or walls. They are generally sown at the beginning of wet season. In Kerala July-August is the optimum season. The initial growth of seedlings is too slow and with the completion of the monsoon rains the seedlings make vigorous growth. The plant, being responsive to day length, starts flowering in October-November when short-day conditions prevail.

Staking

The plants start twining a few weeks after germination. So they need support in the early stages of growth. Normally individual supports are given with local wood materials. Stake or trellises 1.2 to 2 m tall are generally used. Supports can be made of bamboo, coir, branches of trees etc. There are some living plant supports like fruit trees, subabool (<u>Leucaena</u> <u>leucocephala</u>) and <u>sesbania</u> <u>bispinosa</u>. Initial success with planting corn and winged bean together has been obtained - the corn crop matures first and can be harvested, the winged bean then uses the born stake as support.(Shanmugavelu, 1989). These supports prevent pod rot by holding the pods from being affected by soil moisture. Winged bean is also grown as a cover crop but then the yield will be limited.

Pruning

Winged beans grown for tubers are traditionally pruned. Flower removal and pruning increases tuber yield. Vines for green pod yield are not usually pruned.

Manures and fertilisers

Research on the nutritional requirements of winged bean is meagre in our country. Sarnaik et al (1984) reported the response of varying spacings and fertility levels on winged bean. Plants of the Cv. IHR 4 spaced at 30, 60, 90 or 120 cm in row with 100 cm between row received N at 30 or 60 or P_2O_5 at 40, 60 or 80 kg/ha with K_2O at 40 kg/ha as a basal dressing. These treatments had no significant effect on pod length, pod weight, number of seeds/pods, filling percentage and 100 green seed weight. The highest yield (10096.2 g) of pods/plot (72 m^2) was with N at 30 kg/ha or with 60-80 kg P_2O_5 (9506.8 g, 9629.05 g). The dry matter yields increase, with phosphatic fertilisers and Nitrogen affects nodulation.

Growth regulators

Lee (1968) reported the response of selected growth regulators on growth and production of winged bean. 2,3,5 triodo benzoic acid (0, 15, 30, 45 and 60 ppm), 2-napthoxy acetic acid (o, 25, 50, 75 and 100 ppm) and chlonnequat (0, 25, 50, 75 and 100 ppm) were applied to the foliage of winged bean at 3,4 and 5 leaf stage. Plant height was significantly reduced upto about 7 weeks after sowing by the application of growth regulators. There was no significant difference in fresh pod weight between treated and control plants. 2,3,5 triiodo benzoic acid applied at 30 or 45 ppm, 2 napthoxy - acetic acid at 50 or 75 ppm and chlormequat at 50 or 75 ppm, significantly increased number and yield of fresh pods.

Irrigation

Though winged bean is a rainfed crop, it needs irrigation as the season progresses. Weekly irrigations are desirable until the plants are large and have roots deep enough to resist short droughts.

Intercultural operations

As the winged bean seeds germinate late and because the young plants grow slowly, the planting needs special care for several months. The plots should be kept free of weeds by hand weeding, hoeing or by mulching. Mulching also helps to conserve soil moisture. This practice increases tuber yield also.

Harvesting and yield

The green pods to be used as vegetable are ready for harvesting 10 weeks after sowing and extends indefi itely. Each vine yields about 25 pods every 5 or 6 days. Bagchi et al (1989) suggested that the green pods are harvested for upto 21 days after anthesis and the green beans for 21-35 days after anthesis. Beyond that stage it should be utilised as a grain legume.

Cluster bean

Cluster bean or guar is grown for its young tender pods used as a vegetable. It is mainly grown for fodder and seeds for guargum production. There are dwarf and giant types, dwarf types being grown in Punjab, Haryana and U.P. while the giant type is preferably grown in Gujarat. The green pods are rich source of vitamin A, iron and also contain vitamin C.

Soil and climate

It is a shallow rooted crop with a surface feeding nature. The crop prefers well drained sandy loam soil. It can tolerate saline and moderately alkaline soils with PH (7.5 to 8.0) and in heavy soils nodulation is hampered.

Cluster bean is a typical tropical vegetable prefering warm climate even though it can be grown in the subtropics during summer. It is suited for the arid zone of Rajasthan and Haryana. It prefers long day conditions for growth and short day conditions for flowering. It is grown throught the year in South India.

Seed rate and sowing

The seed rate varies, due to the cultivar, planting season etc. To sow one hectare area, about 30-40 kg seed of cluster bean is required. The seeds are sown at a spacing of 45 cmx15 cm. For the Cv. Pusa Sadabahar a spacing of 60 cm x 12-15 cm. is recommended (Singh, 1989).

Cluster bean is grown twice in a year as a spring-summer crop and rainy season crop. Under mild winter a third crop can also be taken. Jain et al (1987) reported the effect of date of sowing of cluster bean seeds on yield and quality of the crop. They found that crops sown on 10th July gave higher seed protein and gum yields than those sown on 25th July or 10th August.

Manures and fertilisers

Manuring is generally restricted to application of Farm yard mannure. It is added @ 150-200 Q/hectare. Inorganic fertilizers are added @ nitrogen, 10-20 kg. Phosphorus 50-70 kg and potassium, 50-70 kg/ha. Nitrogen is applied in two splits, first at the time of planting and later in the flowering stage (Singh, 1989).

Intercultural operations

Cluster bean is a shallow rooted crop. Therefore only shallow intercultural operations are done to provide good conditions for crop growth and to keep down the weeds. Sonani et al (1985) found that the most critical period of crop weed competition was 20 to 50 days after sowing as determined from data on yield and drymatter accumulated by the weeds. A few herbicides like 2, 4-D and DSMA (Disodium methane arsonate) are also used in weed control @ 2 kg/ha.

Harvesting and yield

The pods would come ready for picking, depending upon the cultivar, from 40 days onwards. The total duration of the crop is about 120 days. The yield varies from 5 to 6 t/ha of tender green pods and 6 to 10 q/ha of seeds.

Uses

The tender pods are used as fresh vegetable or sometimes dehydrated and stored for use. It is a nutritious fodder for livestock. The mucilaginous seed flour is valued as guar gum (galactomann) and this gum is used in textile, paper, cosmetic and oil industries (Parthasarathy, 1986).

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Cowpea

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Agronomic management of drumstick, Curry leaf, chekkurmanis and agathi

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Drumstick or Moringa (Moringa pterygosperma) is one of the most popular perennial vegetables in the South Indian households. It is a unique vegetable in which not only fruits but also leaves and flowers are equally useful. Immature fruits are cut into pieces and used in several culinary preparations. Fruits are good sources of vitamins B and C. The leaves besides as vegetables, are also used for seasoning pickles and for flavouring ghee. The leaves are rich in vitamin A (11,300 IU) and C (220 mg/100g). The seeds of mature fruit are sometimes fried and eaten. It also yields an oil known as 'Oil of Ben' which has several commercial uses. Chopra et al 1949 stated that all parts of the tree have medicinal properties.

In spite of all these, the crop remains underexploited and hardly any research is conducted for its improvement. In Kerala the plant is an inevitable component of house-hold garden. An area of 16,569 ha. is occupied by this crop which accounts for more than 50% of the total area under vegetables excluding tuber crops in the state. Current annual production (1988-89) is 16,435 tonnes and the productivity is around 1 tonne/ha. Selected clones of drumstick are capable of yielding upto 30 kg/plant. On per hectare basis, such clones can give up to 18 tonnes/ha. The gap in yield is remarkable and concerted research efforts can rise the productivity of drumstick from 1 tonne/hectare to several

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folds higher.

Drumstick is comparatively a hardy crop which can withstand tropical situations and drought to a great extent. It thrives well under low soil fertility conditions. Not much of manures or fertilizers are given to this crop. Cost of cultivation is approximately Rs. 10,000/ha for new planting and between Rs. 6,000/- to 8,000/- in subsequent years. Major cost is involved in after cultivation and harvesting the crop. After cultivation mainly includes weeding and covering the basins and pollarding.

Soil requirement

Drumstick is not very exact in soil requirements. It grows and yields satisfactorily in all types of soils except those having stiff clays and extremely sandy conditions. Sandy loams containing good amount of lime are preferable. Water logging is injurious and hence well drained soil gives the best growth.

Climate

Drumstick attains the best growth and yields in tropical climate in plains of South India. Muthuswamy, 1954. It prefers 300-1000 mm well distributed precipitation annually. However, it can tolerate drought to some extent. Irrigated crop gives good foliar yield, however, irrigation has to be withheld during Dec-Jan. months to get profuse flowering for greater fruitset. The tree has fragile limbs and branches and are often broken by heavy wind. Hence, in wind swept areas, moringa should be planted preferably in sheltered situations close to a wall or building or other permanent structures or wind break should be provided around the area planted.

Propagation and planting

Drumstick can be propagated by seeds or vegetatively by limb cuttings; the latter being generally preferred to ensure productivity. Budding and air-layering are also possible. Muthukrishnan and Seemanthini, 1974 reported that 1-2m long limb cuttings with 15-20 cm girth are the best materials for planting. They are planted preferably during June-August in 60 cm. cube pits at a spacing of 3-5 m either way. For planting a hectare, 400 to 1200 limb cuttings are required depending on spacing. It is advised to plant the cuttings first in polythene bags filled with potting mixture and get rooted before planting them in the mainfield. This method reduces casualities in the field and gives a uniform stand of the crop. Use of rooting hormones such as Seradix-2 results in 100% rooting of cuttings and air-layers, Sundararaj et al 1967.

Irrigation

The growing plants may not require watering except during hot weather when they may be irrigated once in about eight days. Muthusamy, 1954.

Intercultural operations

The tree basin may have to be cleared of weeds once in an year and slight hoeing of the soil under the trees will be beneficial. Seemanthini, 1964.

Nutrient requirements

Manuring of drumstick is rarely practised, being a hardy tree capable of growing with very little attention. In Kerala, green leaves, FYM and ash are put into ring trenches taken at 60-90cm away from the tree during rainy season and are covered by soil. Sundararaj *et al* 1968 reported that under Coimbatore conditions, application of 7.5 kg. FYM and 370 g of ammonium sulphate/tree/ year gave three-fold increase in yield when compared to unmannured trees. Under Kerala conditions, application of 10-20 kg FYM, alongwith 60 g N, 80g P_2O_5 and 40g K_2O/tree/year is recommended (KAU 1989).

Yield and cropping seasons

Plants raised from sprouted cuttings start bearing form 6-8 months after planting. Muthukrishnan and Seemanthini, 1974. During the first two years, yield will be low. From the third year onwards, regular bearing commences. A tree yields 400-600 fruits annually. In terms of weight, the yield will be 15-20kg/tree/year. A good tree may yield up to 1000 fruits/tree/year weighing upto 30 kg. The major cropping season is March-April. In South Indian conditions, besides March-April sometimes one more crop is obtained during July-September. Under North Indian conditions the tree sheds its leaves in December-January and new leaves appear in February-March. This is followed by flowering and fruit set.

Harvesting and storage

Fruits are harvested while they are tender, using long bamboo poles fitted with curved knives at their end. Fruits are usually harvested while their outer surface is smooth without showing prominant projections of seeds contained inside.

Old trees, as a result or their straggly habit of growth, become ill-shaped and ugly with tall lanky branches causing difficulty in fruit harvesting. In such cases 'Pollarding' is necessary. This is the process of heading back such old, tall and ill shaped branches to produce good shape and also to promote new growth on which fruits are produced in plenty. The fruits harvested are not stored for long since only fresh fruits fetch a premium price. There are no proper storage methods for fruits and hence they are not normally kept for more than 3 or 4 days. Under refrigerated conditions, the fruits may be kept for 10-14 days.

Pests and diseases

The tree is not affected by serious pests or diseases. Certain hairy caterpillars namely Eupterote mollifera, Noorda blitealis and N. moringae sometimes infest unopened flower buds causing flower drop Cherian and Besheer, 1939. Another hairy caterpillar pest which feeds on the foliage and tender shoots, sometimes assumes serious proportions. Kareem et al 1974 reported that certain fruit flies infest the fruits which lead to drying up and rotting of fruit tip.

For controlling caterpillar pests, they can be burned using lighted torches or can be repelled by the application of fish oil resin soap emulsion. BHC (WP) @ 28.5 g/11.25 l is also effective when sprayed 2 or 3 times at fortnightly intervals.

CURRY LEAF

Curry leaf (Murraya koenigii) is an under-exploited perennial leaf vegetable. It is a common backyard plant of South Indian homesteads. Its highly aromatic leaves are used to flavour and season food-stuffs. Leaves are also consumed raw in the form of chutney or preserve by grinding it with coconut gratings and chillies. Leaves retain flavour and aroma for long and even after drying. They are added to almost all the curries and hence its name 'curry leaf'. Leaves are good source of carbohydrate (18.7%), protein (6.1%) and fat (1%) and are reputed as very rich source of vitamin A (12,600 IU) and minerals (4%), IIHR, 1979.

Curry leaf is not cultivated in large scale in Kerala. Certain private ayurvedic pharmaceutical concerns cultivate curry leaf for use in medicinal preparations. In Tamil Nadu (Periyar District), Karnataka (Dharwad Belgaum and North Kannada Dist.) and Andhra Pradesh commercial curry leaf cultivation is gaining popularity. In Periyar district, Tamil Nadu, the crop yields 4 tonnes of fresh leaves/year. There are no established clones or high yielding varieties. However there are two types under cultivation, broad leaved and small leaved. For commercial cultivation broad leaved type is used whereas small leaved type is mainly cultivated for extracting volatile oil. There are also pink-petioled and green-petioled types among which the pink type has a strong aroma and preference in the market. In Tamil Nadu, pink petioled type is more popular and shows remarkable drought-tolerance compared to the green-type.

Jalaluddin et al 1990 stated that curry leaf cultivation is a profitable enterprise especially to marginal and small farmers as it can be grown even in poor soils incurring less inputs and less care. The return/unit area and the benefit cost ratio of its cultivation is comparable or more than any cash crop as it is less labour intensive with more remuneration. In Tamil Nadu, the cost of cultivation is estimated Rs. 3000/ha. and gross return is Rs. 20,000/ha. when calculated at the rate of Rs. 5/kg. of fresh leaves Gowda et al 1990. The cost benefit ratio is 1:5 or even more. Madalageri and Bhagavanthagoudra, 1989 reported that under high density planting, 10,000 plants could be grown/ ha. each plant yielding a mean of 2 kg. fresh leaves/year. Thus the production potential of this crop is 20t/ha. The constraints in curry leaf production are a very fewer, like the pest and diseases which often devastate the crop, unless or otherwise the grower bestows attention to resort to proper management strategies as it warrants.

Soil

Curry leaf is a hardy perennial which can be raised in marginal lands. It thrives well in deep well drained and light soils with high organic matter, Gowda et al, 1990 a.

Climate

Curry leaf, though originated in tarai tract in the foot hills of the Himalayas, its cultivation was spread mainly in plains along the tropical belt. It requires a milder climate with less severe winter and summer. Certain types are winter sensitive and some are insensitive. Madalageri et al 1990 reported that extra harvest of leaves was possible in winter insensitive types (DWD-2) compared to sensitive types which exhibited a definite period of winter dormancy. For commercial cultivation in South India, winter insensitive types are preferred. The plant can tolerate drought to a considerable extent but cannot withstand water logging. In ill drained conditions, the leaves turn yellow and start withering. It can tolerate a temperature range from 18 to 40°C., however optimum is around 30°C. Moderate precipitation well distributed throughout the year enhances foliar growth and yield. Curry leaf plants need plenty of sunshine and plants grown under shade look stunted.

Propagation and planting

Curry leaf is propagated through seeds and root suckers. For commercial planting, seedlings are usually used. Since curry leaf is a self pollinated crop, variability among seedlings is much limited, Indira and Peter, 1988. Root suckers, though give true-to-type plants, may not be available in plenty for large scale planting. Good, plumby seeds are collected during May-June from vigorously growing good mother plants. They are sown in Polythene bags filled with potting mixture and kept under partial shade. Regular irrigation using a rose-can is needed. Within 20-30 days seeds germinate and good seedlings attain a height of 20 cm. within three months. At this stage the plants may be transplanted to the mainfield in pits of 45 cm. cube at 2-5m spacing either way. Gowda _et al_, (1990 a) reported that young seedlings have a serious problem of poor establishment in the field. To avoid casualities, they suggested the use of well grown plants of 1 - 1½ year. In about an year of planting, the crop grows to 1 - 1.5m height. The first harvest of leaves can be made at this stage and the plants are pruned totally leaving short stubs of 30 cm from the ground. This helps to produce 3-5 branches and the plants are maintained as a bush at 1 - 1.5 m height.

Irrigation

In the first year of planting, irrigating the crop once in a week, especially during rainless months, helps in its easy establishment. Once established, the crop does not require much of watering and they can tolerate drought to a remarkable extent. However, irrigation once in a month significantly enhances foliar growth and yield.

Intercultural operations

After each harvest, the field should be thoroughly weeded and irrigated. Dead and diseased branches should be removed and the gaps, if any, should be filled up.

Nutrient requirements

In curry leaf cultivation, application of chemical fertilizers is rarely practised by farmers. Application of organic manure espe cially the empty earheads of cumbu (after threshing) at the rate of one basket/plant is followed by local farmers of Periyar district, in Tamil Nadu. Farm yard manure is applied once in two years. Gowda et al (1990 a) recommended 25 tonnes of FYM and 60 kg. N, 10kg P_2O_5 and 10 kg K_2O/ha. annually. Fifty percent Nitrogen and entire quantity of P and K are to be applied during June. Rest of N is applied after six months. Balaji, 1988 reported that curry leaf plants need to be fertilized with 50-150g N, 25g of P_2O_5 and 25gfof K_2O/plant annually for continuous growth and yield. Gowda *et al*, 1990 b however reported that higher levels of N may increase the attack of pests and diseases. They also reported that plants allowing to a natural growth (than pruned at different levels) and applied with 150g N, 75g P_2O_5 and 75 g. K_2)/plant annually gave the highest leaf yield. Instead of single application, splitting of fertilizers and applying it after each harvest is more beneficial in increasing yield. As per KAU 1989 application of 10-20 kg FYM and 60, 80 and 40g of NPK respectively/plant/year gives good growth and high yield under Kerala conditions. Bhargavantragoudra,1990 studied the effect of certain growth promoting substances and nitrogen in the growth and yield of curry leaf.

Harvesting and yield

Curry leaf is conventionally grown in South Indian homesteads as a perennial tree crop with wider spacing ranging from 2m to 5m either way. In this method, a hectare of land will accommodate only 625 to 2500 plants. Trees are allowed to grow tall and they attain 4-5m height within 3-4 years. This makes harvesting difficult and the yield/tree does not go beyond 8 kg/year. At this rate the annual yield/hectare is only 4-5 tonnes of leaves. A high density bush culture planting method was proposed by Madalageri and Bhagavantragoudra, 1989 which has the potential of yielding up to 25 t of fresh leaves/ha. According to this method 10,000 plants are accomodated in a hectare area at 1m x 1m spacing. Harvesting is done every 3 months. Initially the yield will be poor, but will increase with successive prunings. In each harvest 5 - 6t of fresh leaves/ha can be expected. Three to four harvests are possible in a year, if the cultivar is insensitive to winter. Under proper management conditions, the crop can be maintained upto 25 years.

Harvesting is done with sharp knives when the leaves attain full size and when their colour turn dark green. Since the leaves are used afresh they are to be marketed immediately after harvest. There are no proper storage methods for leaves. Harvesting leaves with 30-45 cm long lateral branches and preventing direct exposure to sunlight and packing them in banana leaves will help to retain the freshness of curry leaves for upto 48-72 hours after harvest. On drying, the leaves get shedded from the petiole. However they retain the aroma even after drying.

Pests and diseases

In red soils, termite attack is a serious problem for curry leaf cultivation. Dusting 5% BHC to the soil gives an effective control , Gowda, *et al*, 1990. Jalaluddin *et al*, 1990 reported Citrus psylla (*Diaphorina citri*), *Citrus* butterly (*Papilio demoleus*), black fly (*Aleurocanthus woglumi*), scale insects (*Anoidiella orientalis*), leaf roller (*Tonica zizyphi*), bark borer (*Indarbela tetraonis*), leaf weevils (*Myllocerus discolour*) and certain hairy caterpillars as common pests of curry leaf. Some of them assume serious proportions under vulnerable situations. However, the pests are easily manageable when plant protection measures are taken in time under close monitoring. Though, hand picking and use of insect traps are the best advocated methods, they may not be feasible in commercial plantings. Use of natural enemies comes as next best method. As a last resort, chemical insecticides can be applied but one should be very careful in avoiding their unscrupulous use as it may lead to the residual toxicity problem as the leaves are meant for direct use. Preferably the non-residual chemicals like Dimethoate, Fenitrothion, Malathion and Monocrotophos are used to bring down the pest population to below threshhold level. Even for these chemicals, the farmer must allow a safe waiting period of not less than 3 weeks for harvest of leaves after pesticide application.

CHEKKURMANIS

Chekkurmanis (*Sauropus androgynus*) is a small evergreen, slow growing bushy plant attaining a height of 2 - 3.5m. As a leaf vegetable, it is usually maintained as a perennial plant at a height of 1 - 1,5m by frequent harvest of leaves and apical stem. Due to the high nutritive value of the leaves, the plant is popularly called as 'multivitamin green'. Leaves are rich source of carbohydrates (11.6%), protein (6.8%), fat (3.2%) Vitamin A (9510 IU), thiamine (0.48mg/100g), riboflavin (0.32mg/100g), vitamin C (247 mg/100g) and good amount of minerals. The plant is a native of India and Burma and was introduced to Kerala from Malaysia in 1953.

Chekkurmanis, occupying a prominent place in almost all household kitchen gardens of Kerala, has not yet been cultivated in large scale for commercial purpose. Hence no data on area and production of this vegetable are available. On a rough estimate, its annual productivity is 30 tonnes of green leaves/ha. and production potential is upto 50 tonnes/ha. A homestead plant gives 1-3 kg of leaves/year. The cost of cultivation of this crop is very meagre since it requires not much of after-care. It is a drought tolerant crop, however, irrigation during summer helps to increase the number of leaf harvests.

Climate and soil requirements

Though plants are found at higher elevations upto 1200 m above MSL, it grows luxuriantly at lower elevations at 500 m MSL and below. The plant grows to a tall shurb when untrained in humid areas. Sunlight has profound influence on leaf shape and size and also in leaf yield, Shanmugavelu, 1989. When the plants are raised under shade, it produces broader leaves, whereas under full sunlight, it produces narrow leaves. Under partial shade and irrigated conditions, crop performs the best and the leaves are larger and more yields can be obtained. It comes up well in all types of soils. However, the growth and yield are high when they are grown in rich well drained sandy loam or semi-laterite soils. The plant produces leaves throughout the year and frequent clippings of apical tender shoot and leaves enhances branching and further grwoth.

Propagation

The crop produces viable seeds and plants can be propagated both by seeds and using stem cuttings. Seed propagated plants come to harvest little later and hence vegetative method is commonly adopted. Herbaceous stem cuttings (6-12 months old) may be collected with 5-6 nodes or 20-30cm length and planted in polythene bags containing sand. Treating cuttings in 50mg/1 NAA solution hastens rooting, Shanmugavelu, 1989. It takes 20-25 days for rooting. Rooted plants are transplanted to pits of 30 cm cube in trenches of 30 cm. width and 30 cm. depth. Usually, it is grown as a hedge or fence around other vegetable plots or kitchen garden. For planting a hectare area, about one lakh cuttings are required.

Manurial requirement

Shanmugavelu, 1989 reported that in each pit taken for planting chekkurmanis 5 kg. FYM is added in addition to 25g each of urea, superphosphate and muriate of potash. Liquid manure, prepared by placing cowdung in a gunny bag in a trough of water and soaked for 48 hours, then drained and diluted four times is applied at fortnightly intervals after each harvest. This is very effective in getting a luxuriant vegetative growth. Chemical fertilizers are not usually applied. However, application of 30g of 7:10:5 NPK mixture/plant supplemented with 1% urea spray after each clipping enhance leaf yield considerably, KAU, 1989; Indira and Peter, 1988.

Harvesting

First harvest of leaves is possible after 3-4 months of planting, when the plant reaches about 60 cm. height. Subsequently in every fortnight, another harvest is possible, if the plants are manured and irrigated. Plants are usually trimmed to 1 - 1.5m height to facilitate easy harvest. The tender shoots and leaves are used for culinary purposes. Shredded leaves cooked with coconut flour forms a delicious side dish for meals. Leaf bits added to blackgram flour and made into 'Vada' is a nutritious snack. Alongwith greengram the leaf shreds are made into certain curries to be consumed along with 'idlies' and 'dosai' as breakfast. The fresh tender leaves also form a good salad.

Pests and diseases

The plant is devoid of any serious pests and diseases except an occasional incidence of scale insects and aphids which can be controlled by spraying Malathion @ 1 ml/1 water. Caution should be taken not to pluck the leaves and tender shoots immediately after spraying the insecticide.

AGATHI

Agathi (*Sesbania grandiflora*) is a quick growing tropical tree valued for its edible leaves, tender pods and flowers. Leaves are also used as a good fodder and flowers are highly ornamental. Stem of the tree is rough and straight and used as a standard for trailing black pepper and betelvine plants. In Tamil Nadu, the plants are grown around banana garden as a wind-break and around coconut seedlings as a shade plant. The wood is soft and bark yields good fibre and a gum. The plant has medicinal values as well. Its leaves are rich in protein (8.4g/100g of edible portion), vitamin A (9000 IU), vitamin C (169mg/100g) and vitamin B Complex. Flowers contain 1.8 g protein/100g of edible portion. Flowers aregood for making 'Bajji'. Agathi is one of the few vegetables which provides iodine (2.3mg/100g of edible portion). Hence regular consumption of agathi leaves is good for goitre patients.

Agathi is not cultivated in large scale for vegetable purposes. It is grown in parts of Punjab, Delhi, Assam, Tamil Nadu and Kerala mainly for fodder and shade purposes. It is high time that we fully utilised this under-exploited nutritious plant for food purposes. The potential for leaf vegetable production of this crop is very high. On an average, it produces 40 tonnes of edible leaves/ha/year. Its potential for leaf production is upto 95t/ha/year. No works are reported on standardising its agronomical or nutritional requirements. If properly exploited, giving optimum cultural conditions, the crop has much greater potentiality in vitamin A rich green leaf vegetable production in the country.

Climate and soil requirements

Agathi grows well both in lower plains and in high ranges upto 1200m above MSL. The tree grows to a height of 12m if left unpruned. It requires plenty of sun-shine and under shade, the leaf yield and leaf size are affected. It comes up well in all types of soils, but grows the best in black cotton soils. Indira and Peter, 1988. It grows quickly when surface soil is loose and uneven. It is also resistant to drought.

Propagation

The tree produces long slender cowpea like pods during October-December which mature during summer and provide viable seeds. Seeds are first sown in nursery beds or in polythene bags filled with sand and dried cattle manure (1:1). Seedlings of 30-45 cm height are transplanted to mainfield in pits of size 30cm cube during May-June. Seeds can also be sown _in situ_. Two or three seeds are sown per pit and later only the best one seedling is retained in a pit. Pits are taken at 90-100cm spacing either way. In a hectare area 10,000 to 12,300 plants are planted.

Manuring

No reports are available on manurial requirement of the crop. However, application of nitrogen fertilizers are reported beneficial for growth and leaf yield in agathi. In Tamil Nadu, two months after sowing, ammonium sulphate is added, Indira and Peter, 1988.

Harvesting

Leaves are produced throughout the year in agathi. Three to four harvests of leaves are made at an interval of 3-4 months. First harvest is made after 3-4 months of planting. Tender leaves are harvested retaining older leaves. During summer, irrigation is given after leaf harvest. Tree flowers during September-December Young flowers and pods are harvested during this time and used to prepare 'Bajji' and several other dishes. Shredded leaves when cooked with 'grams' and coconut flour form a good side dish for lunch. The fresh tender pods are used just like cowpea.

Pests and diseases

Seedlings, in the early stages of planting, are affected by a blight disease caused by <u>Colletotrichum capsaici</u>. It can be controlled by applying 1% boredeaux mixture. There are also certain maggots (of drosophilid fly) which bore into the shoots of mature plants causing gradual wilt. They can be controlled by dusting with BHC (5%)

Prospects

Prospects of cultivating agathi for food and other purposes are great. The white flowered types can be cultivated for edible purposes where as the red flowered types, which are slightly bitter, can be used for other purposes. Leaves and flowers are also valued for their medicinal properties. The juice of the leaves and flowers is used in nasal catarrah and headache. A poultice made from leaf juice is applied to bruises. Leaves are useful for curing sore mouth. Juice of flowers is applied to the eyes to cure dimness in vision.

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Management of watermelon, Ridgegourd, Spongegourd and Bottlegourd

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Watermelon

Climatic requirement

Watermelon cannot withstand frost and needs a long growing season with a relatively high temperature. The seeds do not germinate satisfactorily below 21°C. It is less effected by atmospheric humidity when compared to muskmelon.

Soil requirements

Deep, well drained, rich sandy loam exposed to the sun are the best for watermelon. In Kashmir, it is grown on sandy alluvial soils. In U.P., it is grown on low priced sandy soils along the beds of Ganges and other rivers. It can also be grown in garden soils, and slightly slopy, gravel soils and even on highly acid soils - as high as pH 5.0. In Rajastan, it is grown on completely bare and new dunes both on wind-ward and lea-ward sides of the dunes (Chauhan, 1989).

Land preparation

Land is prepared by ploughing 2-3 times and finally planking it for the preparation of beds. Beds are made 2.4m wide with 60 cm. wide furrows between them.

In another method, pits of 60cm diameter and 30-45 cm depth are taken at the desired spacing. Pits are taken at a spacing of 2 x 3 m (KAU, 1989).

Sowing and seed rate

In U.P. and Delhi, it is sown in February and in central India from February to June. In hilli regions, it is sown from middle of February to end of March and from middle of July and in South India from middle of January to end of March.

Seed rate varies from 5.6 to 7 kg/ha.

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Manures & fertilizers

Dhesi _et al_ (1964) obtained higher yields with N,P,K at the rate of 50:25:25 kg/ha.

Kerala Agricultural University recommendation is as follows. Apply FYM @ 20-25 t/ha as basal dose along with half dose of N (35kg) and full doses of P (25 kg) and K (25 kg). The remaining dose of N (35 kg) can be applied in two equal split doses at the time of vining and at the time of full blossoming.

Analysis of growth and yield of variety Arka Manik in relation to irrigation and N fertilization revealed that increasing levels of N fertilization (60 kg $\longrightarrow$ 120 kg $\longrightarrow$ 180 kg/ha) increased dry matter accumulation and distribution through high leaf area index, leaf area duration and CGR and contributed a large proportion of dry matter to fruits resulting in higher yield (Hegde, 1988).

Irrigation

During the initial stages of growth, irrigate at an interval of 3-4 days. Irrigate alternate days during flowering and fruiting periods. After fruit formation, irrigation is restricted.

Results of an irrigation study in the variety Arka Manik indicated that frequent irrigation when the soil matrix potential at 15 cm. depth reached - 25 KPa resulted in maximum dry matter accumulation and distribution, leaf area index, leaf area duration, Net assimilation Rate and C.G.R. leading to higher yield (Hegde, 1988).

Interculture

To keep down weeds, intercultural operations should be done before spread of vines. Weedicides like butralin 1.7 kg and Ethalfluralin 0.8 to 1.0 kg per hectare as pre-emergent spray is effective.

Spreading of dry grass over the surface of soil before spread of vines help to avoid the direct contact of fruits with the soil.

Effect of growth regulations

Singh and Dixit (1975) reported earliness and increased fruit yield with NAA (100 ppm), MH (200 ppm) and TIBA (50 ppm).

Arora et al (1985) got more female flowers and yield with the application of GA_3 (25 ppm).

Harvesting

Fruits are ready for harvesting 30-40 days after pollination. From sowing to harvest, it takes about 90-120 days. Ripening stage is indicated by:

(i) Withering of tendrils
(ii) Change in colour of the ground spot from greenish white to pale yellow.
(iii) On thumping, the metallic sound of rind changes into a dull or dead sound.

Yield

40-60 tonnes/ha.

Handling and storage

Watermelons require careful handling as they are easily damaged. They cannot be stored for more than 2 to 3 weeks.

Storage studies in watermelon varieties Charleston Grey and Jubilee showed that preservation of sugar content was best with storage at 32°F but pitting and brown staining of the rind occured by day 8. Avoidance of these chilling symptoms and maintenance of sugar content were achieved by conditioning at 80°F for 4 days after harvest. Conditioned fruits could be stored at 70°F for upto 8 days without loss of marketable produce. Conditioning of the fruits can easily be achieved by placing in a ventillated non-refrigerated building after harvest (Picha, 1988).

Bottlegourd

Climatic requirements

Hot and moist climate is good for its cultivation. It is highly susceptible to frost. High rainfall and cloudy days promote disease and insect pest infestation. Under moderate climate, it can be grown throughout the year (Chauhan, 1989).

Soil requirements

It can be grown an any type of soil but loam and fertile sandy loam soil rich in organic matter are best suited. It can also do well in clayey soils if proper drainage is given. It does well in pH ranging from 5.5 to 7.

Land preparation

It can be sown in pits or beds. If sown in beds, then 2 to 3 ploughing is enough. In case of pits, digging of the soil for 15 to 20 cm should be done. Spacing is 1.5 x .9 - 1.2 m. Singh (1989) recommends a spacing of 2 - 3 m x 1.5 m.

Sowing and seed rate

In U.P., Punjab and Delhi, first crop is sown in February-March. Second crop is sown in June-July and third crop in October-November. In Bihar, it is sown from January to July and in November while in Rajstan it is sown from January to March (Chauhan, 1989).

Bottlegourd can be sown in February-March, June-July and October-November (Singh, 1989).

Seed rate is 4.5 to 5.5 kg/ha in summer and 2.2 to 3.2 kg/ha in rany season.

Irrigation

Summer crop requires irrigation at frequent intervals. There is no need for irrigation to rainy season crop except in long dry spells.

Interculture

Shallow cultivation is done before spread of vines. Weeds should be removed. Weedicides like Fluchloralin at 3 litres and Butachlor at 2.5 litres per hectare is excellent for weed control.

Storage

Bottlegourd fruits can be kept for 2 to 3 days without any damage under shade. They can be kept still better if they are sprinkled with water and stored in shade in a well ventillated place.

Ridgegourd and spongegourd

Climatic requirements

Both have got a wide range of adaptability. But they thrive best in warm humid regions.

Soil requirements

Though both the crop can be grown in any type of soil, well drained loam soil rich in organic matter is the best.

Land preparation

Land is ploughed 3 to 4 times, followed by one planking. It is sown in pits 60 to 90 cm apart or in lines of beds at the same distance. Plant to plant distance is 30 cm.

Sowing and seed rate

Early crop can be sown from January to March and late crop in rainy season. In hilly region, sowing is taken up in June-July. In Mysore, it is sown from February to October.

About 3.3 to 4.5 kg seed is enough for one hectare.

Manures and fertilizers

Each pit should be filled with 10 kg of well rotted farm yard manure plus 100 g of complex No. 6. Thirty days after sowing, 100g of ammonium sulphate may be applied as top dressing (Shanmugavelu, 1989).

Pruning

Pruning of ridgegourd to six pruning branches with a medium spacing level (45 cm) produced the longest plants, gave maximum

Manures and fertilizers

Bottlegourd is a shallow rooted crop and responds well to fertilizers. About 150-200 quintals/ha of farm yard manure or compost should be applied during land preparation. Besides 40-60 kg nitrogen, 40-60 kg phosphorus and 60-80 kg potassium should be applied.

Pruning

Pruning reduced the number of branches which is directly correlated with number of fruits and yield in bottlegourd (Sharma et al (1988).

Staking

It is better to provide Stake during rainy season. Staking will avoid the direct contact of fruits with wet soil. The growth and development of fruits are better when they are hanging. Generally, summer crop is not stalked. But it is advisable to spread dry straw or grass on the ground before the spread of vines.

Effect of growth regulators

Randhawa and Singh (1976) observed that GA 10-20 ppm, Cyeocel at 40-60 ppm and MH 200-300 ppm improved the female to male flower ratio in bottlegourd.

NAA 25 ppm proved most economical for large scale production of bottlegourd (Singh and Randhawa, 1969) . Saimbhi and Takur (1973) found ethephon 500 ppm to be effective in increasing fruiting and yield in bottlegourd.

Harvesting

Fruits of bottlegourd should be harvested when they are tender. The smaller and tender the fruits, the more is the price that it fetches.

Yield

130-235 quintals/ha.

Recent trends in the insecticidal control of key pests of vegetable crops*

Dr. C.C. Abraham**

The importance of vegetables in the balanced diet has been very well recognised, but the current level of dietary intake is only around one third of the optimum level of 280g/adult/day. This is mainly due to shortfall in production, the present annual output being only 45 million tonnes as against the requirement of 75 million tonnes. By the turn of the century, the requirement of vegetables for domestic consumption will be of the order of 120 million tonnes. Shortage of vegetables is very keenly felt in urban and suburban areas where the prices are steadily shooting up. It is time that we undertake a dynamic, target-oriented production drive to step up vegetable production in the country by quantum leaps.

Pesticides have been recognised as the key inputs for increasing the production of horticultural crops including vegetables. In India, these crops account for one third of the total annual pesticide consumption, which is of the order of 72,000 tonnes. The use of insecticides in an indiscriminate manner without any consideration of the need

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has led to the extensive spread of the toxicants in the environment and transport of their residues from one farming system to the other, leading to their build up and often magnification in the food chain. Widespread misuse of organochlorine insecticides such as DDT and BHC has already led to the build up of terminal residues in vegetables, fruits, milk and milk products.

In a carefully designed bio-rational strategy for pest management in vegetable crops, over-dependence on conventional insecticides should be dispensed with. Insecticides are to be chosen carefully on the basis of their innate toxicity to the key pests, bio-degradability and residue dynamics. There is a dire need for need-based applications of insecticides linked to the visual thresholds. It is time for us to accelerate the tempo of research efforts on toxicant with more target specificity and environmental safety with a view to identify the ideotypes which can replace the broadly toxic compounds that are currently used widely.

Benign and less expensive methods of pest control such as host plant resistance, bio-control and use of botanical pesticides possessing insectistaticidal properties are to be properly integrated along with chemical control in a compatible manner in IPM packages for vegetable crops to obtain stable levels of control at reasonable costs.

Indiscriminate application of insecticides in vegetable crops has brought about several hazards such as development of insecticide resistance to pests, terminal residues, environmental pollution, destruction of natural enemies and resurgence of primary and secondary pests. Development of insecticide resistance in the diamond back moth *Plutella xylostella* (L.) attacking cabbage and cauliflower, *Helicoverpa* (*Heliothis*) *armigera* (Hubn.) on a wide range of crops including tomato and the fruit and shoot borer *Leucinodes orbonalis* Guen. on brinjal is a serious problem caused by overuse of insecticides. The resurgence of *Bemisia tabaci* Genn. on several crops including tomato, greater incidence of the stem fly *Ophiomyia phaseoli* (Tryon.) on french bean and cowpea as well as that of the gall midge *Asphondylia capsici* and the mite *Hemitarsonemus latus* on bell pepper are other examples of recently emerging problems induced by insecticides (Sreenivasan, 1988).

INSECTICIDES FOR VEGETABLE CROPS - EMERGING TRENDS

The use of organochlorine insecticides in vegetable crops is a very dangerous practice which has to be curbed by means of coordinated extension efforts.

Synthetic pyrethroids are ideal candidates for use in vegetable pest control in view of their sharp contact toxicity stimulus and fast biodegradability. As a class, they are excellent against lepidopterous tissue borers. The massively increased potency of these compounds makes it possible to use them in relatively very smaller quantities. A wide range of photostable pyrethroids such as permethrin, cypermethrin, deltamethrin, fenpopathrin, flucythrinate and tefluthrin are currently available for pest control. Tefluthrin is a novel pyrethroid insecticide for controlling a wide range of soil insect pests.

Cartap hydrochloride (Takeda chemical Industries) based on the Nereistoxin principle possessing a novel mode of action consisting of blockage of ganglionic transmission by receptor binding, can be advantageously used to tackle pest species which have developed resistance to OP and carbamates. This is available in India as Padan SP 50%. For controlling the diamond back moth <u>Plutella xylostella</u> which developed resistance to synthetic pyrethroids and the OP group of insecticides, padan was found to be successful when applied at 0.3% ai. But recent reports show that the insect has developed resistance against cartap hydrochloride also. Further studies on the scope of using this insecticide on vegetable crops would be very rewarding.

Ethofenprox is a unique insecticide based on CHO molecular frame developed from the lead skeletons of fenvalerate and cypermethrin with added toxic stimulus and much reduced hazards to fishes and mammals. Trebon (Mitsui Toatsu Chemicals) based on ethofenprox is available as a 20% EC formulation to be used at 100 g ai/ha against pests of vegetable crops.

Avermectins are a new class of insecticide - nematicide, derived from the soil microbe *Streptomyces avermitilis*. These compounds block electronic potentialities between interneurones and excitatory motor neurones in the ventral nerve cord. Work on the utilisation of this compound for controlling nematodes and insect pests of vegetable crops is likely to be quite useful.

The use of granular insecticides such as carbofuran and phorate for controlling pests of vegetable crops has several advantages of extended systemic toxicity against sucking pests. Application of these toxicants at seeding and/or at transplanting or as bare root dips is a very useful measure to curb sucking insect pests which occur in the early growth phase in bhendi, brinjal and bittergourd crops, but the tendency to use these compounds in the post-flowering stage is highly hazardous. A waiting period of at least 60 days will be necessary in the case of carbofuran treatments, while, for phorate the period should be at least 80 - 90 days (Avasthi, 1981). The tendency to use carbofuran in excessive quantities even beyond the flowering stage of bittergourd has somehow become popular among farmers in Kerala. This is a dangerous practice which has to be discontinued for the better.

Carbosulfan (dihydro dimethyl benzofuranyl methyl carbamate) has all the advantages of carbofuran with the additional advantage of stability under alkaline situations.

Seed treatment with carbosulfan 25% DS at 1.25% ai on a w/w basis is reported to be effective to control the sucking insects which occur during the early growth stages of vegetable and other crops. The formulation contains a binder adhesive, which ensures uniform sticking of the toxicant on the seed coat. In bhendi and cowpea, early season pests are limiting factors in the survival of plants and seed treatment with carbosulfan is, therefore, a very useful practice.

INSECTISTATICIDES FOR PEST CONTROL

The emerging trend in crop protection is to make use of insectistaticides for decimating populations by suppressing growth and reproduction rather than causing rapid mortality. Plant derived products, chitin synthesis inhibitors (diflubenzuron, triflumuron, buprofezin); hormones such as juvenoids, ecdysteroids; antihormones and nutrient antagonists belong to this novel group of pesticides.

Plant derived compounds present a treasure chest of bio-active principles for pest control. Among a wide range of botanicals evaluated, the products from the neem tree Azadirachta indica and the China berry Melia azederach (Meliaceae) have shown great potential in controlling insect pests. The feeding inhibitory properties of the Neem Seed Kernel Extract (NSKE) are due to the presence of the three terpenoids, namely, meliantriol, azadirachtin and solannin. Due to the complexities of the molecular structure, neem terpenoids are quite unlikely to be synthesised. Indian neem kernels contain only 0.75 g of kg^{-1} of azadirachtin, while the kernels from neem trees grown in Ghana are richer, the content being 3.50 g kg^{-1}. NSKE is to be used at 3-4 per cent for protecting vegetable crops against lepidopteran larvae. Neem oil emulsion at 3 per cent also possess antifeedant properties, but as compared to NSKE, this is inferior.

A decoction prepared by boiling neem leaves in water has also been reported to be effective against sucking pests (Nandagopal *et al*. 1990). Appropriate formulations, proper timing and methods of application are important considerations in the use of neem materials for pest control in vegetable crops. Among other plant species reported to possess insectistatic principles, the sweet flag, *Acorus calamus* (Araceae) malabar nut *Adathoda vasica* and *A. beddoni*; red bean vine, *Abrus precatorius* (Fabaceae) Indian privet, *Vitex negundo* (Verbenaceae), *Annona reticulata* (Annonaceae) are more important candidates for further evaluation against vegetable pests.

Acorus calamus rhizomes contain an essential oil the vapours of which are capable of inducing sterility in female insects by causing resorption of the terminal oocytes in the ovarioles. The active ingredient involved is beta-asarone. In males, sterility is induced by immobility, agglutination and malfunctioning of the sperms, due to suppression of the interstitial cells of the vas deferens. The essential oil is highly superior to classical chemosterilants which possesses toxic, mutagenic and carcinogenic properties (Anon..1983). A major application of *A. calamus* rhizomes is in protecting various kinds of seeds and grain from pest infestation in storage.

The chitin synthesis inhibitors such as diflubenzuron, triflumuron are effective against lepidoptera while buprofezin is specific against Homoptera. Very little work has been done on their utilisation for vegetable pest control. Work on these aspects needs to be stepped up.

Juvenile hormone analogues based on kinoprene are ideal for controlling white flies infesting vegetable crops grown in green houses. Methoprene based formulations for the control of Agromyzid leaf miners in vegetables and sciarid flies infesting mushrooms have already been cleared for field use.

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Nematode problems in tropical vegetables and their management

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It is now scientifically well recognised that plant parasitic nemetodes act as a limiting factor in agricultural production. Several plant nematodes are implicated to cause serious damage to vegetable crops leading to production of poor quality produce and yield loss. Vegetable production in every part of the country is impaired to a greater or lesser extent by nematode pests. In more recent times, awareness of nematode attack on vegetable crops have increased greatly in economic proportions. An extensive list of plant nematodes associated with various vegetable crops in India was reported by Sitaramaiah, (1984). However, studies connected with the pathogenic capability of some important fifteen species of plant nematodes alone are established. (Table 1.). In the foregoing pages, the nematode problems and their management on the important tropical vegetables are discussed.

A. Tomato

Tomato (*Lycopersicon esculentum*) is associated with eight species of plant nematodes among which the root knot (*Meloidogyne spp.*) and the reniform (*Rotylenchulus reniformis*) nematodes are the serious pests (Table 1). These two nematodes are almost prevalent in all the vegetable growing areas/fields in our country.

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Table 1. List of Important Plant Nematode Parasites associated with Tropical Vegetable Crops

Vegetable Crops	*Meloidogyne incognita*	*M. javanica*	*M. arenaria*	*M. thamesi*	*Xiphinema basiri*	*Rotylenchulus reniformis*	*Hoplolaimus indicus*	*Helicotylenchus sp.*	*H. dihystera*	*Pratylenchus capitatus*	*Tylenchorhynchus sp.*	*Heterodera canjani*	*Meloidogyne lucknowica*
Tomato	x	x	-	-	x	x	x	x	-	x	x	-	-
Eggplant	x	x	-	x	-	x	x	x	-	-	x	-	x
Ōkra	x	x	-	x	x	x	x	x	x	x	x	x	-
Cowpea	x	x	-	-	-	x	x	x	-	-	x	-	-
Chillies	x	x	x	-	x	x	x	x	x	-	x	-	-
Ashgourd	x	x	-	-	-	x	x	x	-	-	x	-	-
Bittergourd	x	x	-	-	-	x	x	-	-	-	x	-	-
Ribbed gourd	x	x	-	-	-	x	x	-	-	-	x	-	x
Pumpkin	x	x	-	-	-	x	x	-	-	-	x	-	-
Amaranthus	x	x	-	-	-	x	x	-	-	-	-	-	-

x = Parasitic

\- = not parasitic

Root knot nematodes (*Meloidogyne* spp.)

Among the root knot nematodes, *M. incognita* and *M. javanica* (Srivastava, 1969) are the two important species attacking tomato. They attack the plant alone or in concommittance according to the distribution of the population present in the vegetable fields. An analysis of crop loss caused by *M. incognita* was done by Reddy, (1985) and he reported that a a preplant nematode population density of 20 larvae/gram of soil in the field, can result in yield reduction by 39.7%. This loss was due to the few number and low weight of fruits produced and delayed fruits ripening. According to Parvatha Reddy, (1985), the avoidable yield loss due to *M. incognita* alone could be between 40-46%.

Presence of this nematode attack can easily be identified by the swelling (galls) produced on the roots even in the nursery beds as well as in the main field. These nematodes feed on the conductive tissues in the root systems and cause pathogenic effect in blocking uptake of nutrients and moisture; which indirectly reflect on plant growth and its physiological functions. Alam *et al*, (1974) reported that the amount of water absorbed by tomato plants infected by *M. incognita* @ 50, 500, 5000 larvae/plant were 4.97, 3.54 and 1.64 g respectively against 6.02 g absorbed by a healthy plant. Ganguly and Das Gupta, (1988) reported that *M. incognita* infection in tomato (var. Pusa Ruby) induced quantitative changes in protein and polyphenol oxidase.

Not only the infection by root knot nematodes alone affect the productivity of tomato crop, their infection lead to further invasion by the soil borne pathogenic fungi and bacteria leading to disease complexes. Routry *et al*, (1986) found that prior infection of *M. incognita* 7 days earlier increased wilt caused by *P. solanaceanum* upto 75%. Ramnath and Kamal Wanshi, (1989) reported that *M. javanica* infection predisposes tomato plants to attack of *Penicillium digitatus* and *Rhizoctonia bataticola* enhancing root necrosis and damping off of tomato seedlings. Root knot nematode and *Fusarium* causing wilt of tomato, are also well known.

Reniform nematodes

The other important nematode which attack tomato is the reniform nematode *Rotylenchulus reniformis*. The life cycle and pathogenic effect caused by this nematode are worked out by Sivakumar and Seshadri, (1972). They reported that *R. reniformis* is mainly a phloem feeder in tomato roots. It causes hypertrophy hyperplasia, thicknening of cell walls, granulation of protoplasm, enlargement of nueleoli and nuclei in the infected cells. Giant cells are formed. Deposition of lignin and suberin are observed. The infected cells have excess of starch granules and proteins compared to normal cells. Around the feeding site 100-150 giant cells are formed. No cell changes are found in xylem tissues. Tomato is found to be a very good host for this nematode and the population development and increase on tomato is 136.9%, (Sivakumar and Seshadri, 1971). Recently the dagger nematode *Xiphinema basiri* is reported to attack tomato plants and cause pathogenic effect, (Roy, 1973). The nematode attack produces typical "Fish hook" symptom on root tips of tomato roots. This nematode is an external feeder.

Control

Management of nematodes attacking tomato are studied and different ways of tackling them are reported by several workers. Tomato varieties resistant/tolerant to the nematode infection have been evolved (Table 2).

Table 2. Details of tomato varieties/cultivars resistant/ tolerant against plant nematodes

Varieties	Nematode against	Authors
Beef Master, VNF 360, Betterboy, Bigset, Bonus, Contessa, Hessoline, Montecarlo, Motabo, Motella Piernita, C_1, 3110, 3279, 3104.	*M. incognita* *M. javanica*	Mahajan and Mangat, (1984)
NTDR - 1	11 isolates of *M. incognita* 4 isolates of *M. javanica*	Narayana and Reddy, (1983).
Radiant, Ronita, NMR-1, S.L. 120	*M. incognita*	Singh and Reddy, (1982).
Punjab NR-7 (Cross of S_{12} x NMR-1)	*M. incognita* *M. javanica* Fusarium wilt	Nandpuri *et al* (1988).

Chemical control

Several measures to prevent the infection of nematodes are reported by workers. Among the chemical methods, bare root dip treatment and application of granular pesticides are successful in eliminating nematode infection. Treatment of nursery to produce nematode free seedlings for transplantations, is suggested as one of the methods.

Sivakumar _et al_, (1976) reported that application of Carbofuran @ 0.18 to 0.36 kg ai/ha ten days after transplantation gave control and higher yield of tomato infested with _M. incognita_. In case of _R. renoformis_ infection carbofuran @ 0.15 to 0.30 kg ai/ha or aldicarb @ 0.4 to 0.8 kg ai/ha 10 DAT was effective; and increased yield. They found that application of lower doses were more economical. Thaker and Patel, (1985) observed that bare root dips of tomato seedlings with phenamiphos @ 250-750 ppm for 15/30 mts or Isofenphos @ 500-750 ppm for 30 mts gave minimum root knot index in case of _M. javanica_ infection and control of the nematode. Jain and Bhatti, (1988) found that phosphomidon @ 1000 ppm for 8 hrs before transplantation gave effective control of the same nematode but was phytotoxic. They also reported that transplanting 8 weeks old seedlings alone reduced root knot infection compared to 4 weeks old seedlings. Application of aldicorb 1 kg ai/ha at transplantation reduced the nematode attack and increased yield. Haque and Padmavathy, (1985) reported that increased aged seedlings of tomato transplanted reduced the _R. reniform_ nematode attack. This may be probably due to maturity of roots giving a mechanical protection for the penetration of the nematodes.

B. Brinjal

Eggplant (Brinjal) (Solanum melongena) is attacked by four species of root knot nematodes, the reniform nematode and three species of ectoparasitic nematodes (Table 1). Among these, the root knot nematodes Meloidogyne species and Reniform nematode R. reniformis are the most important ones.

Root knot nematodes (Meloidogyne species)

Among the root knot nematodes, M. incognita and M. javanica attack egg plant frequently. M. thamesi and M. lucknowica also infect the crop. Crop loss caused by the root knot nematodes on brinjal is reported anything between 50-75% (Sanwal, 1951). Gaur and Prasad, (1980) reported that an yield reduction of 80% could occur , if there are 4000 juveniles/250 cc soil/plant as initial population by attack of M. incognita. They found that yield reduction could be due to hastened maturity of the crop and short duration of fruiting stage of the infected plants. Dhavan and Sethi, (1976) found that even 1000 larvae of M. incognita/1000 g soil could result pathogenic effect on eggplant. In Haryana under field conditions, the yield loss due to M. incognita attack on brinjal is reported 34-45% by Bhatti and Jain, (1977). Hrishnappa et al, 1981 found that M. incognita attack could result 44.8% yield loss by nematode alone. In a nematode protected plot by applying 8 kg ai/ha of phorate the yield obtained was 20500 kg/ha where as the yield in unprotected field was only 11300 kg. Impacts on plant growth by nematode attack were studied by Kurian and Kuriyan, (1981) and they found that 10,000 larvae/plant resulted in reduction of 64.5% leaf production, 32.6% shoot length, 61.2% shoot weight, 34.9% in root weight and 82% in yield. Apart from the damage caused by nematode alone, they predispose plants to other insect pests and fungal/bacterial diseases. Sitaramaiah and Sinha, (1984) observed that the combined effects of *Pseudomonas solanacearum* (Biotype 3) and *Meloidogyne javanica* on eggplant were greater than independent infections. They found that even 10 egg masses/plant could facilitate disease development in a period of six days. Mishra and Nath, (1988) reported that 85% of the root knot infected egg plants were further attacked by red spider mites and shoot and fruit borer pests. In ungalled plants, no attack of these pests were noticed. The nematode infected plant root system could change the chemical composition in plants, predisposing them to attack by other pests (Wallace, 1973).

The Reniform nematode

The pathogenic effect caused by *Rotylenchulus reniformis* on egg plant was studied by Singh and Khera, (1979). They found that this nematode causes heavy damage on plants, even @ 100 nematodes/1500 cc soil as initial inoculum. They reported that this nematode feeds on cortical parenchyma cell of roots, leading to hypertrophy of cells and mechanical changes in the tissues. They also observed that the nematode could bring about 55% and 75%, reduction in dry shoot and root weight due to its attack, at a population level of 10000 larvae/plant within a period of 90 days.

Control of nematode attack in brinjal

Since brinjal is invariably attacked by the common important plant nematodes, it is imperative that suitable pest management practices are adopted; to obtain optimum yield return from the crop. Checking nematode attack not only increases yield but also saves the crop from other serious fungal and bacterial diseases.

Studies conducted at OUAT Bhubaneswar using Karanj or neem cake against *M. incognita* increased yield 8-10 quintals/ha. over untreated plants,(Anon, 1979). It is also reported that application of carbofuran 3 G @ 1 g/30 cm^2 as preplanting field treatment gave three fold increase in yield. Dipping roots of brinjal seedlings in 1% carbofuran solution for 6 hrs before transplanting prevented nematode attack. Three weeks old seedlings dipped in 1200 ppm Oxamyl (Vydate) for 20/30 mts gave good control of *M. incognita* infection in eggplant and no phytotoxicity was observed by Alam *et al*, (1973). Bare root dip treatment of brinjal seedlings before transplanting in 500-1000 ppm of Aldicarb, carbofuran or turbufos for 10-15 mts against, reniform nematodes (*R. reniformis*) were effective in reducing soil/root population upto six weeks of treatment,(Krishnaprasad and Krishnappa, 1981).

Cultural operations are also effective in reducing nematode population in soil in the field. Deep digging in plots (20 cm depth) prior to transplanting seedlings, raised in nursery treated with metham sodium @ 25 ml/ m^2 and spot application of aldicarb @ 1 kg ai/ha reduced nematode attack and increased yield.

Attempts made to find out resistance against the nematodes by earlier workers failed. Recently, Ravichandra *et al*, (1988) reported that a cultivar viz. Gulla of eggplant popularly grown in Southern Karnataka was highly resistant to race 1 and race 2 of *M. incognita* and slightly susceptible to *M. javanica* and race 3 of *M. incognita*.

C. Bhindi (Okra) (*Abelmoschus esculantus*)

This vegetable crop is attacked by two important kinds of nematodes viz. the root-knot (*Meloidogyne spp*) and the reniform (*Rotylenchulus reniformis*) nematodes. Apart from the above, three more nematodes attack this crop. Whenever okra is rotated with/after the solanaceous vegetables the enhanced population resulted in the field attacks of this crop (directly seeded) and damages severly. Field level studies conducted on the avoidable yield loss caused by the root knot nematodes alone is 28-91% in Okra, (Reddy and Singh, 1981). In Rajastan, Yadav *et al* (1975) observed that the yield increase in field trials conducted for chemical control of nematodes attacking Okra, varied from 30-70% by different chemicals. Anwar and Alam, (1989) reported that both *M. incognita* and *R. reniformis* caused significant reduction in plant growth in Okra c.v. Pusa Savani. Water absorption capacity of roots were impaired. In concomitant infections, the reduction in plant growth as well as water absorption capability (WAC) were more pronounced. The nematode attack also reduced the uptake of nutrients. Haque *et al*, (1972) found that in aerial parts of root-knot (*M. incognita*) nematode infected plants, less of NPK levels were present compared to uninfected ones. The roots of nematode infected plants contained more of

NPK. Sharma et al. (1980) reported that synergistic effect on root rooting was present in Okra plants. When both *M. incognita* and *Rhizoctonia bataticola* attacked together, pronounced increase of proline in roots was observed.

Nemetode management

Several workers attempted to check the nematode attack on Okra by use of chemicals and other non-chemical methods. Sivakumar and Meerzainuddin, (1974) observed that application of K in combinations with P or N or K alone check reniform nematode multiplication. N alone increases multiplication whereas P and K caused the lowest multiplication. According to Sivakumar and Seshadri, (1972) Bhindi is not a very good host for reniform nematode and increased population by 40% only. Rao *et al.* (1987) reported that Aldicarb or Carbofuran @ 1 kg ai/ha with Neem cake @ 0.5 t/ha checked reniform nematode attack, increased growth and yield. Kumar and Sivakumar. (1981) attempted seed treatment with nematicide and fungicide for control of wilt complex involving reniform nematode and *R. solani* in okra. They observed that 5% carbofuran (w/w) or aldoxicarb (2%) with starch as sticker was effective in control of pre and post emergence wilting. Yadav *et al.* (1975) obtained 70% increased yield in Okra by use of Vydate (0.2%) as seed tratment and foliar spray for control of nematodes at field level. Use of dry azolla as bio-fertiliser 2% by w/w basis checked root knot nematode attack in Okra by Thakar *et al.* (1987). Four weeks old decomposed subabool leaves @ 40 g/kg soil with carbofuran @ 1 kg ai/ha was effective in checking attack of root knot nematode in okra according to Paruthi *et al.* (1989). Ramanath *et al.* (1982) found that application of decomposed material of Argemone mexicana (weed) @ 2 kg/6 M^2 plot controlled M. javanica attack in okra. Use of oilcakes or saw dust or paddy husk 500 g/plant or Cromolaena or neem leaves 250 g/plant applied to basins of plants a week prior to planting control nematodes on Bhindi, (Anon, 1989). In Assam, M. graminicola infected Bhindi, (Roy, 1990). The TNAU, Coimbatore has released a variety AE 116, resistant to M. incognita.

Chillies (Capsicum annuum)

Though about 30 species of plant nematodes are reported to be associated in soil with Capsicum spp., (Sitaramaiah, 1984), chillies are attacked by about six important nematodes, among them the root knot nematode M. incognita, M. arenaria and M. graminicola, (Rao et al, 1984), the spiral nematode Helicotylenchus dihystera, the stunt nematode Tylenchorhynchus sp. and root-lesion nematode Pratylenchus dellateri are the most important. Field tests carried out at Udaipur on crop loss caused by the root knot nematodes revealed 50% yield loss @ 4 larvae/g soil as initial population. These nematodes definitely cause pathogenic effect on chillies. M. areanaria causes yellowing decline disease in Tamil Nadu, reduction in shoot length and weight and root weight of infected plant. It produces distinct symptoms on the plant viz. interveinalchlorosis, downward cupping of leaves and significantly reduced yield of infected plants, (Rajagopalan et al, 1969). H. dihystera and P. dellateri cause preceptible reduction in root growth resulting less vigour and growth of plants and crinkiling of leaves at 50 nematodes/ 1500 cc of soil at planting time, (Muthukrishnan et al, 1975). Chillies also serve as a good host for the reniform nematode and sustain populations built up.

As many as 19 varieties and cultures of chillies were screened for resistance against root knot nematodes but none were free from infestation, (Rajagopalan, et al, 1971). Recently Jain et al, (1983) reported that CAP 63 and line No. 579 were highly resistant and moderately resistant respectively to *M. javanica* in Haryana. Screening tests with chillies conducted for resistance against *M. incognita* has not met with success, (Anon, 1984). In Orissa, deteailed trials with chemicals for control of chillies nematodes were carried out, (Senapathy, 1983). According to Muthukrishnan, (1973) application of Fensulfothion @ 7.5 kg ai/ha around base of plant at planting time effectively controls. root-knot nematode infection. Under the AICRP on Nematodes, screening tests carried out at different centres revealed that varieties Pusa Jwala, Sindhuri and Chanchal are resistant against *M. incognita* and varieties Mohini, Chaman are found moderately resistant to the same nematode, (Anon, 1987). Several lines tested were promisingly resistant and being further tested.

Gourds

Bittergourd (*Momordica charantia*) is attacked mainly by the root-knot nematodes *M. incognita*, *M. javanica* and the reniform nematode *R. reniformis*. The root-knot nematode attack induces unthrifty growth of vines, with production of small sized leaves which crinkled in the margins. The fruits are under sized. Detailed studies on assessment and the exact nature of crop loss and damage are to be worked out. The above mentioned three nematodes also attack ribbed gourd and cause similar type of damages on the plants. Hussain and Saxena,(1969) reported that Meloidogyns spp. cause galls on the stem of L. acutangula which are in the soil level and these galls are similar to the root galls. They also attack ashgourd (Benincasa hispida) and pumpkin (Cucurbita moschata),(Sethi et al, 1964). Field trials conducted at Rahuri showed that 36.5% of yield loss is caused by M. incognita when the initial nematode population is 4-6 larvae/g of soil,(Anon, 1987). Paruthi and Gupta,(1985) reported that M. javanica induced growth reduction on bottle gourd (Lagenaria siceraria) even with 100 larvae/kg soil at sowing time of seeds. Siddiqui et al,(1974) observed that M. incognita produces galls of various sizes and shapes and plants undergo temporary or permanent wilting under water stress. This nematode is a steelar feeder and changing the parenchymatous cells to meristematic and abnormal phloem occur.

Cowpea

Sitaramaiah,(1984) had recorded that cowpea (Vigna sinensis) is associated with 18 nematodes, among those three species of root-knot nematodes (Meloidogyne), spiral nematodes (Helicotylenchus sp.) five species of stunt nematodes (Tylenchorhynchus sp.) the lance nematode (Hololainus indicus) and the reniform nematode (Rotylenchulus reniformis) are important. The cyst pegionpea nematode Heterodera cajani is also an important one. Among all these, Meloidogyne spp. and Rotylenchulus reniformis,(Khan et al, 1969) are the most important, frequently attacking the crop and causing considerable damage. Reddy,(1988) recorded the avoidable crop loss due to root-knot nematode on cowpea as 29%. Unpadhyay and Singh, (1985) observed that

M. javanica infected plants at higher nematode levels exhibited yellowing, shedding of leaves and stunting of plants with reduced rhizobium nodulation. Nanjappa et al,(1978) reported that emergence of cowpea seedlings were delayed and seedlings stand reduced by 11% due to R. reniformis @ one nematode/g of soil. Cowpea can be subjected to con-comitant attack of M. incognita and Heterodera cajani under field conditions. In such cases the two nematodes are found mutually affected and inhibited for host infection and total multiplication. Prior infection by one is detrimental to the other,(Sharma and Sethi, 1976a). However they observed that H. cajani was faster in causing infection than M. incognita. They also found that both the nematodes singly or in con-comitantance reduced growth significantly, affected root nodulation and N content in plant. Reduction of N content is found more in M. incognita alone attacked plants than H. cajani. These two nematodes, attack 'N' nodules also. Sharma and Sethi, (1976b) also observed that low concentration of carbohydrates in plants can be one factor responsible for resistance/tolerance. In susceptible plants, more carbohydrate accumulation was noticed by them. Studying the interaction of fungi with the nematodes, Khan and Hussain (1988) found that Rhizoctonia solani along with M. incognita caused greater reduction in plant growth than by R. reniformis. Varaprasad, (1985) observed that H. cajani along with Fusarium solani and R. bataticola caused reduction in plant growth. However, the nematodes adverse effects were mitigated especially with high level inoculam of R. bataticola but the cyst formation was higher and not affected. According to Gangully and Das Gupta, (1988) superoxide dismutate enzyme activity increased in susceptible varieties and was less in resistant varieties (C152 and 82-1-B). It is reported that this enzyme is necessary for protection of cell and helps development of the nematode in susceptible variety (Pusa Barsati).

Management

Upadhyay and Singh, (1985) reported that aldicarb @ 2 kg ai or phenamiphos 2.5 or 3.0 kg ai/ha were effective in increasing plant growth and reduction of root galling. Several workers reported the availability of resistance in cowpea against M. incognita. The lines IC 8444, IC 20626, IC 44671 are resistant (Das et al., 1988) whereas IC 9642-B and TVY 2430 P are also resistant, (Singh and Reddy, 1982), the popular ones being C152 and 82-1-B. According to Thakar and Patel, (1984) V-16 variety is highly tolerant to R. reniformis. Sharma and Sethi, (1976c) reported that Barsathi mutant, P910, P426 (126R), Iron, P309 (85-R) and New Selection were free from galling.

Amaranths

The root knot nematode M. incognita and other species are the most important pests attacking the edible amaranths cultivated for vegetables. Severe infestation by the nematode causes under sized leaf and poor stand of the plants. The typical symptoms of nematode attacks exhibited by plants are midday wilting of foliage eventhough they are green and the wilting recovers in the evenings and morning periods. Though no exact information on crop loss and damage, the nematode can cause is known on amaranths; raising of this leaf vegetable in rotation after any other vegetable, definitely get nematode attack and thereby poor yield. Reddy *et al* (1980) screened 46 varieties and four *Amaranthus spp.* *A. candatus*, *A. cruentus*, *A. hypochondriacus* and *A. tricolor* without any success.

Conclusions

Majority of vegetable crops are attacked by the two most important nematodes viz. the species of root knot (*Meloidogyne spp.*) and reniform nematodes (*Rotylenchulus sp.*). The pathogenic effect and crop loss caused by them are established in tomato, brinjal, bhindi, cowpea, chilli, etc. Crop rotation or mixed cropping by these vegetables or continuous monoculture of any of these vegetables result in maximum built up of nematode population in soil, (Khan *et al.*, 1975). Such instances are reported in certain isolated cases. Chemical control of these nematode pests are expensive and lead to pesticide residue problems especially when farmers have to adopt plant protection measures by use of insecticides, nematicides or fungicides for saving their crops from pests and diseases. Judicial application of organics/oil cakes along with modified cultural practices and using resistant/tolerant varieties in a combined form will alone check the nematode pest attack.

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Pests of Solanaceous vegetables and okra and their management

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Brinjal, tomato, chillies and okra are infested by a number of insect and mite pests. For early detection and proper management of pests, before they cause any economic loss, regular monitoring of the crop in the field, correct identification of the pests and timely adoption of control measures are very essential.

Some important points to be born in mind in vegetable pest management are summarised below:

1. More emphasis has to be given for mechanical and cultural methods of control, especially in kitchen gardens.
2. The pests are attacked by many parasites and predators. Before application of insecticides, monitor the levels of parasites and predators in the field. When the population of parasites and predators are high, application of insecticides will be counterproductive.
3. If application of insecticide is essential, choose a chemical with the lowest mammalian toxicity and avoid chemicals with long residual property.
4. Just before application of insecticides, harvest all the ripe and nearly ripe fruits.
5. Next harvest should be done only after the completion of waiting period of the insecticide on the crop.
6. When mite pests are also present, choose an insecticide with miticidal properties.
7. Make sure that the insecticide chosen will not cause any phytotoxicity.
8. Apply the recommended quantity of insecticide to get effective control.

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1. Brinjal

1.1 Borer pests

i) The shoot and fruit borer Leucinodes orbonalis G.

This insect is widely distributed in India and is the most destructive pest of brinjal. The female adults lay eggs in batches of two to four on the underside of leaves, on green stem, flower buds and calyces of fruits. The larva is a borer of tender shoots, leaf petiole, leaf midrib, flower buds and fruits and feeds on the internal tissues. The affected shoots drop and the affected leaves and buds dry and drop. The damaged fruits show circular exit holes plugged with excreta.

The infested fruits are unfit for consumption. Hami (1955) reported that the vitamin C content is reduced to the extent of 68% in infested fruits.

Management :

a) Avoid continuous cropping

b) Collect and destroy the infested shoots and fruits

c) Grow less susceptible varieties. Long and narrow fruits are found to be less susceptible (Sreenivasan and Basheer, 1961). In screening trials, many varieties were identified as resistant or moderately resistant to the pest (Mote, 1981; Panda et al 1971; Nair and Abraham 1987).

d) Spraying Carbaryl 0.15% at intervals of 15-20 days (Anonymous, 1989) or Dichlorvos 0.05% or Endosulfan 0.05% at fortnightly intervals (Deshmukh and Rattanlal, 1969).

ii) Brinjal stem borer Eusophera perticella R.

The caterpillars after emerging from eggs bore into the stems and tunnel downwards. The infested plants wither and wilt.

Management : (as in shoot and fruit borer)

iii) Bud borer Scrobipalpa blapsigona (M).

The larvae bore into the flower buds and the affected buds fall down.

Management : Spray Malathion 0.05%, Endosulfan 0.05% or Dichlorvos 0.05%.

1.2 Leaf feeding insects

i) The Hadda beetles

Henosepilachna vigintioctopunctata (F.)
Epilachna dodecastigma M.
E. implicata M.
E. ocellata R.
E. septima D.
E. demurili

The first one is the most common and the most destructive to brinjal. Cigar shaped yellowish eggs are laid on the ventral surface of the leaves. The grubs and adults feed by scraping chlorophyl from epidermal layers of leaves which get skeletonised and gradually dry away.

Management :

a) Hand picking and destroying the eggs, grubs and adults.
b) Spray Carbaryl 0.2% or Endosulfan 0.05%.

ii) Other leaf feeding beetles

Lema praeusta (F.)
L. semiregularis J.
L. signatipennis J.

These are minor pests of brinjal in Orissa. The adults and grubs feed on leaf tissues. The main host is turmeric. Usually no control is necessitated.

iii) Brinjal leaf roller

Antoba olivacea (W.)
Pterophorus lienigianus

The first one is more common and the caterpillar of the insect folds the leaf from tip downwards and feeds from within the leaf rolls. As a result of feeding, the leaves wither and dry up.

Management :

a) Collect and destroy the rolled leaves with larvae and pupae inside

b) Spray Carbaryl 0.2% or Endosulfan 0.05%.

iv) Brinjal leaf webber.

Psara bipunctalis (F.)

The caterpillars on hatching from the eggs scrape and feed on the epidermal tissues gregariously and later, web the leaves with silken strands skeletonising the leaves completely. Pupation is in soil.

Management : as given against leaf roller

v) Leaf miners.

Scorbipalpa heliopa (L.)
Scorbipalpa ergasima (M.)
Pthorimaea operculella (Z.)

The caterpillars bore into the veins and midribs of leaves and leaf stalks and finally into the top shoots. As a result of feeding, gall like swellings are formed. *S. ergasima* and *P. operculilla* are leaf miners causing blotches on leaf tips.

Management :

a) Removal and destruction of infested leaves
b) Application of a contact insecticide

vi) Other leaf feeding caterpillars.

Selepa docilis B.
S. celtis M.
S. rabdota H.

These pests are of minor importance and usually need no control measure.

vii) Grass hoppers.

Attractomorpha crenulata F
Oxyajaponica japonica (T.)
Poekilocerus pictus (F.)
Orthacris spp.

These are polyphagous pests attacking young brinjal plants. The young and adult feed on leaves consuming the leaf lamina completely.

Management : Dusting the young brinjal plants with 5 to 10% BHC.

1.3 Ants

Solanopsis geminata (F.)

The ant species live in nests and burrows in soil around the base of plants It feeds by nibbling the roots and tunnelling the stem around roots.

Management : Stir the soil around the plants and mix thoroughly with the soil, BHC 5% or Chlordane 5%.

1.4 Termites

Trinervitermes biformis W.
Microtermes spp.

The pests gnaw the roots and stems below ground level and tunnel upwards. The infested plants wither and dry.

Management : Application of a soil insecticide like BHC, Chlordane or heptachlor at 20 kg/ha.

1.5 Sap feeding insects

i) Thrips

Onion thrips Thrips tabaci L.
Groundnut thrips Caliothrips indicus B.
Chilli thrips scirtothrips dorsalis H.
Brinjal thrips Sericothrips solanifolii S.
Blossom thrips Frankliniella schultzei

The nymphs and adults lacerate the tissue and suck the excuding sap. The infested flowers shed prematurely.

Management : Spray 0.05% Dichlorovos, 0.05% Endosulfan or 0.1% Malathion.

ii) Leaf hoppers

Amrasca biguttula biguttula (I)

Empoasca binotata P.
E. parathea P.
E. punjabensis P.
Cestius phycitis (D)

The first mentioned leaf hopper is more common and causes the most damage to the crop. The nymphs and adults suck sap from the ventral surface of leaves and inject toxic saliva into the plant tissues, and cause 'hopper burn'. The insect is the vector of little leaf disease.

Management :

Spraying Dimethoate 0.04%, Phosphamidon 0.04%, Fenvalerate 0.01% or Permethrin 0.0005%. Alternate application of organo-phosphate and synthetic pyrethroid is recommended.

iii) Aphids

Aphis gossypii G.
Myzus persicae (S.)

Both nymphs and adults are found in large numbers sucking sap from leaves and tender apical shoots, devitalising the plant. The infested leaves turn yellow, become deformed and dry away. Honey dew secreted by the insect results in the development of sooty mould affecting photosynthetic efficiency.

Management :

Spraying Dimethoate 0.05%, Endosulfan 0.05% or 40% nicotine sulphate in the proportion of 1:600.

iv) Mealy bugs

Coccidolystrix insolita (G.)

This pest is mainly seen in older plants. The nymphs and adults suck sap from leaves causing yellowing, wilting and drying.

Management : as in aphids.

v) Scale insects :

Aonidiella orientalis (M.)

A. aurantii (M.)
Aspidiotus destructor S.
Chionaspis manni G.
Cerococcus hibisci G.

Damage and management as in mealy bugs.

vi) Lace wing bugs :

Urentius hystricellus (R.)
U. sentis D.

Both nymphs and adults suck the sap from the leaves and such leaves are seen covered with excreta and exuviae. This pest is rarely serious.

2. Tomato

2.1 Fruit and stem borers

i) Gram pod borer *Heliothis armigera* H.

The female adult lays eggs on the leaves, flowers and sometimes on the fruits. Young larvae feed on the leaves. The larvae from the fourth instar onwards make circular holes on the fruits and thrust only a part of the body inside the fruit and feed on the inner contents. A single larvae damage several fruits.

Management : 1) Hand picking and destroying the caterpillar
2) Spraying 0.2% Carbaryl or 0.05% Endosulfan

ii) Stem borer *Eusophera perticella* :

This insect occasionally damages the plant by boring into stem.

iii) The potato tubermoth *Phthorimaea operculella* Z.

The larvae sometimes mine the leaves and bore into petioles and terminal shoots.

iv) Fruit flies : Melon fly *Dacus cucurbitae* (C.)

Eggs are thrust inside the fruits and the emerging maggots feed inside resulting in rotting of fruits.

Management : 1) Apply BHC 10% in the pits before planting to destroy the puparia

2) Apply bait spraying of 0.2% Carbaryl or Malathion containing sugar or jaggery at 10 kg per litre at fortnightly intervals after fruit set initiation (Anonymous, 1989).

3) Remove and destroy decayed fruits Tomato fly, Acritochaeta excisa T. attack the decaying fruits. Occasionally the maggots of this insect bore into the stem as well.

2.2. Leaf feeding insects

i) Hadda beetles

Henosepilachna vigintioctopunctata
Epilachna dodecastigma
(Please refer paragraph 1.2.1)

ii) The tobacco caterpillar *Spodoptera litura*

On emerging from eggs, the larvae feed gregariously scraping the green matter. Later stages of larvae feed voraciously the foliage, at night. The pupation is in the soil.

Management : 1) The field should be ploughed properly to expose and kill the pupae

2) Flood irrigation may be given to drown the hibernating caterpillar

3) Spraying Quinalphos 0.05%, Carbaryl 0.2% of Endosulfan 0.05%.

iii) Ak Grass hopper *Poekilocerus pictus* (F.)

When its specific host *Calotropis* sp..is not available, it feeds on tomato plant.

Management : Dusting BHC 5%

2.3 Sap feeding insects

i) White fly *Bemissia tabaci* (G.)

The insects suck sap from the leaves causing yellowing and crinkling. The honey dew secreted by the insect causes the development of sooty mould. The pest is more serious during the dry season. It is a vector of leaf curl virus disease.

Management : Spraying Dimethoate or Formothion 0.05%.

ii) Mealy bug *Ferrisia virgata* (C.)

The adults and nymphs suck sap from the tender parts of the plant including leaves, shoots and fruits.

Management : Spraying Malathion 0.05%.

iii) Aphids

Aphis gossypii
Myzus persicae
(Please refer 1.5.iii)

iv) Leaf hoppers

Amrasca biguttula biguttula
Empoasca punjabensis
(please refer 1.5.ii)

v) Thrips Onion thrips *Thrips tabaci*
Groundnut thrips *Caliothrips indicus*
(Please refer paragraph 1.3)

Blossom thrips *Haplothrips ganglbaueri*
Frankliniella schultzei
Scirtothrips dorsalis

These thrips infest the flowers causing wilting and premature fall. *F. schultzei* is a vector of tomato wilt virus which causes bud necrosis.

vi) Other sap feeding bugs

Nazara viridula
Cyrtopeltis tenuis
Tricentrus bicolor

The bugs suck sap from the foliage. This damage is not serious.

2.4 Fruit sucking moths *Othreis fullonica* (C.)

The adult moths puncture the fruits and suck the juice. The attacked fruits shrink, shrivel, rot and fall down. The pests are of minor importance in tomato.

2.5 Mites

The red spider mite *Tetranychus noecaladonicus* A.
T. cinnabarinus

The young and adults suck sap from leaves. The infested leaves turn reddish brown and bronzy and wither and dry away.

The eriophis mite *Aceria lycopercici* infest the leaves and occasionally the twigs also.

Management : Spraying wettable sulphur, Dimethoate 0.05% or phosalone 0.05%.

3. Chillies

3.1 Sap feeding insects

i) Chilli thrips *Scirtothrips dorsalis*

Both nymphs and adults lacerate the tissues and suck the excuding sap. Mainly the leaves and rarely the buds and flowers are attacked. The infested leaves curl and the buds become brittle and drop. In dry conditions, the entire plants wither and die. The insect is the vector of leaf curl disease.

Management : Spraying Dimethoate 0.05%, Phosalone 0.05% or Monocrotophos 0.05% (Anonymous, 1989).

The other thrips infesting chillies are :-

Caliothrips indicus
Frankliniella schultzei

ii) Aphids *Aphis gossypii*
Myzus persicae
Aphis cytisorum
(Please refer paragraphs 1.5.iii)

iii) Mealy bugs and scales

Ferrisia virgata C.
Saissetia coffeae
Aspidiotus destructor
Lepidosaphes piperis

(Refer paragraph 1.5.iv and 1.5.v)

iv) White flies *Bemisia tabaci* (G.)
(Refer paragraph 2.3.1)

3.2 Fruit and stem borers

1) The pepper berry borer

Longitarsus nigripennis (M.)

The grubs bore into the berries and the adults scrape the leaves and fruits.

Management : Spraying Endosulfan, Dimethoate, Quinalphos or Monocrotophos at 0.05% concentration (Anonymous, 1989).

The insects *Spodoptera litura* and *Heliothis armigera* are also reported as fruit borers of chillies occasionally.

ii) Stem borer *Eusophera perticella*

Nature of damage and management as in brinjal

iii) Top shoot borer *Laspeyresia hemidoxa* M.

The caterpillar bores into the tender top shoots.

Management : as in fruit borers.

3.3 Leaf feeding insects

i) Army worm *Mythimna loreyi* (D.)
II) Leaf roller *Archips micaceanas* (W.)
iii) Lucern caterpillar *Spodoptera exigua* (H.)
iv) Leaf feeding beetle *Monolepta signata* O.

Management : The damage by these insects is usually not serious. Apply BHC 5% or Carbaryl 5% dust in case of severe damage.

v) Cut worm *Agrotis ipsilon* (H.)

The caterpillar cuts the seedlings at night and hide in soil at day time.

Management : Soil treatment with BHC or Heptachlor.

vi) Chafer beetles *Anomala bengalensis* B.
Holotrichia consanguinea (B.)
H. reynaudi B.

The grubs remain in soil and feed on the roots while the adults feed on the leaves. There is only one generation in an year.

Management : Soil treatment with BHC, Heptachlor or Chlordane.

3.4 Termites *Odonototermes obesus* R.

Incidence of this pest is more in sandy and sandy loam soils.

Management : Soil treatment with Chlordane, Heptachlor or BHC.

3.5 Fruit flies *Dacus dorsalis*
Dacus cucurbitae

(Refer paragraph 2.1.iv)

3.6 Fruit sucking moths

Othreis spp.
Ophideres spp.
Ophiusa coronata F.

(Refer 2.4.

3.7 Mites *Polyphago tarsonemus latus* (B.)
Tarsonemus translucens (G.)

The young and adults suck sap from the ventral surface of the leaf and devitalise the plants. The first one is a vector of chillie leaf curl disease or 'murda' disease.

Management : Spraying Phosalone 0.1% (Sreeramulu, 1976)

4. Okra

4.1 Shoot and fruit borers

i) Okra shoot and fruit borer *Earias vittella* F.)

When the crop is a few weeks old, the newly hatched larvae bore into the tender shoots and tunnel downwards. The infested shoots wither and droop down. With the formation of buds, flowers and fruits the larvae bore into them. The damaged buds and flowers wither and fall down. The damaged fruits will be deformed, stunted in growth and with bore holes plugged with excreta.

Earias insulana (B.) is similar to *E. vittella* and common in drier places. The insects *H. armigera* and *S. litura* are also seen occasionally damaging the fruits of okra.

Management : 1) Collection and destruction of infested fruits and shoots

2) Spraying Carbaryl 0.2% or Dichlorvos 0.05%.

4.2 Stem borers

Cotton stem borer *Sphenoptera gossypii* C.
Cotton stem weevil *Pempherulus affinis* F.
Cotton shoot weevil *Alcidodes affaber* F.

They bore into the stem and rarely into the petioles and cause swellings.

Management : Pruning and prompt destruction of infested shoots and petioles. Okra plants should not be allowed to stand in the field after the final harvest of fruits.

4.3 Sap feeders

i) Leaf hoppers *Amrasca biguttula biguttula* I.
Empoasca binotata
(Refer 1.5.ii)

ii) Red cotton bug *Dysdercus koenigii* (F.)

Eggs are laid in soil. The nymphs and adults suck sap from fruits and to some extent from leaves as well. The feeding by insects deprives the plants of carbohydrates, amino acids and proteins (Saxena, 1955). The pest is especially attracted to plants bearing mature and breaking pods kept for seed purpose.

Management : Application of any contact insecticide controls the pest.

iii) Dusky cotton bug _Oxycarenus lactus_

The nymphs and adults suck sap from fruits of okra when okra is cultivated in the vicinity of cotton. Usually the loss in negligible.

Iv) Other bugs

Lab lab bug _Coptosoma cribraria_ F.
Membracid _Tricentrus tricolor_ D.
" _Leptocentrus obliquis_ W.

The nymphs and adults suck sap and devitalise the plants. The pests usually need no control.

v) Aphids _Aphis gossypii_

(Refer para 1.5.iii)

vi) White fly _Bemisia tabaci_

(Refer para 2.3.1)

vii) Mealy bugs _Ferrisia vircata_ (C.)
Nipaecoccus viridis (N.)

(Refer para 1.5.iv)

viii) Scale insects

Saissetia coffeae
Parasaissetia nigra
Ceroplastis floridensis

(Refer para 1.5.v)

ix) Thrips

Three species of thrips infest the flowers

Microcephalothrips abdominalis (C.)
Franklinielle schultzei (T.)
Haplothrips gowdeyi (F.)

The feeding of thrips results in drying and premature shedding of flowers.

Management : Spraying phosphamidon, Dimethoate or Monocrotophos 0.05%.

4.4 Leaf feeding insects

i) Leaf roller <u>Sylepta derogata</u>

The larvae initially feed on the surface tissues from the ventral side of leaves and later roll the leaves and feed from within.

Management : 1) Collect and destroy the leaf rolls with the caterpillars inside.
2) Spray Carbaryl 0.2% or Fenitrothion 0.05%.

ii) Semiloopers

<u>Anomis flava</u>
<u>Xanthodes groellisi</u>
<u>Acontia intersepta</u>
<u>A. malvae</u>
<u>A. transversa</u>
<u>Tarache nitidula</u>

The first two are the most common.

Management : Application of a contact insecticide like, Quinalphos, Carbaryl, Endosulfan or Malathion.

iii) Cut worms

<u>Agrotis ipsilon</u>
<u>A. flammztra</u>

Occassionally, the cut worms seriously damage the crop by cutting the seedlings at the base during night.

Management : Dusting seedlings with BHC 5%.

iv) Leaf eating weevils

<u>Myllocerus maculosus</u>
<u>M. Variegatus</u>
<u>M. viridanus</u>
<u>Astychus literalis</u>
<u>Ptochus ovulum</u>

The weevils feed on leaves. No control is needed.

v) Leaf miner *Trachys herilla* O.

The grubs of this Buprestid beetle mine the leaves making zigzag galleries.

vi) Grass hoppers

Ak grass hopper *Poekilocerus pictus*
Rice grass hopper *Oxya japonica japonica*
(Refer para 1.2.vii)

vii) Blossom beetles

Oxycetonia versicolor
O. albopunctata
Mylabris pustulata
M. phalerata

These insects feed on flowers and rarely on leaves. Collection and destruction will be enough to control this pest.

viii) Ants :

Phidohogiton aiverous (J.)
Tetramorium smithi M.

These ants feed on petals and ovarian tissues and pollen grains.

4.5 Mites

Tetranychus cinnabarinus (B.)
T. neocaledonicus A.
T. macfarlanei B.
Oligonychus coffeae (Nietner)
Phytoseius minuts, Narayanan
Amblyseius delhiensis (Narayanan and Kaur)
(Refer para 2.5)

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Pests of cucurbits and their management*

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Cucurbits are the largest group of summer vegetables grown all over India. Among the species under cultivation, the bittergourd (Momordica charantia Linn.), snakegourd (Trichosanthes anguina Linn.), pumpkin (Cucurbita moschata Poir.), cucumber (Cucumis sativus Linn.), melons (Citrullus vilgaris Linn. and Cucumis melo Linn.) and the ashgourd (Benincasa hispida Thunb.) are relatively more important.

The cucurbitaceous crops are prone to attack by a large number of insect and mite pests, the major ones being the fruit flies, red pumpkin beetle, the epilachna beetles and mites.

Fruit flies

This is a group of very harmful insects belonging to the family Tephritidae which are serious pests of a wide variety of cucurbitaceous fruits. The fruit flies belonging to the genus Dacus (Bactrocera) are the most dominant and destructive in India. The more important species are the following:

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	Primary hosts	Alternate hosts
D. cucurbitae Coq.	Bittergourd, snake-gourd, pumpkin, ridgegourd	Guava, peach, datepalm, citrus
D. zonatus Saund.	Bottlegourd, ridgegourd	Apple, peach
D. dorsalis Hendel	Bittergourd	Mango, guava, peach, apricot, cherry, pear, sapota, ber, citrus
D. hageni De Meij	Bottlegourd, ridgegourd	Apple, peach
D. ciliatus Loew.	Melons, gourds,	Apple, *Coccinea indica*

Myopardalis pardalina Bigot is an important pest of musk melon, water melon and cucumbers in the Punjab and Bihar.

Life history and nature of damage

The adult stages of fruit flies have a long life expectancy of up to three months, depending on the availability of food materials. During the period of inclement weather characterised by temperatures above 37°C and relative humidity levels below 40° and lack of preferred crop plants. they huddle together in suitable shady niches on the under-sides of nearby groves of small trees and bushes.

The females lay eggs singly or in clusters of 4 - 10 beneath the skin of tender fruit and from the oviposition puncture, little fluid oozes out which dries up in the form of a small globule or dot of resinous material on the fruit. The young maggots bore into the pulpy portion and feed on the internal content of fruits causing them to rot and drop. The larval duration ranges from three days in summer to three weeks in winter. Full fed larvae fall to the ground and pupate in the soil. Pupal period lasts for 6-9 days in summer and extends up to four weeks in winter.

Management of Fruit flies

Being an internal borer, control of the insect by direct insecticidal application is extremely difficult.

There are very simple and effective methods of prophylaxis against the pest. Widespread adoption of these methods in accordance with an appropriate IPM programme will bring about adequate level control of the fruit flies. Large scale control compaigns are inevitable for hastening the transfer and adoption of the IPM technology.

Plant and field hygiene

Collection of infested fruits and their destruction, particularly at the late stages of infestation is a very practical and effective method of reducing the population load of the flies.

Growing resistant varieties

Growing varieties of gourds refractory to infestation by the fruit flies is the most effective and safest method of control. In screening trials conducted at the I.I.H.R., Bangalore, the bittergourd cultivars bearing the accession numbers IIHR-89 (Maharashtra local) and IIHR-213 (Karnataka local) were found to be moderately resistant. Work done in the College of Horticulture led to the identification of the moderate level of resistance of the NBPGR accessions MC-103, MC-104 and MC-114 of bittergourd to fruit fly infestation (Padmanabhan, 1989).

Resistance in snakegourd and other gourds to fruit flies has not been reported. There is a dire need to conduct extensive surveys to locate the sources of resistance to fruit flies in gourds and to utilise them for development of elite varieties possessing resistance.

Destruction of adults

The adults are quite responsive to several attractants which can be used in traps or for poison baiting.

Pollen bearing flower spikes of *Spathiphyllum cannaefolium* contain volatile principles such as benzyl acetate, methyl eugenol, methyl chavicol which are attractive to adults of *D. cucurbitae* (Lewis *et al*., 1988). Isolation of such compounds from plants and their utilisation for controlling fruit flies appear to be quite exciting. Citronella or eucalyptus oils (10 drops in 300 ml of water) have been reported to attract *D. cucurbitae*, but recent trials did not give any encouraging results. *Dacus dorsalis* adults can detect 1×10^{-8} g or less of methyl eugenol, but to D. cucurbitae this has not been demonstrated. Blends of citronella and methyl eugenol have also been reported to be effective against Dacus spp, but recent trials gave inconsistent results on this. A bait containing fermented palm juice 50 ml, saturated sugar solution 50 ml and malathion 50% WP 5 g is reported to give the maximum catch of both sexes of D. cucurbitae. The bait solution is to be kept exposed in shallow pans protected from rain at the canopy level.

Cue-lure (aceto xyphenethyl methyl ketone) has been proved to be an effective attractant for adults of D. cucurbitae.

Bait sprays consisting of Fenitrothion 50% EC (2 ml) or Fenthion 50% EC (2 ml) or Trichlorphon 50% EC (3 ml) and jaggery (10 g) extended in 1 litre of water is effective to control adult flies. The spray is to be applied coarsely on the ventral sides of foliage.

Ovipositional deterrents

Seo et al. (1983) reported that benzyl isothiocyanates (BITC) which occurs in raw papaya act as an ovipositional inhibitor to D. cucurbitae. Alcohol extract of the neem seed oil is reported to inhibit oviposition by D. cucurbitae (Singh and Srivastava, 1983). Since the alcohol extractive of neem seed oil possesses the inhibitory properties it is quite likely that Neem Seed Kernel Extract (NSKE) at about

4 per cent also might confer such protection when topically applied to developing gourd fruits. Work on the evaluation of ovipositional deterrentsof botanical origin offers considerable scope for their exploration in fruit fly management.

Use of trap crops

Ridgegourd Luffa acutangulla is reported to attract large numbers of adult flies. Bait sprays applied to such trap crops are likely to be far more effective than direct treatment of the main gourd crop under cultivation.

Mechanical control

Covering the developing fruit with polybags (150 gauge) of adequate size is an excellent method to afford protection against the fruit flies. The fruits are to be covered soon after they are formed and left in that condition for up to about 30 days until the fruit rind thickens.

Cultural control

Deep ploughing of the soil before raising the crop is very helpful to expose and destroy the soil borne pupae of the flies.

Chemical control

Direct insecticidal control of the insect is not effective against the fruit flies in view of the concealed feeding habits of the larvae. One round of spraying given at the time of fruit formation and another round at 10 days later with fenthion 0.05%, carbaryl 0.2%, malathion 0.2% or fenitrothion 0.05% are effective to reduce fruit infestation. Among these insecticides, fenitrothion is the most effective against adults (Doharley and Butany, 1986).

In spite of serious hazards due to terminal residues in fruits, the application of carbofuran granules right from sowing until harvest has somehow become a widespread practice in Kerala among farmers to control the fruit flies in bittergourd. Recent studies (Cherian Thomas, 1989) show that carbofuran can be safely applied to the bittergourd crop at 0.75 kg ai/ha, only at the time of seeding, if residues in fruits are to remain below MRL. Though the application of carbofuran granules at 1.5 kg ai/ha thrice, namely, at seeding, vining and at flowering is quite effective in controlling the fruit flies and other key pests, this cannot be recommended for adoption, except in seed plots due to severe residue hazards. If a schedule is required in endemic areas, a combination of carbofuran application at 0.75 kg ai/ha at seeding, followed by bait sprays or contact sprays during the early fruit development phase would be the most advantageous and safer.

The pumpkin beetles

The red pumpkin beetle *Rhaphidopalpa* (*Aulacophora*) *foveicollis* Lucas and two allied species, namely, *R. atripennis* Fabr. (elytra blue) and *R. cincta* (elytra yellow with black border) are major pests of several cucurbits. <u>R</u>. <u>foveicollis</u> show distinct preference to the musk melon followed by pumpkin and cucumber in that order. Bitter gourd is not susceptible to this insect. <u>R</u>. <u>atripennis</u> prefers sponge gourd and ridge gourd and occur widely in N. India, while <u>R</u>. <u>cincta</u> is more common in the south.

The adults cause damage to cotyledons, leaves, flowers and they cut irregular holes on the plant parts fed upon. In North India, the adults stay in a state of quescience hiding in suitable niches. As soon as it begins to warm up, the over wintering population becomes active and invade the spring crop which is then in the early stages. Eggs are laid in the soil around the base of the crop and the grubs develop in the soil taking 2-3 weeks to complete. Pupation takes place in the soil in oval chambers for three weeks. One full life cycle takes 4-8 weeks.

The grubs are soil dwelling and cause severe damage to seedlings by feeding on the roots. When numerous grubs concentrate on small seedlings, the damage is very spectacular. They also feed on stems and even fruits on which the attack starts at the portion resting on ground. The grubs continue to cause damage at later stages, but is not very spectacular as in the case of seedling.

As the eggs are laid in soil and the grubs hatch out there, before entering the roots/ stems, it is essential to treat the soil around the base of plants with a suitable insecticide preferrably carbaryl which is reported as the most effective insecticide against this insect by Pareek and Kavadia (1988). Soil treatment is to given with carbaryl 10% DP at the time of sowing. The adults are temporarily repelled from plants dusted with house-hold ash and this method could be adopted in homesteads. Dusting the crop with fine household dust and carbaryl 5 or 10% DP mixed at equal proportions at intervals of 15 days will be helpful to reduce damage by the adults. Endosulphan, phosaline and chloropyriphos also show remarkable toxicity to the beetles and as such these insecticides can be used for spraying or dusting the crop, as an alternative to carbaryl.

The Epilachna beetle

The adults and grubs of these coccinellid beetles (spotted beetles) are injurious to gourd crops particularly the bittergourd. They vary in colour, size and the number of elytral spots. *Henosepilachna vigintioctopunctata* (*Epilachna 28 punctata*) is the dominant species in S. India. *H. vigintioctopunctata* and *H. 12 punctata* are spot variations of only one species and they breed freely. *H. demurili* which are dull copper coloured occur exclusively on bittergourd while *H. septima* infest the snake gourd and bittergourd crops.

The adults and grubs of the spotted beetle feed on the epidermal and pallisade tissues of leaves leaving the skeleton of anastomosing veins in a lace-like pattern. The infested leaves wither and dry up as a result of feeding injury.

The yellow, elliptical eggs are glued vertically on the undersurfaces of leaves in prominent batches, each of which may contain up to several hundred. The grubs are yellowish and spiny and take 12-18 days to complete development. Pupal period is only about six days.

In small homestead gardens, collection and destruction of the egg batches and shaking of the adult beetles to a pail of kerosinated water will be quite useful. Insecticides are very expensive and may not quite cost effective against the beetles. However in fairly large scale commercial gardens insecticides will be required to protect the crop from ravages of insect. The toxic stimulus of synthetic pyrethroids to the fourth instar grubs, pupae and adults of *H. 28 punctata* was found to be remarkable, the descending order of the toxicity being in the order of deltamethrin, fenvalerate, cypermethrin (Rao *et al.*, 1989). Carbaryl 0.1% or endosulfan 0.05% are also recommended against the pest.

Although a number of natural enemies of the spotted beetle are known, none of them is effective enough to make bio-control a practical possibility. Eggs are parasitised by *Tetrastichus ovulorum* (Ferr.) and *Achrysocharis appani*. The important larval parasites are *Pediobius epilachnae* and *Chrysocharis johnsoni*. *Pleurotropis foveolatus* parasitises grubs as well as pupae. The extent of field parasitism in grubs and pupae sometimes reaches 74 per cent in summer. The parasitised grubs and pupae can be easily distinguished by the darker cuticular colouration. It would be useful to collect and keep the parasitised grubs and pupae i suitable containers having perforated lids to allow for the adult parasites to escape. This is an effective method of conserving the parasitoids of the epilachna beetle.

Host plant resistance to *Henosepilachna* spp. has been explored extensively in *Solanum* spp. (Natarajan, 1991), but such an effort is yet to be made in the gourds. Moderately and highly resistant types of *Solanum* spp. possessed higher amounts of reducing and non-reducing sugars and ortho-hidroxyphenols than the susceptible types. Assessment of gourds for such traits and resistance to the beetle will be very rewarding.

Mites

Red spider mites belonging to the genus *Tetranychus* are important pests of cucurbits, particularly cucumber, melons and the ashgourd. Among the various species of *Tetranychus*, *T. neocaledonicus* Andre. is more common on gourds and melons. They inhabit the lower aspects of foliage under thick webs and cause damage by desapping. The infested leaves show brown blotches on the upper aspects and gradually wither and dry up. *Eutetranychus orientalis* Klier. also occur widely on cucumbers in peninsular India. They are generally found on the upper leaf surfaces under webs.

During rainy season, mite populations dwindle considerably and they pick up thereafter reaching peaks in the summer months.

For controlling light and medium infestations of spider mites, acaricides are not necessary. Spray applications of water using compression air or power sprayers is found to be quite effective to control them. Water sprays are already recommended for the control of the cassava mites (K.A.U., 1989). The remarkable efficiency of overhead irrigation in the control of spider mite pests of the groundnut crop has been reported by Ranga Rao *et al*. (1990). Such an approach in red spider mite control is also suggested by Wheatley *et al*. (1990). The impact of water droplets and the wetting are considered as the prime movers in bringing about mite control. In cucurbit crops grown in summer, water sprays using conventional/power sprayers may be a highly rewarding treatment for mite control and for increasing fruit yields. For controlling severe infestations of mites, Dimethoate 0.05%, Dicofol 0.05% or the wettable powder formulation, Microsul 80% WP at 0.2% will be essential. For preserving the wide spectrum of predatory fauna associated with the mites, insecticidal applications are to be reduced to the bare minimum levels. In this context, sulphur formulations are preferrable to conventional acaricides which are broadly toxic to mites and insects.

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Pests of Amaranths, Beans and Peas

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Amaranths

Rich in vitamins, proteins and iron, Amaranths are loved by most Indians as a delicious leaf vegetable. The major insect pests of amaranths are the leaf caterpillars and the stem weevils.

Leaf caterpillars

Hymenia recurvalis (F.) (=*Hymenia facialis* (Gramer), *Psara basalis* (Moore) and *Eretmocera impectella* Walker are the major caterpillar pests on amaranths. These caterpillars web together the leaves and feed the tissues from within. *H. recurvalis* is widely distributed in Asia, Africa and Australia. It attack the crop all the year round especially during summer and rainy seasons.

Small, round, white eggs are laid singly or in batches of 2 to 5. The freshly hatched larvae are greenish with white streaks. They feed on the leaf tissues and the leaves dry up slowly. Pupae are brownish and pupation is in soil. The egg period is for 3 to 4 days, larvae 12 to 16 days and pupal period 8 to 12 days. Adults are small, black, slender and the wings are dark with white streak in the middle. The total life cycle is completed in 3 to 4 weeks.

P. basalis is a common pest of Amaranths in Kerala and its

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habits and nature of damage are very similar to that of *H. recurvalis*. However, the adult moth is distinctly different and it has various shades of rufous tinge on thorax, abdomen and wings. The wings have dark margins and small white specks.

E. impectella is widely distributed in India and its outbreaks are sporadic in nature. Eggs are deposited on leaves and after hatching, the larvae web the leaves with white silken threads and feed from inside. Caterpillars are brownish-yellow or brownish-grey in colour. Pupation occurs in white silken co cocoons attached to the leaves. Life-cycle is completed in 3 to 4 weeks and the moths have cuperous head, thorax and wings.

In addition to these major leaf webbers, there are a number of leaf caterpillars known to attack amaranths. They include *Dichocrocis punctiferalis* (Guenee), *Spodoptera litura* (F), *Spodoptera exigua* (Hubner), *Spodoptera exempta* (Walker), *Heliothis armigera* (Hubner), *Hymenia perspectalis* (Hubner) etc.

Control

As far as possible, chemical sprays should be avoided on vegetables and especially so on leaf vegetable crops. However, if it becomes a necessity, choose relatively so far pesticides like malathion (0.05%) or carbaryl (0.1% to 0.2%). Prompt collection and destruction of the larvae and affected leaves is an effective means of pest management in small kitchen gardens and recent reports indicate that the moths are attracted to ultraviolet traps.

Sprays of the bacterial formulation of *Bacillus thuringiensis* Berliner, is reported effective against amaranths leaf webbers.

In nature _H. recurvalis_ is known to be parasitized by _Apanteles delhiensis_ Muesback and Rao, _Apanteles ruidus_ Walker and _Cardiochiles hymenise_ Fischer and Prasad. These and many other unknown parasites will be able to play a definite check on the ravages of the pests in insecticideal free crop husbandry.

Stem weevil

Amaranths stem weevil, _Hypolixus truncatulus_ (Boheman), is widely distributed in India and neighbouring countries and it attacks almost all species of _Amaranthus_. Adult beetles are ash grey in colour and feed tender leaves and stems causing minor damage to the crop. The major damage is caused by the grubs tunneling the stem making zigzag holes. As a result, the stems often split longitudinally, stunting and twisting of the plant, swelling of the branches and stems, supression of shoot and leaf production and the plants dry up slowly.

Female beetles scoup circular holes on the stems and leaf and lay smooth oval, pale yellow egg singly. An average of 20 eggs are laid by a single female. On hatching, after 4 to 10 days, the grubs start feeding and the grown up grubs which are stout and white pupate inside the stem below the epidermis at the ground level or at the axil of a branch. Larval period lasts for 12 to 24 days and the adult period ranges between 10 to 60 days.

Control

Amaranths weevil attacks both wild and cultivated species of Amaranthus and varieties with large and succulant stem are comparatively more damaged than those with sturdy stems and small leaves. But most cultivated varieties of amaranths have succulent stems and hence this information has no practical value.

Perhaps the cheapest means of weevil management is the destruction of alternative hosts (wild amaranths) and keeping a reasonable interval between two crops so as to prevent the carry over of the pest from one season to the next. Secondly collect and destroy all affected plants during the early phase of the infestation.

A number of natural enemies are reported attacking the various stages of the pest. These include Telenomus javensis Dodd, Anastatus sp., and Pareuderus torymoides Ferriere feeding on eggs, Eurytoma curculionum Meyrick, Aprostocetus krishnieri Mani, Dinarmus sauteri Mani and Xeridescopus sp. attacking the grubs. As far as possible these bioagents should be preserved by timely adoption of non-chemical insect control measurers. As a last resort, chemical treatment using dichlorovos (0.05%) or Malathion (0.05%) may be used when the pest out break is very severe.

Some of the minor pests of amaranths are the polyphagous grasshopper Attractomorpha crenulata F., aphids, Aphis craccivora Koch, Lipaphis erysimi (Kaltenbach) and Myzus persicae (Sulzer), mealy bugs Ferrisia virgata (Cockerell), Scale insects Coccus hesperidum (L.) and Pulvinaria durantae Targioni, thrips Aelothrips collaris Priesner, Aeolothrips fulvicollis Bangall, Haplothrips ceylonicus Schmutz etc. Besides the leaf eating beetle Aspidomorpha exilis Boheman and the leaf twisting weevil Apoderus *tranquebaricus* (F.) are also reported causing minor damage to the crop. The flea batle *Chaeticnema* sp. is also found making small holes on amaranth leaves in some parts of Kerala. However no control measures are generally adopted against these minor pests.

Beans

Beans are important as a nutritious vegetable rich in proteins and as a legume that fixs nitrogen through its root nodules. Indian bean (*Dolichos lablab* L.), French bean (*Phaseolus vulgaris* L.) winged bean (*Psophocarpus tetragolonobus* de candille) and cluster bean (*Cyamopsis tetragonoloba* L.) are the common beans cultivated in India.

Beans, especially the Indian bean and the French bean are subjected to attack by many insect pests. However, winged bean and cluster bean are relatively free from insect damage.

Aphids

Aphis craccivora Koch, *Aphis gossypii* Glover, *Aphis fabae* scopoli, *Aphis adusta* Zehutner, *Aphis*, *rumicis* L. and *Acyrthosiphum pisum* (Harris) are some of the aphid pests reported on beans from India. Of these, the most common one is *A. craccivora*. They are small greenish-black, pear-shaped insects. Reproduction by parthenogenetic means and both winged and wingless forms are present. One female gives birth to about 20 young ones during its reproductive phase of 5 to 8 days. Males are rare and females take 6 to 8 days to reach maturity. Aphids are sap sucking insects and they also act as vectors of bean mosaic virus disease.

Control

Spray if necessary with 0.03% dimethoate or phosphanidon or 0.04% diazinon during the early phase of the crop. Repeat the spraying after 8 to 10 days. Mechanical removal of the aphid colonies during the initial stages of the pest attack or the cultivation of resistant varieties is also recommended.

Coccinellid predators like Coccinella septumpunctata L. and Menochilus sexmaculatus (F.) are effective checks on aphid menace. Sometimes syrphid larvae are also active devouring different stages of the aphid colony.

Pod borers

Pod borers are serious manace to beans. Larvae of Maruca testulalis (Geyer), Exelastes atomosa (Walsingham), Heliothis armigera (Hubner) and Adisura atkinsoni Moore are the important pod borers.

M. testilalis is commonly known as spotted pod borer and it attacks most of the varieties of vegetable legumes. They are also reported on tobacco, rice, castor etc. Yellowish, oval, eggs are laid on or near flower buds and the incubation period is 2 to 3 days. The young larvae web the inflorescence and feed from within the pod. It feeds on the seeds and the entrance hole is plugged with excreta. The larvae may bore into tender stems as well. Fully grown caterpillars are 2 cm long and are light brown in colour with black spots and the larval period is 10 to 14 days. They pupate in debris within the pod or on soil surface. Pupal period lasts 8 to 10 days. Adult moth is slender with fuscous brown head, thorax and abdomen. Fore wings are also fuscous brown with a distinct white spot and a semi-hyaline spot near the white spot. Hind wings are semi-hyaline with brown distal area.

E. atomosa is commonly known as plume moths and is delicate, dry-grass coloured and possess deeply fissured wings. They are widely distributed in the tropical regions of the old world and is a very common pest on redgram. Palegreen eggs are laid singly on the pods, flowers or leaves and the egg period lasts for 3 to 6 days. The larvae densely clothed with short hairs and long spines bore into the pods and feed on seeds. It often bites its way into unopened flower buds consuming the developing anthers. The larval period is about 16 to 30 days. The larvae do not enter the pods completely for feeding as in the case of H. armigera. Pupation outside the pods and the pupal period lasts for 3 to 7 days. Pupae are also thickly covered with spine like hairs and they resemble the larvae.

A. atkinsoni is widely distributed in India. They lay spherical eggs singly on leaves, buds or young pods. Incubation period is for 3 to 4 days and the brownish green caterpillars bore inside the developing pods and feed on the seeds. Larval period lasts for 14 to 15 days and pupation usually is in soil. Pupal period is for 10 to 13 days and the moths are medium sized and pale yellowish brown in colour.

H. armigera, commonly known as gram pod borer or American boll worm, is a polyphagous pest of pulses, cotton, sorghum, chillies, groundnut, tobacco, tomato etc. It is widely distributed in the tropics, subtropics and even in some of the temperate regions of the world.

Yellowish-white eggs are laid singly on leaves, flowers or pods and one female may lay upto 3000 eggs (average 1200 to 1600 eggs). Incubation period is 2 to 4 days. The larvae feed on the foliage. They cut clean, circular holes on the pods and empty the contents. Characteristically the larvae while feeding thrust the head inside leaving rest of the body outside. The larval period lasts for 18 to 24 days. When fully grown the caterpillars are dark-green with whitish and dark-grey longitudinal stripes. Pupation in soil in an earthen cell and pupal period about 6 to 21 days. Pupae are dark-brown with a sharp spine at the end. Moths are medium sized, stout and brownish.

Control

Pod borers are rather difficult to control because of their concealed nature and due to restrictions for the use of toxic chemicals on vegetables. Growing resistant varieties or mechanical destruction of life stages and affected parts are recommended where ever feasible.

The pod borers are often attacked by various parasites and the parasite population should be conserved as far as possible. In addition, spraying of the bacterial formulation _B. thuringiensis_ is reported safe and effective against some of the borer pests of legumes.

When the pest attack assumes serious proportions, insecticidal spray of 0.2% carbaryl, 0.05% endosulphan are justified.

In addition to these major pests a number of minor insect pests are reported on legumes. _Riptortus pedestris_ F. and _Riptortus fuscus_ F. suck sap from developing pods and the infested pods become shrivelled and dries up. Caterpillars of Lampides boeticus (L.) and Euchrysops cnejus (F.) burrow into the buds and tender pods. Weevils like Callosobruchus chinensis (L.), Callosobruchus affinis Froll etc., are minor pests in fields. But under storage conditions they are often serious pests necessitating control measures like fumigation.

Peas

Cow pea (Vigna unguiculata (L.)) and garden pea (Pisum sativum L.) are grown extensively as vegetable crops. The green tender pods of peas are cooked and served as a delicious vegetable curry. These vegetable crops are also capable of fixing atmospheric nitrogen there by enriching the soil fertility.

Pea aphids and pod borers are the major pests of peas.

Pea aphid

Cowpea aphid, (Aphis craccivora Koch), is a cosmopolitan species of considerable importance. Its incidence on the crop is often very early. The pest build up is very fast. Plants heavily infested at the juvenile stage soon become wilted and frequently perish while older plants are stunted in growth and display distorted leaves. Their fruit set is reduced. Aphids also effect cowpea yields indirectly by transmitting virus diseases.

Pea aphids are green, yellow or pink with peas shaped body and long cornicles. Males are rare. Female may be winged or wingless. Reproduction is pathenogenetic and one generation is completed in about seven days.

Control

Fortnightly application of chemicals like dimethoate 0.03% or formothion 0.05% are effective to contain the pest. But the chemicals may create hazards to human health and produce undesirable side effects on non-target insects, animals and plants. Cultivation of aphid resistant varieties is the most effective and the least expensive cultural practice. Some of the aphid resistant cowpea varieties are Vs 350, Vs 438 and Vs 452.

Coccinellids (*Coccinella arcuata* and *Menochilus sexmaculatus*) and syrphids (*Ischiodon scutellaris*) are a common site on aphid colonies and these useful predators are sure to exercise considerable check on the fast build up of aphid colonies.

Pod borers

A. atkinsoni Moore, *E. atomosa*, *M. testulalis*, *H. armigera* and *Etiella ziuckenella* (Treitschke) are all found boring pea pods and feeding the contents.

Control of pod borers are similar to that of bean pod borer control. Chemical control measurers include spraying with 0.05% diazinon or endosulphan or cypermethrin (25 g active ingredient/ hectare) at weekly intervals.

The list of minor pests listed on peas are very lengthy. They include grasshopper *Colemania sphenarioides* Bolivar, leaf miner *phytomyza atricornis* (Meigen), stem fly *Ophiomyia phaseoli* (Tryon), white fly *Bemisia tabaci* (Gennadius), sap sucking bugs *Anoplocnemis phasiana* (F.), *Ragmus importunitas*

Distant etc. Seldom these pests attain serious proportions and practivally no specific control measurers are needed to check these pests.

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Fungicides in Vegetable Disease control

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Several chemicals are available for the control of fungal diseases of vegetables. There are various methods clarifying fungicides. Following classification is on the basis of their chemical nature. Based on the mode of action they are also classified into contact and systemic fungicides. Contract fungicide is one which is aimed to seek out the fungus at rest either before or after the fungus has found the host while systemic fungicides are these which act by entering into the system of the plants.

I. Contact Fungicides

1. Sulphur

Sulphur is one of the oldest fungicides known to man. Even now sulphur is one of the most widely used fungicide against powdery mildew disease. Sulphur is available both as inorganic and organic fungicides.

A. Inorganic sulphur

In the inorganic form sulphur is available as elemental and as lime-sulphur.

(a) Elemental sulphur

Trade names : Cosam, Thion, ESSO Wettable Sulphur
Kolodust, Microsul, Vegfru, Végsulf.

Formulations: Dust and Wettable powder

Properties

Elemental sulphur is a yellow powder which is insoluble in water. The particle size of sulphur dust formulation is an important factor which governs the disease controlling property of the fungicide. An ideal dusting formulation should have particles of size of

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47-74 microns. Among the wettable sulphur types the one which is commonly available in India is the "micronised sulphur".

The exact mode of action of sulphur is not yet known. It is assumed that it compete with oxygen as hydrogen acceptorand disrupts the hydrogenation and dehydrogenation mechanism of the fungal cell leading to its death.

Uses

Sulphur is a good contact fungicide and acaricide and it controls a wide variety of plant diseases, the most important being the powdery mildews.

Precaution

Sulphur is comparatively a harmless fungicide to human beings. But in tropics and subtropics its use on vegetables is restricted as it causes scorching of leaves when the atmospheric temperature is above 30°C. Cucurbitacious plants are highly sensitive to sulphur hence it is advisable not to use this fungicide for the control of powdery mildew, and other diseases of cucurbits. To prevent possible tint, avoid use of sulphur fungicides on vegetables and fruits for processing particularly near harvest.

(b) Lime sulphur

Lime-sulphur is prepared by boiling sulphur and rocklime in water. The proportion of lime and sulphur used for preparing lime-sulphur varies from place to place.

Active ingredient

Calcium poly sulphide (CaS_nSx) and small quantities of Calcium thisulphate.

Properties

Action of lime-sulphur is due to elemental sulphur, hence the mode of action is same as elemental sulphur.

Uses

It is effective against powdery mildews, mites and scale insects.

Precautions

It is capable of causing both chromic and acute damages to the sprayed plants particularly in hot sunny weather and at the fruit formation stage. Lime-sulphur is alkaline in reaction and it is not compatible with most of the pesticides.

Vegetable diseases controlled

Lime-sulphur is not commonly used against vegetable diseases. However, it could be used for the control of rust disease of beans.

B. Organic sulphur

Most of the organic sulphur fungicides belong to the group "Dithio carbamates". All carbamates". All carbamate fungicides presently available commercially are derivatives of dithio carbamic acid.

The carbamate fungicides are classified into three groups.

a. Thiuram disulphide
b. Metallic dithio carbamates
c. Bis dithio carbamates.

a) Thiuram disulphides

This is a highly versetile carbamate fungicide nitroduced in 1934.

Active ingrediant	:	Tetramethyl thiuram disulphide
Trade name	:	Thirum, Thiride, Hexathir
Formulations	:	Dust, Wettable powder, Collpidal suspension

Properties

Thiram is one of the least phytotoxic fungicide. In highly alkaline soils the fungicidal ability of thiram is expressed only slowly.

The mode of action of thiram is mainly through chelation of required heavy metals.

Uses

Thiram could be used for soil, seed, foliar treatments and also for post harvest treatment of fruits and vegetables. "Thiram soak method" could be used effectively for the control of externally and some internally seed borne diseases of vegetables. Several normally insoluble fungicides, notably thiram did infact dissolve to a very slight extent in water. If the seeds are soaked for 24 hours in a 0.2% thiram suspension maintained at 30°C, the seeds absorbed thiram and as this occurred, more of the compound dissolved to give a constant concentration of 30 ppm in the soaking solution. The thiram absorbed by the seed killed internal fungi but was quite non toxic to the tissues of the most seeds. Vegetable seed infection by Septoria, Phoma, Alternatia, Ascochyta, Mycosphaerella, Stemphyllum etc. are controlled by thiram soak method.

Precautions

Thiram should not be sprayed on fruits and vegetables just before harvest if they are to be preserved by canning or deep freezing because it may tint and damage the containor. Thiram gets degraded on the stored seed surface and hence if the treated seeds are intended for long periods of storage, compensatory dose is required. Waiting period, one week. Maximum residue limit is 3 ppm for tomato and 0.10 ppm for potato.

(b) Metallic dithiocarbamates

Two metallic dithiocarbamates commonly used for the control of plant diseases are (1) Ziram (2) Ferbam.

(i) Ziram

Active ingredient	:	Zinc dimethyl dithio carbamate
Trade name	:	Cuman, Hexazir, Zerlate, Ziride
Formulations	:	Wettable powder, colloidal suspension, Flowable liquid, Emulsifiable concentrate.

Properties

It is incompatible with copper, iron, mercury compounds of lime. Ziram is the most stable among metallic dithiocarbamates. It does not build up in soil. The mode of action of Ziram is similar to thiram.

Uses

This is a protective foliar fungicide for fruits and vegetables against Alternaria and Septoria sp. Ziram is effective in controllin rust of beans, anthracnose of cucurbits, and blight of tomatoes. It is a mild repellant to birds rodents and cucumber beetles. Ziram controls zinc deficiency diseases of crop plants to an extent.

Precautions

Ziram has been found to cause irritation to nose and skin. It is advisable that workers allergic to ziram should take adequate protection while spraying. Ziram is phytotoxic to some zine sensitive plants. Maximum residue limit of ziram to tomato is 3.00 ppm and 0.10 ppm for potato.

(ii) Ferbam

Active ingredient	:	Ferric dimethyl dithiocarbomate
Tradename	:	Hexaferb, Ferbam, Fermate
Formulations	:	Wettable powder

Properties

It is compatible with most pesticides, but its use with copper, lime and mercury compounds tends to reduce the fungicidal efficiency. The mode of action of feribam is similar to thiram

Uses

Ferbam is effective for the control of rot of cucumber, blight, leaf mold and fruit rot of chillies. As a foliage spray it is also used to correct iron deficiency.

Precautions

It leaves black residual spots of spray on cloths and sprayed surfaces. Ferban tends to decompose on prolonged storage or exposure to moisture or heat. Hence it should be stored in a cool dry place. Maximum residue limit in vegetables (Tomato) in 3.00 ppm.

C. Bisdithio carbamates

(i) Zineb

Active ingredient	:	Zinc ethylene bis dithio carbamate
Trade name	:	Zineb, Dithane z.78, Hexathane, Lonacol
Formulations	:	Wettable powder and Dust.

Properties

Zineb is unstable in presence of light, heat and moisture. It is compatible with most of the pesticides except lime. In presence of calcium it loses its residual action. The toxicity of Zineb and other bisdithiocarbamates in mediated through isothiocyanate which reacted with fee SH group essential for functioning of SH bearing enzymes.

Uses

Zineb protects foliage and fruits especially that of citrus, against greasy spot, rusts and mites and potato and tomato from blight, Botrytis sp., downy mildew and rusts. Zineb could also be used as a soil fungicide to control damping off disease caused by

Rhizoctonia sp. Tomato is able to absorb zinc from zineb and zineb sprays could reduce zinc deficiency in plants. Zineb has also mild nematicidal properties.

Precautions

Zineb is phytotoxic in case of zine sensitive plants. Under certain conditions it causes deoliation in vines. Repeated applications of Zineb or maneb to tomato plants may induce nitrogen deficiency in the succeeding sugarcane crop. Store below 30°C. Waiting period, one week. Maximum residual limit 0.10 ppm for potato and 3.00 ppm for tomato.

(ii) Mancozeb

Maneb in the pure form is not marketted in India instead it is sold as Mancozeb.

Active ingredient	:	Manganons ethylenebis dithiocarbamate (Maneb) Plus 2% Zinc ion.
Trade name	:	Mancozeb, Dithane M 45
Formulations	:	Wettable powder and powder for seed treatment

Properties

Mancozeb has properties almost similar to Zineb. It is compatible with most pesticides except fixed copper and bordeaux mixture.

Uses

Mancozeb is a protective fungicide effective against a wide range of foliage fungal diseases including *Phytophthora infestans* on potato, *Venturia inequalis* of apple and various rust diseases. It is also effective as a seed treatment fungicide in cotton, potato, groundnut, tomato, cereal grains, etc. Regular spraying of mancozeb has been found to suppress red spider mites. Mancozeb have been found to be more effective than zineb in controlling several vegetables diseseas. It is also a mild bactericide.

Precautions

Maneb is phytotoxic to some varieties of cucurbits. Excessive application of it causes phytotoxicity to cauliflower, tomato, lettuce,etc. Prolonged storage of seeds treated with maneb results in reduction in germination. However, mancozeb is less phytotoxic than maneb. Store below 30°C. Waiting period one week. Maximum residual limit for potato is 0.10 ppm and 3.00 ppm for tomato.

2. Copper

Different copper fungicides based on copper sulphate, copper carbonate, cuprous oxide and copper oxychloride are available. However, only copper sulphate and copper oxychloride based fungicides are popular.

A. Copper sulphate based fungicides

(a) Bordeaux mixture

Eventhough Bordeaux Mixture is more than 100 years old, even now it is one of the popular fungicides.

Active ingredient : Bordeaux mixture is prepared by mixing copper sulphate solution with suspensions of hydrated lime. The antifungal compound formed as a result of the reaction between copper sulphate and hydrated lime is not clearly known.

Formations : Bordeaux mixture is prepared as 1% spray and 10% paste.

Properties

It is an aqueous suspension of a flocculent blue, slowly settling amorphous precipitate which on standing, tends to become crystalline and of purple colour. Toxic action of Bordeaux mixture may be due to denaturing of proteins.

Uses

It is a foliar and soil fungicide. Bordeaux paste is used for wound dressing. Bordeaux mixture is effective against leaf blights, fruitfalls, downy mildews, rots and damping off associated with large number of diseases, notable exceptions being apple scab and powdery mildews. It has also been found effective in reducing the incidence of certain bacterial diseases like citrus canker.

Precautions

Bordeaux mixture has always to be used while fresh. On standing it looses its funcicidal property. Bordeaux mixture is usually alkaline in reaction, hence it is not compatible with pesticides which are hydrolysed by alkali. Bordeaux mixture can be phytotoxic to plants like apple, high yielding varieties of paddy and maize, particularly in cool cloudy weather when the somata remains open.

(b) Cheshunt compound

It is a copper sulphate based fungicide introduced in 1921 for control of damping off diseases

Active ingredients

It is prepared by mixing 2 parts by weight of copper sulphate with 11 parts by weight of ammonium carbonate. In aqueons solutions the copper of cheshunt compound is present largely as cupramonium sulphate.

Properties

It is a water soluble powder. If left exposed, it gradually loses ammonia and becomes less effective.

Uses

Solution of cheshunt compound is used for watering of soil and seed boxes for control of damping off (3g/lit).

B. Copper oxychloride

Copper oxychloride is the most widely used fixed copper fungicide.

Active ingredient	:	Copper oxychloride
Trade name	:	Fytolan, Blitox, Bluecopper, Coptox, Cupramar, Oleocop, Fycop, Blimex.
Formulations	:	Wettable powder, Dust, oil based formulations

Properties

It is incompatible with sulphur, lime and iron containing pesticides. Toxic action is mainly through denaturing of proteins.

Uses

This is a protective fungicide. Used as a foliar spray, dust or diluting with oil. This is effective against most of the fungai controlled through Bordeaux mixture.

Precautions

Do not store in iron containors. Do not use where fumigation with hydrogen cyanide gas is practiced. Maximum residue limit permitted in potato is 1.00 ppm and 20 ppm in other vegetables.

3. Mercury

Mercuric compounds have been known to be a very potent fungicide and bactericide. In view of its extreme toxicity to human beings and animals and phytotoxicity to plants its use is being reduced. In many countries use of mercury fungicides have even been banned.

Two groups of mercury fungicides are available - organic and inorganic. Two inorganic compounds of mercury - mercurous chloride and mercuric chloride are used at 1:1000 dilution for seed treatment and for soil denching.

Organic compounds of mercury are common in use. In India the organic mercurial fungicides are based on Ethyl mercury chloride, phenyl mercury acetate or methoxyethyl mercury chloride. These are used for treating seeds (dry, wet or slurry) or for drenching soil.

The organo mercurials used for dry seed treatment usually contain one percent mercury. They are used at the rate of 2.5g/kg of seed. In wet seed treatment the compounds contain 3 to 6% mercury and 0.25 to 0.5% solution is used for seed, tuber and sett treatment.

Organomercurials are extremely toxic and atmost care must be taken while handling them. Mercury compounds may injure seeds in higher concentrations and when stored under conditions of inadequate moisture control.

4. Heterocyclic nitrogenous compounds

The heterocyclic nitrogenous fungicides are almost as commonly used as the carbamates. Two important fungicides of this group are captan and captafol.

A. Captan

Active gradient	:	N (trichloromethyl thio) 4 cyclohexene 1,2 - dicarboximide.
Trade name	:	Captan, Orthocide, Hexacap
Formulations	:	Wettable powder, Dust.

Properties

Captain is unstable under alkaline conditions. It is non corrosive but its decomposition products are corrosive. It is compatible with most of the pesticides. Mainly foliage protectent. It is usually non phytotoxic. Captain is a safe fungicide and has a FDA tolerance of 100 ppm as against 7 ppm for organic sulphur fungicides on virtually al the common fruits and vegetables.

Uses

Captan is one of the most versatile and general fungicide. Captan is widely accepted by vegetable and fruit growers as it does not produce any adverse effects on appearance and quality of the product.

Precautions

It is toxic to fish. Avoid oil sprays on fruits. Certain varieties of Orange, Apple and Peas are sensitive to captan sprays.

B. Captafol

Active ingredient	:	Cis-N (1,1,2,2,- tetra.chloroethyl thio) - 4 - cyclohexene - 1-2 dicarboximide
Trade name	:	Difolatan
Formulations	:	Wettable powder, Dust
Properties	:	Similar to captan

Uses

Captafol controls foliage and fruit diseases of tomato and potato. It is also used to reduce wood rot fungi in the lumber and timber industries.

Precautions

Phytotoxicity has been reported in case of grapes, apples and roses under certain wather conditions.

5. Dinocap

Inorganic sulphur is one of the best and widely used fungicide against powdery mildew diseases. However, it could not be used against certain crops like cucurbits because of its phytotoxicity. Dinocap is an ideal substitute of sulphur for control of powdery mildews on sulphur shy or sulphur sensitive plants.

Active ingredient

It is a mixture of 2,4 - Dinitro - 6 - octylphenyl crotonate and 2,6 dinitro - 4 - octyl phenyl crotonate.

Trade name : Karathane, Mildex, Crotothane.

Formulations : Wettable powder and emulsifiable concentrate

Properties : It is unstable in presence of alakli. As it is soluble in oil it cannot be used as a oil based spray.

Used

Dinocap is effective for the control of powdery mildews. Besides giving protective action, it also acts as an eradicant. It is also a mild miticide.

Precautions

Inhalation of Dinocap should be avoided and hair and skin should be protected from its staining property. It is toxic to fishes.

6. Tin

Three organo tin compounds viz. Triphenyl tin hydroxide (Fentin hydroxide), Tripenyl tin acetate and Triphenyl tin chloride have been developed and marketed as fungicides. Among this Fentin hydroxide is the most common one.

A. Fentin Hydroxide

Active ingredient : Triphenyl tin hydroxide

Trade name : Duter

Formulations : Wettable powder

Properties

It is practically insoluble in water. It is compatible with other wettable powder formulations but incompatible with emulsificable concentrates and oils.

Uses

This is a effective against diseases caused by <u>Cercospora</u>, <u>Alternaria</u>, <u>Septoria</u> and several other fungi. However, its use is limited because it is phytotoxic to vines, ornamentals and several green house plants.

Precautions

Fentin hydroxide causes phytotoxic reactions in many plants. The crops may differ in their tolerances and hence concentration of the fungicide to be used should vary from crop to crop.

7. Chlorothalonil

Active ingredient	:	Tetrachloro isophthalonitrile
Trade name	:	Kavach
Formulation	:	Wettable powder

Properties

This is a broad spectrum organic contact fungicide. This is relatively immobile in soils. It is non toxic to honeybees. The fungicide at the recommended dose is not phytotoxic to crop plants. The inhibitory action of chlorothalonil is due to its action upon SH radicle in cytoplasm and/or enzymes of fungi.

Uses

Chlorothalonil is effective against downy mildews, white rust and alternaria leaf spot of cabbage, rust and anthracnose of beans downy mildew, powdery mildew and anthracnose of cucurbits and anthracnose leaf spots and powdery mildew of chillies.

Precaution

The acceptable daily intake for chlorothalonil is 0.015 mg/kg/day in U.S.A. The residue tolerance for chlorothalonil in most of the fruits and vegetables ranges from 5-10 ppm.

II. Systemic Fungicides

1. Acylalanines

Acylalanine group of fungicides was developed in 1973. Among the various acylalanines only metalaxyl is of practical importance as a systemic fungicide.

A. Metalaxyl

Active ingredient	:	DL-N-(2,6 dimethyl phenyl) N-(2 methoxy acetyl) alaninate.
Trade name	:	Apron 35 WS; Ridomil 72 WP.
Formulations	:	Wettable powder and seed dressing water soluble powder.

In India pure metalaxyl is not available for spraying. It is available as a wettable powder formulation containing 8% metalaxyl and 64% mancozeb.

Properties

Metalaxyl has residual and systemic activity. It is rapidly absorbed and transported upwards to all new growths in plants. At the suggested dosage rates, metalaxyl is compatible with other pesticides. If applied as a curative, the fungicide inhibits lesion growth and sporulation and inhibit spore germination. Host reaction probably also contribute to the curative action of metalaxyl. The fungicide exerts its greatest effect on RNA synthesis.

Uses

This group of fungicide is specific to Oomycetons fungi especially Peronosporales - (*Phytophthora*, *Pythium*, *Pseudoperonospora*, *Bremia*, *Sclerospora*, *Sclerophthora* and *Albugo*) - Apart from controlling the fungal diseases metalaxyl promotes growth of VAM and increase the tolerance of citrus roots to three species of nematodes.

Precautions

Metalaxyl failures in connection with the development of resistance have been observed in cucumber infected with *Pseudoperonospora cubensis*, potato infected with *Phytophthora infestans* and *Pythium* sp. Development of resistance could be reduced by using mixed fungicides and reducing the number of applications of metalaxyls per cropping season.

Minimum waiting period between last application and harvest for grapes is five weeks. For other crops the waiting period has not been established.

2. Phosphonates

Fosetyl-Al, the aluminium Salt of tris-O-ethyl phosphonate released for commercial use in 1977 is the only phosphorate group of fungicide available.

Active ingredient	:	Aluminium tris (ethyl phosphonate)
Trade name	:	Aliette
Formulations	:	Wettable powder (80%)

Properties

It is stable under normal storage conditions. In aqueons solution the half life of the product is more than 100 days. Aliette is incompatible with foliar fertilizers and nutrient solutions often used in horticulture. It enters plants rapidly, where it persists for a time of between four weeks and four months. It has both acopetal and basipetal movements. The primary effect of fosetyl may be probably on the fungus and somehow involved in the interference with membrane structure and function.

Uses

This is highly effective against Oomycetous fungi, especially *Phytophthora* and *Pseudoperonospora*. It is used for the control of downy mildew of cucurbits when sprayed at the rate of 3g/lit.

Depending on the intensity of the diseases one to two sprays are required per month.

3. Morpholines

Morpholine is one of the heterocyclic ring compounds. The best known fungicide of this group is tridemorph.

Tridemorph

Active ingredient	:	N-tridecyl-2,6-dimethyl-morpholine
Trade name	:	Calyxin
Formulations	:	Emulsifiable concentrate

Properties

Morpholines is compatible with common weed killers, fungicides, insecticides and growth regulators. At recommended dose the fungicide in harmless to bees. The fungicide is taken up by roots and leaves. Movement is only acropetal. It imparts protection upto 30 days. Tridemorph is strongly absorbed into soil particles so little leaching occurs. It inhibits sterol biosynthesis and interfere with protein and lipid biosynthesis.

Uses

Active against nearly all taxonomic group of fungi except peronosporales. It is effective for the control of powdery mildews of cucurbits (30 ml in 100 lit.) and rust of peas (40 ml/100 lit).

Precautions

Under intense sunlight and high temperature calyxin spray causes scorching on winter wheat plants. A few cases of resistance of *Erysiphe graminis* to morpholines have been reported.

4. Triazoles

[illegible]iazole derivatives are used as fungicides in India : Triadimeton [illegible] [illegible]onozole.

A. Triadimefon

Active ingredient	:	1-(4-chlorophenoxy) - 3,3 dimethyl - 1 - (1-H-1,2,4 triazole) 2 butanone
Trade name	:	Bayleton
Formulations	:	Wettable powder, Emulsifiable concentrate and Dust.

Uses

It is effective against a range of Ascomycetes and Basidiomycets and against some Deuteromycetes but it does not give satisfactory control of Oomycetes. It is mainly used for foliar application and partly acts in the vapour phase within the plant. It also controls a number of bacteria, including species of Rhizobium, Pseudomonas, Corynebacterium and Arthrobacterium. Triademefon is effective for the control of powdery mildews of tomatoes, chillies and cucurbits.

B. Hexaconazole

Active ingredient	:	Butyl (2,4 - dichloro phenyl) IH-1,2,4 - trizole - 1- ethanol
Trade name	:	Contaf
Formulations	:	5% Emulsifiable concentrate)

Properties

Hexaconazole is a protectant and eradicant systemic fungicide. It rapidly degrades in soil and mobility in soil is low. It penetrates rapidly into plants and it has a latent period of greater than 3 days. Movement is only acropetal. It acts as an inhibitor of of ergosterol biosynthesis in fungi.

Uses

It is mainly active against Ascomycetes and Baridiomycets and is especially employed against powdery mildew, rust and scab. It has little activity against Oomycetes. Hexaconozole has been proved effective against powdery mildew of tomato and leaf spots of chillies caused by Alternaria and Collectotrichum.

5. Organophosphate

Organophosphorus systemic fungicides were first used in 1960 when triamiphos was introduced. Since then various chemicals have been developed such as ditalimfos (1966), Edifenphos (1968) IBP (1968) Pyrazophos (1977). Practical application of these compounds has always remained rather limited because of their highly selective action. Triamiphos, ditalimfos, and pyrazophos are selective powdery mildew fungicides while edifenphos and IBP are active against Pyricularia on rice. Tochlofos methyl is effective against Rhizoctonia solani on potato. Organo phosphate fungicides are not generally used against fungal diseases of vegetables.

6. Carboxiamides

This group of systemic fungicides are also known as carboxylic acid anilides, carboxanilides or amides or anilides or oxathiins. The systemic fungicidal property of oxathiins was first reported by Von Schemeling and Marshal Kulka in 1966. The two oxathiin derivatives developed by them are known under the common name carboxin and oxycarboxin. These compounds are probably the first systemic fungicides to succeed on a practical scale.

A. Carboxin

Active ingredient	:	5,6 dihydro - 2- methyl - 1,4 - oxathiin-3 carboxanilide
Trade name	:	Vitavax
Formulation	:	Wettable powder

Properties

Vitavax is water soluble and non phytotoxic on crops used. It is not stable when applied to soil and complete degradation may take place in 10-30 days. Movement inside the plant mainly apoplastic. The mode of action of these compound is considered to be the interference with synthesis of systemic protein, RNA and DNA in rapidly metabolising cells. It also inhibit mitochondrial respiration.

Uses

Carboxin is effective against basidimycets such a rusts and smuts and Rhizoctonia solani. Carboxin spray at 0.5% controls Collectotrichum fruit rot of chillies. This is also effective against Rhizoctonia root rot of cucurbits. Treatment of chilli seed with carboxin captan mixture (2.5g/kg seed) plus one soil drench (1000 ppm) controls damping off caused by R. bataticola.

B. Oxycarboxin

Active ingredient : 2-3 dihydro - 5. Carboxanilido - methyl-1, 4, oxathiin - 4,4 dioxide

Trade name : Plantvax.

The properties and uses of oxycarboxin are almost similar to carboxin. Ocycarboxin besides being toxic to basidiomycets is also toxic to fungi like Bipolaris, Drechslera, Curvularia, Aspergillus Cladosporium, Alternaria, Botrytis, Monilia and phycomycetons fungi like Cunninghamella. The fungicide is not commonly used against vegetable diseases.

7. Benzimidazole

Benzimidazole is the parent substance of a family of systemic fungicides, including benomyl, thiophamate-methyl and thiobendazole. Thiobendazole was first introduced in 1961 as anthihelminthic, in 1964 its systemic fungicidal property was described. Later many other benzimidazole derivatives appeared of these benomyl and carbendazim are well known systemic fungicides.

A. Benomyl

Active ingredient : Methyl-N-(1-butyl carbamoyl)-2-benzimidazole carbamate

Trade name : Benlate

Formulation : Wettable powder

Properties

Benomyl is a protective and eradicant fungicide with systemic activity against majority of Ascomycites and Deuteromycetes. A number of Basidiomycetes are sensitive where as Oomycetes and Mucorales among the Zygomycets are not. It is effective against mites primarily as an ovicide.

Benomyl is taken through roots, seeds and leaves and its movement is mainly acropetal. On absorption benomyl is hydrolysed to methyl-2-benzimidazole carbamate (MBC), a compound regraded as the component responsible for fungitoxicity.

Benomyl is compatible with fixed copper, mercury and carbamate fungicides and organophosphoms, chlorinated hydrocarbons and carbamate insecticides. Benomyl is not compatible with alkalies and the formulation become unstable above pH 8.5.

The action of benomyl appears to involve DNA synthesis directly or some closely associated aspect of nuclear or cell division.

Uses

Benomyl is used as seed treatment, foliar spray, post harvest dip and for soil application. Apart from controlling fungal diseases benomyl in low concentrations protects plants from Ozone injury. Benomyl is also very effective against sowfly damage in apples.

Precautions

Benomyl is usually not phytotoxic. But high concentrations especially as soil drench may cause toxicity (eg. stunting of cabbage and pea). Though soil application of benomyl is reported to control many vascular wilt diseases such as *Fusarium* wilt of tomato, *Verticillium* wilt of potato, etc. care should be taken before application to see that pathogenic population of Peronosporales does not present in the soil. Because of this, for seed treatment benomyl is to be used in combination with other seed protectant fungicides.

B. Carbendazim

Active ingredient : Methyl 2 - benzimidazole carbamate

Tradename : Bavistin, Saivistin

Formulations : Wettable powder

Properties and uses : Similar to benomyl.

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Viral diseases of tropical vegetables and their management

S. Balakrishnan*

Viral diseases cause serious losses in many tropical Vegetable crops. Careful crop management is a basic necessity for the control of most of the important viral diseases of tropical vegetables as well as other crops. Aphids and whiteflies are the vectors of most of the important viral diseases of tropical vegetable crops (Table 1). Therefore, majority of the work on the management of the viral diseases of tropical vegetable crops is on viruses transmitted by aphids and whiteflies.

Management of viral diseases has to be done as a co-ordinated effort by using all or some of the methods which can be classified as follows: (1) Destruction of sources of viruses (2) Use of virus-free planting materials (3) Manipulation of cultural practices (4) Development of resistant varieties (5) Control of vectors (6) Alteration of vector efficiency (7) Therapy of infected plants (8) Cross protection and (9) Use of botanicals.

1. Destruction of sources of viruses

Source of viruses can be volunteer plants, ornamental plants, other crop plants and weeds. Destruction of these sources of viruses is a very important aspect in the control of viral diseases in a systematic manner. But the efficacy of this will depend upon the detection of these host plants when they are sufficiently young. Capoor and Varma (1951) suggested destruction of the weed host Hibiscus tetraphyllus and roguing of diseased bhindi plants at the earliest stages of infection for the control of yellow vein mosaic disease. Similarly, elimination of weed hosts of chilli viruses by application of herbicides before planting chilli was more effective than the subsequent use of insecticides on the crop. But viruses with wide host ranges such as cucumber mosaic and tomato spotted wilt are difficult to be controlled by removal of collateral hosts (Chenulu, 1982).

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2. Use of virus-free planting material

This is an important method of control of viral diseases, especially in viruses propagated through seed materials (Ramakrishnan, 1963). The methods which can be employed to obtain virus-free planting materials are use of naturally occuring virus free material, heat therapy, meristem tip cultures, cold treatment and chemotherapy.

3. Cultural methods

Cultural methods which can be manipulated to reduce the incidence of viral diseases as well as damage caused by them include crop rotation, altering of date of sowing, spacing, fertilizer application, planting of barrier crops etc.

Crop rotation can be used as an effective method of control of viruses which have very limited number of collateral hosts. Viruses which are not causing infection in weed plants are spread from one season of the crop to the next, directly without any collateral hosts. The management of such diseases can be effectively done by giving a gap between successive crops. This helps to break the cycle of infection, but it will be successful only if the field is isolated in an area where there are crop barriers (Raychaudhuri, 1977). Capoor and Varma (1951) recommended a closed season for bhindi crop for at least two months in summer.

The spread of tomato mosaic virus successively from crop to crop was found to be a very difficult cycle to break. Man is the main vector of this virus and more over, the crop may become infected initially when the roots of young plants come into contact with infected root debris of the previous crop that remained in the soil. Root debris was found infective even after two years in the soil (Broadbent, 1969). Tomatoes planted within five weeks of clearing of diseased plants become infected, whereas those planted after other crops had been grown for six months between tomato crops remained healthy.

When insect vectors have well defined periods of dispersal, it may be able to plan the cultivation of the crop to avoid them. It is found that in Kanpur (India), the incidence of the whitefly vector and that of yellow vein mosaic will be significantly lower in bhindi sown in March as compared to that sown in April or May (Singh and Singh, 1989).

Spacing is known to have considerable effect on the spread of viral diseases in plants. Closer spacing generally reduces number of infections per unit area. The mathematical relationships of size of plants and spread, of systemic diseases have been discussed by Van der Plank (1947). He suggested that as an approximation, in cases where disease is brought from outside the crop, the proportion of infected plants in proportional to their size, provided the proportion is small. Size is defined as the catchment zone of the invading insects which is considered to be inversely proportional to the number of plants per unit area. Even in cases where a systemic disease spreads within a crop, the rate of infection is proportional to size of healthy plants. When percentage of infection is low, systemic diseases could be controlled by close planting which reduces the size of plants and increases the number per unit area. When the percentage of infection is high, control is more difficult but still possible if infection occurs when plants are small. By close planting and thinning out later, the diseased plants could be eliminated. This method is recommended for the control of tomato spotted wilt in South Africa.

Incoming insects often land on outer edges of fields and if they bring viruses with them, more plants are infected near the margins than in the centre of the fields. Highly infected outer zone forms a greater proportion of a small field than large one and the amount of infection entering per acre from nearby sources is approximately inversely proportional to the square root of the field area. Therefore, viral diseases can be effectively managed by making the fields larger in case of diseases for which there is little subsequent spread like tomato spotted wilt.

Only very little information is available on the effect of fertilizers on the incidence and intensity of viral diseases in plants. It is suggested that the better the plants are fed and grown, the more likely they are to become infected with viruses.

The use of non-host plants in interplanting and barrier situations can significantly reduce the rate of virus spread in the field. Barrier crops which are additionally treated with insecticides will increase their effectiveness. A buffer crop when grown between the source of virus and a susceptible crop would reduce the amount of separation required to prevent the disease spread. Use of barrier crops like cowpea and mung bean was found to have significantly obstructed the whiteflies and avoided the incidence of yellow vein mosaic of bhindi (Singh and Singh, 1989). When susceptible crop plants are separated by growing immune plants in between them, virus spread can be considerably lessened especially if the intervening plants are suitable hosts of the vectors.

4. Development of resistant varieties

Attempts to breed varieties of crop plants immune or resistant to important virus diseases have not often been very successful. More stress has to be given on breeding varieties which can reduce the vector population and activity. There can be field resistance because the vectors fail to infest a particular cultivar or the vector may not be able to acquire the virus from it when compared with other cultivars. Plant resistance to vector infestation may affect virus spread also. The preference or non preference of a vector to a cultivar may depend upon many factors including colour of plants. **A few** varieties of bhindi are reported to show field resistance to yellow vein mosaic of bhindi in Hisar. It is pointed out that to get a correct picture of resistant and susceptible genotypes, multilocation trials have to be conducted (Dhankar *et al.*, 1989).

5. Control of vectors

The population of arthropod vectors has to be considerably reduced with insecticides, by encouraging their predators and parasites, by eliminating their alternative host plants or exposure to heat (Broadbent, 1969).

It is difficult to kill the vectors quickly enough to prevent them from transmitting viruses since viruliferous vectors can often infect plants before they die. Phorate, parathion etc. require at least 51 - 180 minutes to kill 90 percent of the aphids (*Myzus persicae*) two hours after the application of insecticide and much longer three days later. Often, spraying the weed boarders of crop fields may be more effective than spraying the crops. When the virus sources are within the crop, the chances of limiting the spread are considerable if the plants are given an insecticidal treatment before the vectors arrive. It may be possible to stop the spread of cumulative viruses and even the spread of stylet-borne viruses may be limited if the vectors are incapacitated before they have made as many flights as they might otherwise have done. Nene (1972) recommended 0.1 per cent Malathion + 0.1 per cent Metasystox + 2 per cent orchard oil to control the whitefly (Bemisia tabaci) which is the vector of yellow mosaic of pulses. Sastry and Singh (1973) carried out trials to restrict the spread of yellow vein mosaic of bhindi by controlling the whitefly vector and found that parathion, Oxydemeton - methyl and dimethoate were effective when applied at ten days interval beginning after germination of bhindi seeds. One application of phorate 10-G at the rate of 10 kg/ha (at the time of sowing) reduced the vector and was more effective in restricting the spread of the virus. Alonzo (1975) evaluated nine spray and three granular insecticides for their relative effectiveness in controlling Bemisia tabaci. Efficiency index was based on incidence of Bean Golden Yellow Mosaic Virus. Metasystox, Nuvacron and Folimat (in that order) proved to be effective spray insecticides. The granular insecticides Furadan and Thimet applied at the time of sowing proved to be effective and were considered to be most promising for various reasons.

Predators and parasites often play a large part in limiting insect population, but their population naturally fluctuates with those of their hosts and often lag behind them. But at least in some cases predators and parasites are implicated to play an important role in limiting the spread of viruses.

Vectors often breed on other crops or wild hosts which are also sources of the viruses. In climates where the summer day temperature remains around 32°C or above for long periods, aphids will seldom survive and this can be taken advantage of to produce disease-free crop (Broadbent, 1969). Nitzany et al (1964) increased the temperature around young cucumber plants by applying a wheat straw mulch at germination. This resulted in a very low population of Bemisia tabaci, until the plants were large enough to shade the straw. As a result of this there was only 1.5% infected plants 30 days after sowing in contrast to 26% in unmulched plants and 27% mulched plants were infected after 40 days when all unmulched plants showed mosaic. Marketable produce was increased nearly three times by mulching.

6. Alternation of vector efficiency

Many factors in the vector behaviour and ecology, influence the development of epiphytotics of viral diseases of plants. (Zitter and Simons, 1980). Some alterations in the vector behaviour may substantially reduce the incidence of viral diseases.

Different cultivars of the same crop may react differently in their value as sources of virus for feeding of vectors. This information can be used along with other methods which are effective interfering with vector behaviour to alter the vector efficiency so as to reduce the incidence of viral diseases.

Aphids are known to respond to certain wavelengths of light. Shortly after development of wings, aphids are strongly attracted to light of shorter wavelengths and fly towards the sky in migratory flights. After flying for several hours their response to shorter wavelengths is reversed and they are repelled by it. At the same time they become attracted to yellow and green and start searching for suitable host plants.

The spread of cucumber mosaic virus, watermelon mosaic virus and many other viruses was found effectively reduced by aluminium foil mulch. Aluminium foil is more effective than black plastic mulch. Sticky sheets of yellow polythene located outside the field are effective to trap winged aphids and reduce the spread of cucumber mosaic and potato virus (Smith and Webb, 1969). The spread of tomato yellow leaf curl was reduced with yellow polythene soil mulches. Yellow sticky - board traps have also been successfully used for the control of whiteflies.

The use of oils to interfere with aphid transmission of a nonpersistent virus was first reported by Bradley et al (1962). Oils has been shown to interfere with the acquisition and inoculation aspects of transmission of viruses. Loebenstein et al (1964) could prevent the incidence of aphid - borne cucumber mosaic virus with emulsions of mineral oil. Hein (1964) protected lettuce seedlings from virus transmitted by Myzus persicae by spraying whole milk on source as **well** as test plants.

Inhibitory effect of oils on the transmission of papaya mosaic by Aphis gossypii (Bhargava and Paul Khurana, 1969) and aphid-borne cowpea mosaic transmitted by Aphis craccivora (Dube and Kene, 1974) have been reported. Khatri and Sekhon (1973) obtained complete inhibition of transmission of chilli mosaic virus by spraying 2 per cent emulsion of light paraffin in water. Virus acquisition was completely checked by heavy paraffin, groundnut oil and castor oil also. Zitter and Ozaki (1978) have reported that the use of a specially formulated mineral oil resulted in control of viral diseases in crookneck squash and tomato with no indication of phytotoxicity.

Aphids generally initiate probes in the grooves which surround the epidermal cells and so the oils which collect selectively in these grooves would presumably be effective in preventing virus transmission. Materials such as plant lipids, milk fat and silicones are relatively viscous substances which are known to inhibit transmission of viruses by insects. Highly volatile oils do not inhibit transmission. The possibility also exists of discovering chemicals which affect aphid behaviour (probing or otherwise) in a manner that interferes with virus transmission.

It is likely that oils may interfere with virus - vector relationships by modifying the surface structure (or charge) of stylets, thus impeding adsorption or elution of virus particles. The inhibitory properties of oils might also result from their electric insulating properties which would hamper the exchange of charges between virus particles, aphid mouth parts and plant cells. Combining oils and insecticides is a good proposition, owing to their complementary effects, ie. oils impede transmission of stylet - borne viruses while insecticides curtail the transmission of circulative viruses (Vanderveken, 1977).

7. Therapy of infected plants or seeds

Chemotherapy and heat treatment were attempted in some plant viruses.

Chemotherapy of virus - infected plants was attempted with a number of chemicals, but large scale application, of this method has not so far been reported. Many purine and pyrimidine analogues were tested for their antiviral properties. Thiouracil was effective in retarding the rate of multiplication of tobacco mosaic virus (Holmes, 1955) and a ring spot strain or potato virus (Sharma and Raychaudhuri, 1956).

A number of viruses were shown to be inactivated by heat treatment but except in some viruses of sugarcane, this method has not come into large scale use (Ramakrishnan, 1963). Eventhough heat treatment is effective in eliminating viruses from seed materials it has not received large scale acceptance because of practical difficulties in doing this.

8. Cross protection

Cross protection afforded by mild strains against virulent strains of viruses was reported in many viral diseases of plants. This was tried in tomato for the control of tomato mosaic.

Mild strain of tomato mosaic virus was produced by culturing the virus in tissues maintained above 34°C. Inoculation of tomato seedlings with the mild strain is sufficient to give 40-60% protection. Early inoculation of the plants with mild strain is required since later inoculation may result in higher percentage of fruit damage. Large scale inoculation has been attempted by application of the inoculum with commercial paint sprayer, artists' brush etc.

9. Use of botanicals

Many higher plants were found to contain effective inhibitors of plant viruses. Some of these inhibitors are able to impart even systemic resistance in plants against many viruses. Many of them are capable of suppressing the symptoms of viral diseases and decreasing the virus titre as well.

Pre-inoculation spraying with leaf extracts of *Bougainvillea sp.* and *Eupatorium odoratum* gave complete protection of cowpea plants against infection by cowpea aphid-borne mosaic virus

Table 1. Viral diseases of tropical vegetables

Name of crop	Name of disease	Major symptoms	Mode of transmission	Host range
Amaranthus	Amaranthus mosaic	Mosaic mottling of leaves and yellowing of leaf veins	Sap transmission	*Amaranthus* spp. and *Nicotiana* spp.
Amorphophallus	Amorphopallus mosaic	Stunting, chlorosis and mosaic mottling	Aphids (*Myzus persicae* and *Aphis gossypii*)	*Amaranthus tricolor*, *Atriplex hortensis*, *Cyamopsis tetragonoloba* and *Phaseolus vulgaris*
Bhindi	Yellow vein mosaic	Vein clearing and Chlorosis of leaves	Whitefly (*Bemisia tabaci*)	*Hibiscus* spp., *Abelmoschus* spp. *Croton sparsiflorus* *Ageratum conyzoides* and *Zinnia elegans*
Bottlegourd	Bottlegourd mosaic	Irregular light green or dark green discolouration with pale yellow chlorotic area on the leaves	Sap transmission	*Cucurbita moschata*, *Cucumis sativus*, *Datura stramonium*, *Luffa acutangula* and *Momordica charantia* are symptomless carriers.
Brinjal	Brinjal mosaic	Mosaic mottling of leaves and deformities like puckering, crinkling and blisters of various sizes may develop on severely infected leaves.	Seed and Sap transmission and aphids (*A. gossypii*, *A. craccivora* and *M. persicae*)	*Solanum* spp., *Cucurbita maxima* *C. pepo*, *Lagenaria siceraria*, *Spinacea oleracea*, *Zinnia elegans*, *Ocimum sanctum*, *Beta vulgaris* etc.

(Contd...)

Name of crop	Name of disease	Major symptoms	Mode of transmission	Host range
Chilli	i. Leaf curl	Curling of leaves, puckering and distortion of interveinal areas and thickening of veins. Axillary buds are stimulated to produce clusters of small leaves.	Whitefly (*Bemisia tabaci*)	*Nicotiana* spp., *Capsicum* spp. *Lycopersicon esculentum*, *Petunia hybrida*, *Crotalaria Juncea* and *capsicum* spp.
	ii. Chilli mosaic	Mosaic mottling distortion and fulfilformy of leaves	Sap transmission and aphids (*A. gossypii* and *M. persicae*)	*Nicotiana* spp., *Solanum nigrum*, *Petunia hybrida*, *Cucumis sativus*, *C. melo* etc.
	iii. Yellow mosaic	Vein clearing yellow patches mottling, puckering, blistering distortion and yellow mosaic	Seed (14 to 18%) and Sap transmission	*Datura* spp. *Amaranthus* spp. *Capsicum* spp. *Nicotiana* spp. *Lycopersicon esculentum*, *Solanum melongena*, *Petunia hybrida* *Cyamopsis tetragonoloba*, *Phaseolus vulgaris* and *Zinnia elegans*.
Lablab bean	1. Yellow mosaic	Bright yellow patches	Whitefly (*Bemisia tabaci*)	*Phaseolus aureus*, *P. mungo*, *Vigna sinensis* and *D. briflous*.
	ii. Enation mosaic	Mosaic, malformed leaves and enation	Sap transmission	Many leguminous plants.

(Contd....)

Name of crop	Name of disease	Major symptoms	Mode of transmission	Host range
Cowpea	1. Cowpea Aphid-borne mosaic	Dark green vein banding interveinal chlorosis, slight distortion of leaves and stunting of plants	Seed and Sap transmission, and aphids (*A. craccivora* *A. gossypii* and *A. malvae*)	Different cowpea varieties and *Vigna sesquipedalis*
	ii. Yellow mosaic	Bright yellow patches alternating with green colour	Whitefly (*Bemisia tabaci*)	
Cucumber	Cucumber mosaic	Mosaic mottling and reduction in size of leaves	Seed and sap transmission and aphids (*A. gossypii*, *A. craccivora* and *M. persicae*)	*Nicotiana* spp., *Cucumis* spp., *Cucurbita* spp. *Luffa acutangula*, *Allium cepa*, banana, maize, tomato, brinjal etc.
Double bean (*Phaseolus lunatus*)	Yellow mosaic	Bright yellow patches on leaves	White fly (*Bemisia tabaci*)	*Phaseolus limensis*, *P. vulgaris*, *P. aureus*, *Dolichos biflorus* and *Canavalia ensiformis*
French Bean	1. Bean Mosaic	Mosaic mottling blistering and downward curling of the leaves	Seeds and aphids (*M. persicae* *A. craccivora* and *A. gossypii*)	*P. mungo* *P. aureus*, *P. lunatus* *P. calcaratus*, *Lupinus albus*, *Cicer arietinum*, *Cyamopsis tetragonoloba* *Crotalaria sericae* and *Vicia faba*.

Name of crop	Name of disease	Major symptoms	Mode of transmission	Host range
	ii. Yellow mosaic	Yellow mosaic on leaves and stunting of plants	Sap transmission and aphids (*M. Persicae* and *A. fabae*)	*Crotalaria spectabilis*, *Gladiolus* sp. *Pisum sativum*, *Melilotus alba*, *Vicia faba* and several leguminous plants.
Lima bean	Lima bean mosaic	Vein clearing puckering of lamina and distoration of leaves	Sap transmission	*Cajanus cajan*, *Crotaloria* spp., *Desmodium* spp. and *Phaseolus* spp.
Pumpkin	i. Pumpkin mosaic	Mosaic mottling with dark and light green patches. Leaves may become filiform.	Sap transmission and aphids (*A. gossypii* and *A. craccivora*)	*Citrullus vulgaris*, *Momordica charantia* and *Trichosanthes anguina*. *Cucumis sativus* is a symptomless carrier.
	ii. Yellow vein mosaic	Vein clearing and chlorosis of leaves	Whitefly (*Bemisia tabaci*)	*Cucurbita pepo*, *Luffa acutangula*, *Trichosanthes anguina*, *Momordica charantia*, *C. moschata*, *Cucumis sativus* and *citrullus fistula*.
Ridgegourd	Mosaic	Light and dark green mosaic mottling, downward curling of leaf margins and general stunting of plants.	Sap transmission and aphids (*M. persicae* *A. craccivora*	*L. cylindrica*, *C. moschata*, *L. siceraria*, *M. charantia* and *Trichosanthes anguina*.

(contd....)

Name of crop	Name of disease	Major symptoms	Mode of transmission	Host range
Runner bean	Runner bean	Mosaic mottling and slight deformation of secondary leaves.	Sap transmission and seeds (42%)	Different varieties of *Phaseolus vulgaris*
Snakegourd	Snakegourd mosaic	Mosaic of leaves and stunting of plants	Sap transmission and aphids (*A. gossypii* and *M. persicae*	*Nicotiana* spp. *Cucurbita* spp. etc.
Tomato	i. Tomato mosaic	Interveinal mottling and yellowing of the leaves with scattered patches on green areas. The leaf surface appears to be crinkled and brittle.	Sap transmission	*Solanum nigrum*, *Solanum melongena*, *Nicotiana* spp., *Datura stramonium* and *Petunia* sp.
	ii. Tomato leaf curl	Stunting of plants and reduction in the size of leaves and internodes. Curling and crowding of leaves. Dark green enation. Plants become pale and partially or completely sterile.	Whitefly (*Bemisia tabaci*)	*Nicotiana* spp. *Capsicum annuum* *Datura stramonium* and *Crotalaria juncea*
	iii. Tomato spotted wilte	Bronze coloured marking on the upper side of young leaflets. This may extend to petiole, stem, calyx etc. Upward marginal rolling and stiffening of leaflets and necrotic spots on	Sap transmission and Thrips (*Thrips tabaci*, *Franliniella* spp.)	*Canavallia ensiformis*, *Datura stramonium* *Dolichos uniflorus* *Nicotiana* spp. *Phaseolus lunatus* *P. vulgaris* *Vigna* spp. *Vinca rosea*

(contd...)

Name of crop	Name of disease	Major symptoms	Mode of transmission	Host range
		the leaves. Necrosis extends to stem near growing tip resulting in wilting and death. On fruits, yellow spots appear often with distinct concentric zones of shades of yellow or bronze alternating with green, pink or red.		*Zinnia elegans* and *Arachis hypogaea*
	iv. Yellow mosaic	Yellow mosaic, reduction in size and twisting of leaves	Whitefly (*Bemisia tabaci*)	
Vegetable marrow	i. Mosaic	Mosaic, filiform leaves and witches broom	Mosaic type is transmitted by *A. gossypii*, *A. craccivora* and *M. persicae*. Filiform type is transmitted by *M. persicae* only.	In mosaic type, the virus infects *Cucumis sativus*, *C. melo*, *Cucurbita moschata*.
Watermelon	Watermelon mosaic	Mild chlorosis, stunting distortion and mottling	Sap transmission and aphids (*A. gossypii* *M. persicae*)	*C. Pepo*, *C. maxima*, *C. moschata*, *Cucumis sativus*, *C. melo*, *Lagenaria siceraria* and *Luffa* spp.

(Sreelakha and Balakrishnan, 1988). Verma and Dwivedi (1983) extracted a virus interfering substance from the sap of plants sprayed with Bougainvillea leaf extract. They have suggested that the reason for the antiviral effect was due to the presence of antiviral substances in the plants after the treatment.

Growth products of many bacteria and fungi are also reported to have inhibitory effect on many plant viruses. Lentemin, hyphal extract of the edible mushroom Lentinus edodes is used in Japan to control viral diseases of tomatoes and sweet pepper (Tomaru, 1987).

Conclusion

Integrated management of diseases and pests are gaining more and more importance owing to the increase in the awareness among scientists and farmers at large, about the harmful effects of chemicals used as pesticides, to the ecosystem. In fact, the incidence of viral diseases is the culmination of the integrated activities of virus, vector and hosts along with other ecological factors. Hence, successful management of viral diseases cannot be achieved by adopting only a single method. Studies on the role of various epidemiological factors on the incidence of viral diseases may lead to the discovery of promising methods of management with the least harmful effects to the ecosystem. The use of pesticides is only one among the several options available for the management of viral diseases. Therefore, if we are able to gather more and more information on the epidemiological aspects, w may need only lesser and lesser amount of pesticides for the management of viral diseases of vegetables so that we may be able to get disease free as well as unpolluted vegetables.

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Diseases of Solanaceous Vegetables and Okra and their management.

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Vegetables constitute an important source of minerals, carbohydrates, proteins, vitamins and roughages. Our daily consumption of vegetables in India at present is about 110g against 400g in Europe and N America and 200 g in Africa and Latin America. Our yields are only 1/3rd to 1/5th of those obtained in other countries. The yield is appreciably reduced because of a number of factors amongst which, the attack of pests and diseases play an important part. Vegetables are comparatively more prone to the attack of pests and diseases because of their succulent and often dense growth.

Tomato

Tomato is one of the most important vegetable crops grown throughout the world. Tomatoes are subjected to attack by a number of biotic agents like fungi, bacteria, virus, mycoplasma and nematodes. Today, over 200 diseases are reported to affect tomato plant.

Diseases caused by Fungi

Damping off

Damping off is a seedling disease common to many of the vegetables. In tropical and sub tropical countries, this disease causes very serious problem in raising seedlings. Loss of seedlings during summer and rainy season is very high, sometimes to the extent of 100%.

This disease occurs in two phases (i) Pre-emergence damping off and (ii) post-emergence damping off. Former causes rotting of seedlings before coming out of the soil surface, where as latter causes toppling of seedlings on ground, due to invasion of pathogen on the basal cortical region, which results in construction and shrinking of the base. The disease is caused by species of *Pythium*, *Phytophthora*, *Fusarium*, *Rhizoctonia*, *Pellicularia*, *Sclerotinia* etc. Among these, *Pythium debaryanum*, *P. aphanidermatum*, *P. butleri* and *P.*

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ultimum are the most common. High moisture, relatively low temperature (high temperature in case of Rhizoctonia) are conducive for rapid development of the disease.

Late blight

The disease appears on leaves, stems and fruits. Brown to purplish black lesions on foliage, which advances rapidly under humid weather, causing blightening of the foliage. On fruits, dark olivaceous greasy water soaked spots are formed and the affected fruits rot. The disease is caused by Phytophthora infestans. Two races of the pathogen are differentiated, T0 and T1. T1 is more aggressive than T 0.

Early blight

This disease appeared in epidemic form in Great Britain during 1944. In India, loss due to this disease is reported to be about 78%. The most characteristic symptoms are produced on the lower leaves, in the form of circular to angular dark brown to black concentrically ringed spots. Severe infection results in withering and defoliation of leaves. The pathogen also causes damping off, collar rot and fruit rot symptoms. The disease is caused by Alternaria solani. Plants grown under high soil moisture and high atmospheric humidity are highly susceptible.

Powdery mildew

The white talc like fungal growth appears on the lower surfaces of leaves, stems and sometimes on young fruits. Corresponding, upper surface of the leaf shows bright yellow spots. The affected leaves dry up. The disease is caused by Leveillula taurica. Fletcher (1988) reported another powdery mildew disease in tomato caused by Erysiphe sp.

Septoria leaf blight

The disease occurs throughout the world. Symptoms can appear at any stage of plant growth. Small circular spots with a greyish centre and dark margin appear on lower leaves. Stems and flowers are sometimes attacked, but fruits are rarely affected. The disease is caused by Septoria lycopersici. High humidity and optimum temperature of 25°C favour disease development.

Leaf mould

It is a very common destructive disease of tomato. In India, it causes loss upto 20 to 30% every year (Chauhan,1987). Purplish or olive green mold appears on the lower surface of the leaves, which coincides with yellowing on the upper surface. Later, the infected lower leaves turn yellow and drop off. The stem, flowers, and fruits are also affected. The disease is caused by Cladosporium fulvum.

Fusarium wilt

This is very serious disease in warm humid conditions. The lower leaves become yellow, wilt and die. Young leaves show clearing of veinlets and drooping of the petioles. Later the entire plants wilt and die. The vascular bundles become brown and plants are stunted in growth. The disease is caused by Fusarium oxysporum f. lycopersici.Races 1 and 2 are commonly found causing the incidence.

Verticillium wilt

Affected plants are stunted in growth and leaves develop dark green patches followed by interveinal and marginal yellowing. Brown discolouration in the xylem vessels and adventious roots develop at the base of the stem. The disease is caused by Verticillium dahliae and V. albo-atrum.

Buck eye rot

The disease is present in almost all parts of the world. The disease is common during the monsoon season. The symptoms are characterised by the formation of brownish circular spots with concentric rings on immature green fruits at the bl ssom end. The affected fruits rot and drop. The disease is caused by Phytophthora nicotiane var. parasitica. High humidity favours the disease development.

Bacterial diseases

Bacterial wilt

One of the important limiting factor for successful production of tomato is the bacterial wilt disease caused by the soil borne pathogen Pseudomonas solanacearum. In India, total loss has been reported due to this disease. The characteristic symptom are the drooping of the leaves followed by rapid wilting of the entire plant. Sometimes, there is an excessive production of adventitous roots along the stem and the vascular bundles become brown. Three races and 4 bioraces of the pathogen have been reported. The disease is favoured by warm temperature, ie. 24-27°C and high soil moisture. Root-knot nematodes increase the severity of the disease.

Bacterial canker

Bacterial canker is one of the worlds major disease of tomato. Yield reduction of about 10% has been reported from USA. It causes a general chlorosis and drying of the leaves. Long brownish streaks appear on the stem and may crack open forming the cankers. Infected fruits develops birds eye spot surrounded by a white halo. The disease is caused by Corynebacterium michiganense pv. michiganense. Seed transmission is the main source of the spread of disease.

Viral diseases

Tomato mosaic

Clinton (1909) was the first to record tobacco mosaic virus infecting tomato. The important viruses responsible for mosaic diseases are TMV, CMV, PVX and PVY. Among these, the most important ones are the TMV and CMV. The loss in yield due to mosaic caused by TMV varies from 20 to 30 percent (Oshima,1978). Leaves show light and dark green mosaic, sometimes with distortion of young leaves. The edges of the leaves become stiff and turn downward. The virus is transmitted through seed, sap and grafting. The symptoms produced by CMV consists of mosaic and narrowing of the leaves. The plants are stunted and leaves distorted to fernleaf. The virus is transmitted by Myzus persicae, Aphis gossypii and through seeds.

Tomato leaf curl

This is a serious disease in some countries. In India, Sastry and Singh (1973) estimated the loss upto 92.3% and 28.9% respectively when plants are affected 20 days and 50 days after transplanting. The plants are stunted. The leaves and internodes are greatly reduced in size. Severe curling, twisting and rolling of the leaves take place and green leafy outgrowth or enations are seen on the under surface of the leaflets. The disease is caused by gemini virus and is transmitted through whitefly, *Bemisia tabaci*.

Tomato spotted wilt virus

Among the virus diseases, tomato spotted wilt virus has become more serious in the recent years.

The noticeable symptoms of the disease are bronzing, thickening of the veins of the younger leaves and sometimes curling. Fruits develop pale red or yellow spots or concentric circles. The virus is transmitted through sap and several species of thrips. *Frankliniella schultzei*, *F. fusca* and *F. occidentalis*.

Mycoplasmal diseases

Tomato big bud

80 to 90 percent incidence is reported in India. The characteristic symptoms are yellow to purple top leaves, phylloid flowers with numerous short stiff branches and greatest enlargement of the calyx. The disease is transmitted by *Orcsius agentatus*.

Nonparasitic diseases

Blossom end rot

It is a disorder due to calcium deficiency. Brown discolouration starts on the blossom end portion of the fruit. In the advanced stage, the tissues shrink, and the skin becomes dark grey to black.

Minor diseases of Tomato

Diseases	Symptoms	Causal organism(s)
Fungal diseases		
Target leaf spot	Brown spots with paperty white centre and surrounded by yellow halo & shot hole formation	Corynespora cassiicola
Cercospora leaf spot	Whitish brown to ash coloured spots surrounded by dark necrotic lesions	Cercospora fuligena
Leaf spot	Circular brown spots on the leaves	Stemphylium solani & Aschochyta lycopersici
Downy mildew	Yellow spots on the upper surface with downy growth on the lower surface of the leaves.	Peronospera tabacini
Stem canker	Dark brown sunken canker at the basal portion of the stem plant collapses & dies	Didymella lycopersici
Stem rot	Brownish decay of the tissue of the stem	Sclerotinia sclerotium
Collar rot	Rotting of collar region of the stem	Sclerotinia sclerotium Alternaria solani
Root rot	The roots become brown, shortened and distorted	Collectotrichum coccodes
Fruit rot		
Phoma rot	Water soaked spots, which become black and leathery with black Pycnidia on the fruit surface	Phoma destructiva
Sclerotium fruit rot	Fruits become soft and watery and sclerotia on the affected tissues	Sclerotium rolfsii
Alternaria rot	Brown, Sunken, irregular spots on the fruits	Alternaria alternata
Nail head spot	Head scab like spots on the fruits	Alternaria solani

)contd.)

Disease	Symptoms	Causal organism(s)
Cladosporium rot	Light brown lesions with dark brown centre	*Cladosporium tennussimum*
Botrytis ring spot	Brownish ring mark with a pucture in the centre	*Botrytis cinerea*
Anthracnose	Water soaked circular spots on the ripe fruit	*Colltotrichum coccodes*
Watery rot	White velvety fungal growth on the decayed tissues	*Oospore lactis* 'fsp *parasitica*
Malustela rot	Irregular lesions surrounded by black spore mass of fungus	*Malustela aeria*
Storage rot		
Fusarium rot	Water soaked lesions and decaying of the fruits	*Fusarium roseum*
Rhizopus soft rot	Fruits become soft and watery	*Rhizopus nigricans*
Stemphylium fruit rot	The fungus produces stalk end rot	*Stemphylium vesicarium*
Nigrospora rot	Water soaked spots, later fruits become black	*Nigrospora oryzae*
Bacterial diseases		
Bacterial spot or scab	Black greasy spots on leaves, stem, and on the fruits scabby dark coloured lesions with crack in the centre	*Xanthomonas campestris* pv. *vesicatoria*
Bacterial speak	Tiny dark brown spots on the fruits and also on the leaves	*Pseudomonas tomato*
Viral diseases		
Group		
Cucumovirus		
Tomato aspermy	Mottling, leaf distortion, proliferation of shoots, Mosaic, narrow leaf	Sap *Myzus persicae*

(contd..)

Diseases	Symptoms	Transmission
Peanut Stunt	Mosaic, narrow leaf	Sap *M. Persicae*
Gemini virus		
Tomato golden mosaic	Leaf curling, chlorosis, mosaic	Sap, *Bemisia tabaci*
Tomato yellow dwarf	Curling, yellowing, twisting, rolling of leaves and stunting	*Bemisia tabaci*
Tomato yellow leaf curl	Stunting, yellowing, curling of leaves	*B. tabaci*
Luteovirus		
Tomato yellow top	Chlorosis, smalling of leaves, branches are stiff and upright	Aphid. *Macrosiphum euphorbiae*
Nepo virus		
Tomato black ring	Black necrotic ring	Nematode-*Longidorus elongatus* & Sap
Tomato ring spot	Curling, necrotic rings on leaves, corky marks on fruits	Nematode - *Xiphinema americana* & Sap
Poty virus		
Potato virus Y	Mottling, vein banding	Sap, *Myzus persicae*
Potex vifus		
PVX	Mosaic, mottling, necrosis, slight stunting	Sap, seed

(contd...)

Diseases	Symptoms	Transmission
To bamovirus		
Tomato shoe string	Mild mottling, under curling of leaves	Sap
Tomato scorch-TMV & Potatovirus-	Chlorotic mottle epinasty, necrosis and stunting	Sap & *Myzus persicae*
Tombus virus		
Tomato burshy stunt	Yellowing, necrotic lesions, bushy growth	Sap
Ungrouped virus		
Tomato bunchy top	Stunting, bushy, small distorted fruits	Sap
Tomato top necrosis	Ring spot on leaf	-
Tomato yellow mosaic	Wrinkled leaves, yellow spots, folded apical leaves	Sap. *B. tabaci*
Tomato yellow net	Chlorosis of vein and veinlets of young leaves	Sap *Myzuz persicae*
Complex disease		
TMV & Tomato leaf curl	Crinkling, yellowing, Premature withering of leaves, stunting, Profuse branching	--
MLO		
Purple top	Stunting, upright appearance, rotting and Purple leaves	--
Stolbur	Yellowish purple discolouration, in ward rolling of apical leaves, and floral abnormalities	Leaf hopper
Marginal flavescence	Chlorosis along the leaf margin, reduction in leaf size, bushy appearance	*Orosius albicinctus*
Non-parasitic disease		
Blotchy ripening	Greenish yellow or waxy area on ripen fruit	Potassium deficiency

Brinjal

Brinjal crop suffers from several diseases like damping off, leaf spots, wilt, fruit rot, mosaic, little leaf etc.

Leaf spots

Alternaria melongenae causes brown irregular spots with concentric rings on leaves and necrotic sunken spots on the fruits.

Cercospora solani.melongenae causes chlorotic spots on the leaves which later become greyish brown. It also causes fruit rot.

Phomopsis blight and fruit rot

It produces damping off, stem, canker, leaf blight and fruit rot symptoms. Lower leaves are attacked first, producing circular, grey to brown spots with black pycnidia at the light coloured centre. The affected fruits are soft, watery and later turn black and mummified as pycnidia develop abundantly over the surface. The disease is caused by Phomopsis vexans.

Fusarium wilt

The leaves become flaccid, hang down and become yellow. The plants gradually dry up. The disease is caused by Fusarium solani.

Verticullium wilt

Loss caused by the disease extend from 5-90% in Tamil Nadu. The initial symptom is the temperory drooping of old leaves, pale yellow patches in the intervienal areas on the leaf lamina and later dropped off. Browning of the vascular tissues of the root and stem. The disease is caused by Verticillium dahliae. The optimum temperature for the disease development is 22-24°C.

Bacterial diseases

Bacterial wilt caused by Pseudomonas solanacearum is one of the most serious disease of brinjal in warm humid areas. There are three races of the pathogen of which races 1 and 3 are more pathogenic to egg plant than race 2. Presence of root knot nematodes increases wilt incidence.

Viral and mycoplarmal diseases

Mosaic

Several viruses infect brinjal plants and produce different shades of mosaic including vein banding. The disease due to TMV or CMV causes, pronounced mosaic mottling, reduction in leaf size and various deformities like puckering, crinkling, on severely infected leaves. The virus is sap transmissible and also through *Myzus persicae*, *Aphis gossypii*.

Little leaf :

It is the most serious disease causing crop damage in field ranging from 40 to 80%. The disease is reported to be caused by MLO. Leaves become small, thin, soft and pale green. Axillary and latent buds are stimulated into growth and internodes are shortened. The affected plants become bushy, flowers become phylloid, and fruits are seldom set. The disease is transmitted through *Hishimonas phycitis* (Dist.). *Empoasca devastans* is a less effective vector.

Minor diseases of brinjal

Diseases	Symptoms	Causal organism
Sclerotinia blight	Discoloured spots on the stem, necrosis and wilting of the plant, rotting of fruits.	*Sclerotinia sclerotium*
Collar rot	Decortication, necrosis of tissues of the stem	*Sclerotium rolfsii*
Pythium fruit rot	Fruit skin turn tan colour, tissues become watery and light brown	*Pythium aphanidermatum*
Phytophthora fruit rot	Water soaked lesions, soft and watery fruits, white cottony mycelium on fruits	*Phytophthora nicotianae* var. *nicotiane*
Mosaic		Transmission
Alfalfa mosaic virus	Veinbanding, yellow blotches, slight puckering, stunting	Sap, aphids

Diseases	Symptoms	Causal organism
Non-aphid brone mosaic	Mottling, puckering, flower colour breaking, mottling of fruits.	Sap
Egg plant mosaic virus (Tymogroup)	mild to severe mosaic	Sap, beetles <u>Epitrix sp</u>.
Egg plant severe mottle virus (Poty group)	Mottling, blistering, malformation and abnormal serrations of the leaves.	-
Egg plant mottle dwarf virus (Rhabdo group)	Stunting, leaf narrowing, vein chlorosis, crinkling of leaves, crackling of fruits	-
Egg plant mottled crinkle virus	Chlorotic rings, mosaic symptoms on leaves, stunting	-
Phyllody (MLO)	Stunting, malformed leaves, virescent flowers	Grafting

Chillies

India is known as the home of spices. Chilli occupies the central place amongest spices. Chilli crop is known to suffer from fungal, bacterial, and viral diseases apart from root-knot nematodes.

Fungal diseases

Damping off is the serious disease in nursery.

Die back and fruit rot

This is the most important fungal disease of the crop. It has been reported to decrease yield by 10-75% (Bansal and Grover,1969). Symptoms appear mostly on ripen fruits as circular sunken spots, which later enlarges forming concentric marking with dark fructification. Badly diseased fruit turn straw coloured and drop off. The fungus may also attack stem causing die back symptoms. The disease is caused by (<u>Colletotrichum capsici</u>). The fungus is seed borne. Maximum disease development takes place at 28°C and 96.7% relative humidity.

Powdery mildew

This disease is common in all chilli growing areas particularly during winter season. The disease is characterised by a white powdery growth on the under surface of the leaves. The affected leaves turn yellow and defoliated. The disease is caused by *Leveillulla taurica*.

Frog eye leaf spot

Small circular chlorotic spots, which later develop to a light greyish centre with dark brown margin. Severely affected leaves drop off prematurely. The disease is caused by *cercospora capsici*.

Alternaria leaf blight

Dark brown leathery spots with concentric rings and whitish centre are produced on the leaves. Affected leaves turn yellow and die prematurely. The disease is caused by *Alternaria solani*.

Blight and fruit rot

This disease is caused by *Phytophthora capsici*. It is serious during moist weather. The older plants show root rot, stem canker, leaf blight and fruit rot symptoms.

Bacterial diseases

Bacterial wilt

Bacterial wilt of chillies caused by *Pseudomonas solanacearum* is a wide spread disease in Kerala. Drooping of leaves and sudden wilting of the plants are the main symptoms.

Viral diseases

Chilli mosaic

Chilli mosaic is one of the important disease of chilli, Incidence of mosaic around Delhi region varied from 20-27% (Anand *et al*.,1961) and in Karnataka it ranged from 50-96%. Chilli is attacked by 14 different viruses including TMV, CMV, PVX and PVY. The disease is characterised by distortion of leaves with puckering and pronounced mottling. The leaves are reduced in size and become filiform. Flowers and fruits may not be formed or may remain small and distorted. The virus is transmitted through sap, seeds, *Myzus persicae* and *Aphis gossypii*.

Leafcurl

Leaf curl complex of chilli is a most serious and devastating disease which cause an economic loss of 100 percent. (Anon,1976). Curling of leaves, reduction in leaf size and shortening of internodes are main symptoms. The whole plant assumes a bushy appearance and stunted growth. Moghe (1977) reported that this complex disease is due to infestation of thrips, mites and a virus. The virus (tobacco leaf curl) belong to gemini virus group, which is transmitted by white fly.

Minor diseases of chilli

Disease	Symptoms	Causal Organism
A. Fungal		
1. Blossom blight	Rotting of buds, flowers, leaf blight, die back of shoots and stem	*Choanephora cucurbitarum*
2. Root rot	Yellowing of leaves, decaying of the base of the stem and root and wilting of the plants.	*Sclerotium rolfsii*
3. Wilt	Drooping and yellowing of older leaves, girdling of the stem and brown discolouration of roots.	*Fusarium solani*
4. Fruit rot	Sunken spots with dark brown margin and light grey centre covered by olive brown fungal growth	*Alternaria solani*
B. Bacterial		
1. Bacterial leaf spot	Small, circular dark b brown or black greasy spots on the leaves. Canker on stem, wilting of branches water soaked spots on fruits.	*Xanthomonas campestris* pv. *vesicatoria*
C. Viral		
Chilli vein banding mosaic (PVY)	Mosaic, vein banding symptoms	Transmitted by *Myzus persicae* & *Aphis gossypii*

Okra

Okra (Abelmoschus esculentus L) is an important vegetable crop in the tropical and sub tropical parts of the world.

Wilt

The disease is caused by Fusarium oxysporum f. vasinfectum. The symptoms appear as yellowing, stunting followed by wilting and rolling of leaves. Vascular tissues show brown discolouration. The fungus is soil borne and optimum temperature required for disease development is 22-28°C.

Powdery mildew

White greyish powdery coating is seen on the upper surface of the leaves. The affected leaves dry up. The disease is caused by Erysiphe communis.

Leaf spot

Cercospora malayensis produces circular to irregular brown spots and C. abelmoschi causes sooty black spots on the lower surface of the leaves. Severely affected leaves dry up.

Choanephora fruit rot

Recently it has been noted that, okra production suffered severe loss due to choanephora rot caused by Choanephora cucurbitarum. Premature fruit abortion of okra, result in 70-80% fruit loss (Anon,1983). The symptoms are characterised by water soaked fruits, growth cessation, premature fruit abscission or shrivelling and profuse fungal growth on infected fruits.

Yellow vein mosaic

The yellow vein mosaic is a devastating disease that makes the okra cultivation difficult and uneconomic. The loss due to this virus disease has been reported to range from 50-90%. The main symptoms are vein clearing and veinal chlorisis of leaves. The yellow net work of vein is very conspicuous and the vein and veinlets are thickened. In severe case, the entire leaf turns yellow. Fruits are smaller, malformed and become pale, tough and fibrous. The disease is neither transmitted through sap nor seed but through white fly, Bemisia tabaci and okra leaf hopper Empoasca devastens.

Minor diseases of okra

Diseases	Symptoms	Causal organisms
Fungal		
Phoma leaf spot	Straw coloured spots with purplish margin, black pycnidia at the centre & shot hole symptoms.	Phoma putaminum
Curularia leaf spot	Spots with dark brown margin & dark sporulation at the centre.	Curularia lunata
Leaf blight	Necrotic spots with black pycnidia on upper surface of leaves	Macrophomina phaseolina
Phoma canker	leaf spot, stem canker, fruit rot	Phoma exigua
Leaf spot	Spots with greyish centre, and pycnidia, shot hole symptom	Phyllosticta hibiscini
Leaf blight	Brown spots with concentric rings	Alternaria hibiscinum
Rust	Rusty pustules on the leaves	Uromyces heterogenus
Pod spot	Lesions with grey centre bearing minute fructification	Ascochyta sp.
Anthracnose	Anthracnose of stem, fruits and leaves	Collectotrichum hibisci
Bacterial		
Bacterial leaf spot	Brown spot with dark brown margin, bacterial ooze exudes from the spot, yellowing of vein and vein lets	Xanthomonas campestris pv esculenti
Viral		Transmission
Leaf curl	Curling, thickening of veins	Whitefly, grafting
Enation leaf curl	Curling & enations	B tabaci
Mosaic	Green and yellow patches on the leaves	beetle

Disease management

Control of fungal diseases

Cultural methods

Crop rotation

The influence of crop management practices on disease severity has long been noted by vegetable growers. Practice of crop rotation including non-solanaceous hosts has been suggested for reducing soil borne diseases like wilt, stem rot and root rot disease.

Soil fertility

The addition of calcium to the soil in the form of hydrated lime, ground lime stone or gypsum has been shown to decrease the severity of Fusarium wilt in tomato. The incidence and severity of Fusarium wilt of chilli was reduced after application of N and lime (Sarhan and Sharif, 1986). Use of well decompared FYM and application of P & K in the soil reduce the incidence of damping off disease.

Soil modification

The soil preparation practices of deep ploughing crop residue has reduced the sclerotinia rot of tomato and verticillium wilt of brinjal. Raised beds in well drained soils reduced the incidence of damping off, Phytophthora root rot and buckeye rot of tomato.

Sanitation

Removal of crop debris has long been recommended for many diseases. Destruction of weed host is very important for powdery mildew diseases.

Irrigation

Optimum irrigation should be adopted for minimising the damping off and root rot diseases. Overhead irrigation favours the foliage diseases like late blight, grey mold and also buckeye rot of tomato.

Environmental condition

Soil temperatures are initial factors influencing soil borne diseases. High relative humidity and periods of leaf wetness are important factors influencing foliage diseases. Condition of low relative humidity appear to favour powdery mildew.

Flooding

The association of flooded fields and disease control has long been noted for diseases such as wilt and stem rot.

Mulching

Staking the plants and mulching the field with straw reduced the incidence of buck eye rot of tomato as fruit do not come in contact with the soil.

Avoidance

Early planting will avoid the infection of powdery mildew diseases.

Chemical control

Since the time, when Bordeaux mixture was first applied to control foliar diseases of vegetables, there have been continuing advances in fungal disease control.

Seed treatment with Brassicol followed by Topsin-M are most effective for controlling damping off tomato due to *Rhizoctonia solani* while Dithane M-45 and Thiram are the best treatment for chilli seeds. Topsin M and Bavistin are highly effective against damping off caused by *Macrophomina phaseolina* of tomato and chilli (Satija and Indra Hooda,1987). Soil drenching with 1% Bordeaux mixture, captafol and Dithane M-45 have also been effective for controlling damping off.

For the control of early blight of tomato, foliar sprayings of Dithane M-45, Zineb, Captan and systemic fungicides like Benlate, Bavistin have given best control. Kamlesh Mathur and Shekhawat (1986) reported that Blitox-50 is the most effective for controlling *Alternaria solani* followed by Difolatan and Dithane-M-45. These chemical are also effective against other leaf spot diseases of tomato.

In case of late blight, Dithane Z-78 give the best control and highest yield, followed by Dithane M-45, Difolatan and Daconil (Gupta, 1987). Cohen et al. (1979) recommended metalaxyl as soil drench. Zollfrank and Lyr (1988) reported a new phytophthora fungicide - Andoprim-which totally inhibited *Phytophthora infestans* by 10 mg/litre.

Leaf mold disease caused by *Cladosporium fulvum* is controlled by chlorothanolil, Benlate, Bayleton and Captan. Tridemeforn (Bayleton) applied at 10-15 days interval at 250 g ai/ha or fenarimol 36-48 ppm gives excellent control of powdery mildew of tomato (Correll et al., 1988). The powdery mildew caused by *Erysiphe* sp. is controlled by benomyl 0.1%, carbendazim 0.1% and chlorothalonil 0.2%.

Soil drenching with 1% Bordeaux mixture or Fytolan or Benlate or Bavistin are effective for controlling the fusarium wilt of solanaceous crops. Seed treatment and soil drenching with 0.1% benomyl may be highly useful in controlling verticillium wilt.

Thiophanate-methyl or carbendazim applied as soil drenches will control the pathogen of stem canker. Fenarimol in water or in mineral oil or benomyl or iprodione in mineral oil has also been recommended by Steekelenburg (1988) for the control of *Didymella lycopersici*. Seed treatment with carbendazim @ 2g/kg seed and fortnightly application of captafol at 4-8 kg. or chlorothalonil 7 kg/ha reduce the incidence of root rot of tomato.

Captafol and mancozeb have been found effective with control of buck eye rot of tomato (Anon, 1990). Davis (1989) reported that prophylactic foliar spreys of foestyl.A. (12 g ai/litre) is effective in reducing buck eye rot of tomato.

Application of herbicide diphenamid has resulted in increased resistance in tomato to the damping off pathogen. Dinitramine has shown to reduce *Sclerotium rolfsii* damage of tomato. Herbicide, prometryn at 128 and 256 ppm and triazine compounds, Igran and Go Goltix 50-1200 ppm significantly inhibited the growth of *Fusarium oxysporum* f. *lycopersici*, causal agent of tomato wilt. (Ismail, 1989).

For the control of leaf spots and phomopsis blight of brinjal 0.2% Difolatan or 0.2% Captan has been found effective. Jacqua and Gerion (1988) recommended chlorothalonil and mixture of captafol and carbendazim spray at 10-12 days interval for controlling phomopsis blight.

Seed treatment with Thiram or bisdithiocarbomates 0.2% or Bavistin (1g/kg seed) controlled Colletotrichum capsici causing fruit rot of chillies (Anon 1990). Das and Mohanty (1988), obtained best control of die back and fruit rot by spraying carbendazim followed by benomyl, captafol and Dithane-M-45. Foltaf 0.2%, and Fytolan 0.25%, is also effective in controlling die back. These chemicals and 1% Bordeaux mixture with spreader, calcium caseinate, will give control of leaf spot and leaf blight diseases. Sekhar et al. (1988) reported that leaf blight caused by Alternaria solani is effectively controlled by 0.25% Fytolan and 0.2% Dithane M-45 and powdery mildew is controlled by 0.1% Bavistin. Sulfex 0.3% followed by Topsin-M 0.1% and Karathane 0.1% are also found effective against powdery mildew disease of chillies (Anon,1990). Mixture of metalaxyl and copper oxychloride is effective as metalaxyl alone of controlling Phytophthora capsici (Sung and Hwang,1988) causing leaf blight and fruit rot. Drenching the soil with Brassicol 0.11% has been recommended for root rot disease.

Leaf spot of Okra can be controlled by 1% Bordeaux mixture 0.2% Difolatan for 0.1% Bavistin. For the control of powdery mildew, application of Bavistin 0.1% followed by Karathane 0.1% has also been found effective.

Biological control

Application of antagonists are found effective in controlling soil borne diseases. Tomato seeds coated with Trichoderma viride, Streptamyces spp., Bacillus subtilis have shown reduction in the incidence of pre and post emergence damping off. Trichoderma harzianum and other Trichoderma sp have been shown to reduce root rot caused by Sclerotium rolfsii and Rhizoctonia solani. Some Acremonium sp. Verticillium sp and Fusarium sp. were found to be antagonists of Cladosporium fulvum. Tirilly et al. (1987) reported Hansfordia pulvinata an antagonist and hyperparasite of Cladosporium fulvum causing leaf mold disease of tomato.

Trichoderma harzianum and Pencillium griseofulvum inhibits germination of microsclerotia of Verticillium dahliae, causing wilt of brinjal by substances secreted by two antagonists (Henni,1987).

Cho (1987) reported the control of Phytophthora capsici by by using the antagonists Pseudomonas cepacia, Bacillus polymixa and Bacillus sp. together with suitable soil ammendment of organic compost and calcium fertilizers.

Biological control may become available by use of capsidol - a phytoalexin formed from Capsicum annuum. Capsidol applied to tomatoes at 5×10^{-4M} controlled Phytophthora infestans for 8 days. Injection of 1% copper sulphate into capsicum fruit will induce capsidol formation.

Garlic bulb (Allium sativum) at 10% concentration checked the growth of Pythium aphanidermatum causing damping off of tomato and chilli. Similarly soil drenching with garlic bulb and neem leaves brought down the seedling mortality of tomato and chilli due to damping off (Lakshman, 1991).

Geraniol-allelopathin was potent against Alternaria solani causing early blight of tomato (Rizvi et al., 1988). Use of vegetable oils were found controlling the fruit rot caused by Phoma Oospora and Alternaria. Homeopathic drugs such as Thuja, Sulfer-200 inhibit seed borne fungi and increase germination percentage of okra seeds.

Cross protection

Inoculating tomato roots with Fusarium oxysporum f. melonis induce resistance to Fusarium oxysporum f. lycopersici.

Solar sterilization

Recent studies on the use of polythylene sheets for soil solarization have shown promise control of soil borne diseases. Propagules of the soil fungal pathogens Verticillium dahliae, Rhizoctonia solani, Pythium sp. are reduced or eliminated in soil upto a depth of 46 cm.

Use of resistant varieties

Vegetable crops are highly prone to several diseases and the indiscriminate use of fungicides for the control of diseases has several disadvantages, particularly the cost of fungicides and their residual effects. Therefore it is imperative to concentrate on the development of cultivars that are resistant to diseases.

Alternaria solani causes collar rot and early blight of tomato. Lycopersicon pimpinellifolium is found resistant to collar rot and L. hirsutum, tomato varieties Novelty, Sputnik, and West Virgina were found to be resistant to early blight. Fusarium wilt caused by Fusarium oxysporum f. lycopersici is a very serious disease. In India, varieties like Marglobe, Rutger, Pritehards are found resistant to this Fusarium wilt disease. Resistance to both Fusarium and Verticillium wilt is observed in Walter, Tripic, Nova, Tropic Red etc. Screening studies conducted against leaf mold disease have indicated that Lycopersicon pimpinellifolium L. hirsutum and L. peruvianum and varieties Antincold, LMRI, Sapsford No. 1 are found resistant. In India, varieties Sweet 72, Sel-152, S-12, Marglobe, Gambed are resistant to septoria leaf spot. Varieties Monaloo, 2072-10, West Virgina are tolerant to Oidium sp. In India, tomato cultivars HS101, HS 102, Gamed are resistant to cladosporium and phoma fruit rot (Chauhan, 1987). For Didymella stem canker, the resistance is found only in L. hirsutum. In Italy, varieties Bari 214, Campbell 35, Ogosta, Petomech are found resistant to Blossom end rot.

Wild species Solanum nigrum, S. gilo are found to be resistant to phomopsis blight and S. Indicum and S. khasianum are found resistant to verticillium wilt of brinjal. Brinjal cultivars Pusa purple cluster were found resistant to Alternaria and Stemphylium blight and the variety Florida Market is found to be resistant to phomopsis blight and verticillium wilt.

In chillies, varieties Pant C-1 and B7-9 are found resistant to fruit rot and die back disease (perane and Joi, 1986). Pant C-1 is moderately resistant to Phytophthora capsici.

Five biotypes derived from Abelmoschus tetraphyllus, A. manihot A. moschetus are reported immune to powdery mildew of okra. Pusa sawani and Pusa Makhmali are found resistant to okra wilt.

Control of bacterial diseases

Cultural methods

Crop rotation

Rotation for several years with crops immune to disease would probably aid in control of bacterial wilt. In crop rotation, crop sets Okra-cowpea-maize have been effective in reducing the mortality rate oftomato plants due to bacterial wilt.

Green manuring

The incidence of bacterial wilt is reduced with different green leaves and paddy straw. Significant reduction in wilt incidence is observed with neem, glyceridia and sesbania leaves.

Adjusting soil reaction

Use of lime at about 12.5 q/ha may reduce the infection of bacterial wilt.

Field sanitation

Affected plants or plant parts should be removed and destroyed to prevent disease incidence.

Chemical control

Application of bleaching powder at 15 kg/ha in soil before transplanting, has been effective against bacterial wilt (Ramakrishnan, 1981). Application of cheshunt compound at 15 d interval give control of bacterial wilt in chillies. Spraying streptomycin or streptocycline is also found to be effective for controlling bacterial wilt.

Seed treatment with 1 or 5% H_2SO_4 for five minutes is helpful for controlling tomato bacterial leaf spot. Spraying of 1% Bordeaux mixture at an interval of 15 d is more effective. Spraying Agrimycin - 100 (100 ppm) or Bavistin (0.2%) at 10 d interval has also given good control. Combination sprays of copper sulphate and Dithane M.45 have been highly effective for leaf spot of tomato (Jones and Jone.1987).

Seed treatment with 5% HCl for 3 hours or with 1% sodium hypochlorite for 40 mts followed by streptomycin (200-400 ppm) spray has proved effective for bacterial canker of tomato.

Seed treatment with 0.1% mercuric chloride for 2-5 minutes and spraying 1% Bordeaux mixture or copper oxychloride 0.25% is effective in the control of bacterial leaf spot of chillies.

Biological control

The use of microbial antagonist has been noted as a promising control strategy. Various fungi, actinomycetes and bacteria exhibited antibiotic effects against Pseudomonas solanacearum. The rapidly growing bacteria like Pseudomonas flurescens and Bacillus polymixa, FU6 are effective in reducing incidence of bacterial wilt in tomato. Tomato seedlings dipped in suspension of non-pathogenic strains of Pseudomonas glumae induce resistance against Pseudomonas solanacearum. Root dipping tomato in suspension of an avirulent bacteriocin producing strain either MA-7 or NOE 104 prior to transplanting, delayed disease development and reduced disease severity of bacterial wilt (Ren et al.,1988).

Organic amendment, [illegible] like oil cakes from rubber seed, neemcake, caster shell, coconut pith and sand dust have reduced the wilt.incidence (Jaya Prakash and Rajan, 1975). Soil amendment called S.H. mixture containing bagasse, rice husk, oyster shell powder, urea, potassium nitrate, Calcium superphosphate and mineral ash controlled P. solanacearum on tomato. Erkan and Saygili (1987) isolated 2 bacteriophages for Corynebacterium michiganense and 4 phages for Xanthomonas campestris pv vesicatoria from infected tomato material and soil.

Use of resistant varieties

Chemical control is both cumbersome and uneconomical. Use of resistant varieties is the effective and reliable means of control. Resistance to bacterial wilt was reported in Lycopersicon pimpinellifolium and combined in L. esculentum. Tomato cultivars Intan, Ratna, AV-22, AV-15, CL 32-6 are found resistant to Pseudomonas solanacearum. Sinha et al. (1988) reported that BWR-1, BWR-5, LE-79 (Sakthi) show 100 percent survival, 120 days after planting in a wilt sick plot. Lycopersicon pimpinellifolium is also found resistant to bacterial canker of tomato.

Bacterial wilt resistance has been reported in a number of SM series. The line SM6 is resistant to bacterial wilt and is accepted as a source of resistance in brinjal. SM6 was observed resistant to TEP-13 (Race 1) W82 (Race 3). The prickly line SM6-1 is found to be immune to wilt. SM6-7, SM6-6, SM-141-1-1, are found highly resistant to bacterial wilt in Kerala (Gopalakrishnan, 1990).

In the case of bacterial wilt of chillies, varieties Pungent Pride, Cherry red and Kandhari are tolerant. The varieties KAU cluster is resistant to 4 isolates of race 1 and race 3, White kandhari is resistant to six isolates of race 1 of *Pseudomonas solanacearum* (Peter *et al*., 1984).

Selection EC 62716, IC 2472 are found resistant to bacterial leaf spot of chilli.

Control of viral and mycoplasmal diseases

Cultural method

Crop rotation

Generally recommended against soil borne nematode diseases like tomato ring spot and tomato black ring spot.

Avoid continuous cropping to break the disease cycle, so as possible to minimise the spread of virus diseases having limited host range.

Intercropping

The incidence of tomato yellow leaf curl was reduced by planting tomato with capsicum. The population of whitefly was lowered on tomato planted with chilli and cucumber.

Planting date and plant density

Adjusting sowing and planting time of the crops based on vector migration also offer a mean of control of some of the seed borne viruses. Close row spacing lowered the incidence of cucumber mosaic disease in chilli than the wider row spacing.

Barrier crops

Virus free nursery of chillies, brinjal etc. can be raised by growing the barrier crops like barley or sorghum surroundings the seed bed. Boarder cropping (Maize or sunhemp) around tomato crop for the control of tomato leaf curl have also been recommended.

Field sanitation

Roughing out by the infected plants prevent thespread of virus diseases. Destruction of weeds,volunteer plants help in the reduction of tomato mosaic, tomato spotted wilt, yellow vein mosaic of Okra etc.

Use of virus free planting materials

The virus like CMV, TMV, which survive in the seeds of tomato, chilli etc. can be eliminated to some extent through use of virus free seeds. Virus can be eliminated from the seed through heat treatment. Eliminated TMV from tomato seeds is eliminated by subjecting the dry seed to temperatures of 70 and 80°C 3 and 1 day respectively. Dry heat treatment at 70°C for 7 days gave complete inactivation of chilli virus (Stijger and Rast, 1988). Mayee (1977) noticed substantial reduction in brinjal mosaic by storing the seed at room temperature for longer period.

Repellence of vectors by relective surfaces

Mulching

Loebenstein et al. (1975) recorded 6 reduction in the incidence of CMV and PVY in chillies with aluminium and grey plastic mulches. Since the aphids are attracted more towards yellow colour, reduction in CMV and PVY spread in chillies is noticed by using yellow polythelene sheets. Incidence of tomato yellow leaf curl was reduced by using silver plastic mulches. In Brazil, the early infection of PVY was reduced upto 90% by mulching the soil with rice husk. In general, mulching either by aluminium foil or plastic sheets or by rice husk besides reducing the virus spread, also controls the weed growth, conserve the soil moisture and also reduces the loss of fertilizers.

Control of insect vectors by using oils

Out of the different kinds of oil available viz. vegetable, mineral, synthetic and essential oils, the effective control of virus diseases is achieved with mineral oil. CMV in chillies is effectively controlled by oil spray, Atplus 411 E was more effective than Primor 50 DP (Kiss et al., 1988). About 90 percent reduction in the incidence of tomato leaf curl has been observed by 4 sprays of Krishi oil (1.11%) given at 10 days interval without any phytotoxic effect. The use of oil as sprays has several advantages like low cost, good spreading capacity, easy to mix, safe to animals, and insects have not yet developed any resistance to them.

Chemical method

Tobacco mosaic virus on tomato, chilli, brinjal seeds are externally seed borne and soaking the seed in 1% solution of trisodium orthophosphate for 15 mts. helps in eliminating virus from the infected seed. As the viruses are transmitted through insects, control of vectors by insecticidal spray may reduce disease incidence. With the emergence of powerful quick acting insecticides, researches are made to reduce the virus spread by vector control.

Chemical control of vectors

Application of insecticides such as rogor (0.05%), ekalux (0.02%), metasystox (0.02%), thimet (granules @ 15 kg/ha) and dimecron (0.05%) have been recommended to check the spread of tomato leaf curl diseases. Combinations of either H1-PAR of sunoco mineral oil with permethrin methidathion or pirimiphos methyl have given good control of white fly and reduced the spread of TLCV. There are experimental indications that growth regulators like gibberellic acid and 2,4-D reduce incidence of leaf curl and greatly increase the yields. Application of 0.025% methyl demeton at 10 d interval control the insect vector of tomato spotted wilt virus.

Metasystox, Malathion have been recommended for the vector control of little leaf of brinjal. Although, mycoplasmas are reported to be suppressed by tetracyclines, field application of this method has not yet been recommended. Datar (1981) obtained disease control by seedling dip in Tetracycline 500 ppm + soil application of phorate (1.5 kg/ha) at 21 days after planting. Phorate application in field at (1 kg/ai/ha) 10 days after transplanting + phorate seedling dip (0.1 kg ai/500 litre of water) has also been recommended for the vector control, (Anon, 1990).

Insecticides like Diazinon, metasystox have been recommended for the control of vectors of chilli mosaic and leaf curl. Phorate @ 2.25 kg ai/ha and Phosalone @ 0.438 kg ai/ha are the most effective, in reducing the incidence of leaf curl and populations of thrips and mites. Application of Furadan (1.5 kg ai/ha) followed by mineral oil spray has also been recommended for reducing incidence of chilli leaf curl (Anon, 1990).

Soil application of Thimet or Disyston granules, one at the time of planting and again after 40-50 days is recommended to prevent population build up of vectors of yellow vein mosaic of Bhindi. Metasystox 0.2%, carbofuran 1.5 ai/ha, Krishioil and Sumithion 0.3% are effective for whitefly control and lowering yellow vein mosaic disease incidence (Anon, 1990).

Biological control

Cross protection

In cross protection techniques, the crop plants are deliberately inoculated with a mild strain which will give protection against severe strains of the same virus. Rast (1972) used attenuated mutant strain M-11-6 of TMV in a commercial scale against severe strain in tomato. Sulyo (1987) also reported cross protection of TMV in tomato.

Extracts of plants sometimes contain substances inhibitory to virus infection. Infection of PVY on chilli was inhibited from 18.5 to 71% with extracts from Basella rubra (Suria chandra selvan and Narayanaswamy, 1987). In addition, skim milk, whey have been reported to inhibit local lesions produced by TMV.

Use of resistant varieties

For effective control of virus diseases, many times it may not be practicable to implement cultural and chemical measures in time because of cost or some other factor. However, control of virus diseases by use of resistant varieties is the most efficient and economical provided, stable source of resistance can be obtained.

Source of resistance to tomato mosaic virus and tomato leaf curl are mostly in wild species. Resistance to CMV has been reported in Lycopersicon pimpinellifolium and L. peruvianum. Lycopersicon peruvianum, PI 128650 is immune to all strains of TMV. Tomato line LA 1221 & LA 2088 are highly resistant to TMV. Three lines of L. hersutum (LA 386, LA 1777, PI 390513) one line of L. glandulosum (EC 66003) 2 lines of L. peruvianum (PI 127830 and PI 127837) are found highly resistant to tomato leaf curl virus. L. peruvianum and L. pimpinellifolium are found immune to tomato spotted wilt virus and the tomato cultivars, viz. Red cherry small Italian Red pear, and Red current are found resistant to TSWV (Joi and Summar war, 1986).

Wild species, Solanum vivarum is found immune to little leaf disease, while S. ineanum, S. sisymbrifolium are resistant to this disease. Brinjal cultivars, Pusapurple Round, Black beauty, Surati are found tolerant to the disease and Pusa purple cluster is found resistant to the disease. Pusa purple Cluster is also found resistant to brinjal mosaic.

Chilli varieties Puri Red, Puri Orange, G2, Kondivenum are resistant to chilli mosaic virus. Puri Red, Puri Orange, Surajmani and Perennial are resistant to chilli leaf curl virus. A variety Delhi local is found immune to chilli mosaic virus and tolerant to leaf curl virus.

Resistance to yellow vein mosaic virus is limited to the wild species of Abelmoschus. Nerkar and Jambhale (1985) successfully transferred the yellow vein mosaic resistance from A. manihot to cultivated okra by using the back cross method. Breeding for resistance to YVMV was initiated by Singh et al. (1962) led to the development of variety Pusa sawani which had possessed a high degree of tolerance. But in the recent past, its resistance is broken down. Later two varieties Punjab Padmini and Punjab-7 are resistant to yellow vein mosaic (Sharma and Sharma, 1984). Nerkar and Jambhale (1986) reported a variety Parbhani kranti resistant to YVMV. Recently two more resistant varieties, selection-4 and selection 10 (Arka Anamika) are reported from IIHR, Bangalore. (Dutta, 1988).

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Diseases of amaranthus and legume vegetables

Dr.C.Gokulapalan

AMARANTHUS

Collar Rot

The infected plants exhibits rotting of basal stem portions. These parts ultimately turn brown and die off leading to the wilting, lodging and drying up of the entire plant. The disease is caused by the fungus, Sclerotium rolfsii (Sacc.). The sclerotia of the fungus are seen on the infected parts of the stem. In advanced stages of infection shreadding ofthe stem is seen. The fungus can be effectively controlled by spraying 1% Bordeaux Mixture and giving a drench of the same fungicide in the amaranthus beds.

Anthracnose

The disease is characterised by blighting of mature leaves. A large number of acervuli are seen on the uppir surface of leaves. Th infected parts of the leaves often crack and disintegrate. This disease is caused by Colletotrichum gloeosporioides.

White Rust

The disease is characterised by the presence of white corky blisters on the under side of the leaves, when there is severe infection the leaves dry and defoliate. The disease is severe during the cooler months. The spores are released by the bursting of the leaf epidermis and are spread by the moist wind. The disease is caused by the Oomycete, Albugo bliti.

Bacterial leaf spot

This disease has been reported from Tamil Nadu and Maharashtra. It is commonly seen during September-October months in Tamil Nadu. The disease starts as minute, round, water soaked

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spots with a halo. These later become dark brown and sunken and coalese to form larger lesions. The disease is caused by the bacterium, Xanthomonas amaranticolor. Bacterial ooze is often seen on the spots. After wind splashed rains, the disease may spread to the petioles and stem forming canker like lesions.

Mosaic

Thesymptoms include chlorotic spotting, mosaic mottling and deformation of leaves along with stunting of the plants. The virus is sap transmissible and transmitted by aphids (Myzus persicae and Aphis gasypii. The dilution end point of the virus is 1:105 and the TIP is between 60-65°c.

WINGED BEAN

Anthracnose

The foliar symptoms include angular brown and necrotic spots scattered on the leaf lamina. Newly formed spots have a chlorotic halo. The necrotic tissue very often get cracked and fall off giving a ragged appearance. The disease is caused by the deuteromycete, Colletotrichum gloeosporioides. Dark, rounded acervuli are often discernible on the infected parts. Severe infection can lead to considerable economic losses. The disease can be controlled by spraying 1% Bordeaux mixture of 0.1% carbendazim.

Viral Diseases

The leaf curl virus affects this crop leading to abnormal darkening of the foliage which are thickened and puckered. The symptoms manifest after flowering and the flowers drop off, leading to considerable reduction in pod and seed yield.

Necrotic mosaic caused by a filamentous virus has been noticed in this crop. The leaves are distorted and necrotic patches develop on the reduced leaf laminae. The disease increases as the plant matures. Th number of flowers are considerably reduced which reflects on the yield. The virus is mechanically transmitted.

Ring spot caused by cucumber mosaic virus infects the winged bean also. Light green ring spots often coalese to form yellow mosaic. The virus is mechanically transmitted and by aphids (*Aphis craccivora*).

CLUSTER BEANS

Damping off

This disease occurs mostly at the seedling stage. Water soaked lesions appear near the hypocotyl and spreads to the growing roats. Gradually the infected tissues turn dark brown and decay. The seedlings turn chlorotic and collapse. The disease is caused by the Oomycete, *Pythium myriotylum*. The fungus is oil brone and can persist in the infected soil for long periods. Soil drenching with 1% Bordeaux mixture can control the disease and crop rotation with non susceptible crops like millets or grasses in recommended for endemic areas.

Oozomium wilt

The fungus, *Ozzonium texanum* var. *parasiticum* has been reported to cause a severe wilt in cluster bean from restricted areas in Bihar. Thick hyphal strands of the fungus envelops and girdles the shoots and develops numerous chocolate brown sclerotia on the infected portions.

White Mould

This disease occurs on plants of all ages. The most obvious symptom of the disease is the presence of heavy white mycelial mats of the fungus girdling the stem at the ground level. As the mycelial mat appears, the entire shoots quickly wilts and dies. The fungus produces spherical brown sclerotia on the infected parts. Root rot and distruction of the bark and the basal portion of the stem are characteristic features of the disease. Seedling mortality is often very common due to this disease. The disease is caused by the deuteromycetes, *Sclerotium rolfsii.* As the disease is reduced in soils with alkaline reaction, application of lime along with organic manure is recommended as a cultural method for the control of this disease.

Root rot

The fungus, Fusarium solani causes a serious root rot of cluster bean. The affected plants gradually turn yellow and foliar yellowing and drooping results. The roots of such plants harbour numerous dark sclerotia of the causal fungus. As the entire conduction system is incapacitated, the plants succumb to the disease prematurely. Avoiding water stagnation and drenching with 1% Bordeaux Mixture can help in controlling the disease.

Alternaria blight

The disease appears mainly on the foliage as dark brown, round to irregular spots. The disease begins as water soaked spots on the leaf blade which later turn greyish to dark brown with concentric rings. The leaves turn chlorotic and drop off. Severely infected plants are entirely defoliated and fail to put forth new shoots. Theair borne conidia of the fungus, Alternaria cucumerina var. cyamopsidis cause the spread of the disease. The fungus causes symptoms on leaves, stem and pods in severely infected plants. Varieties RGC 581, 635, 757, 749, 737, Guar 279-6 and Guar 47 were found to be tolerant to the disease. Two to three sprays with Antracol 0.2% can effectively control the disease.

Powdery Mildew

Small white powdery patches are seen on the foliage which later join together and cover the lamina on both surfaces and the leaves fall off. The disease is spread in the field by means of the air borne conidia. The disease is caused by the Ascomycete, Leveillula taurica. The disease can be controlled by spraying 0.1% carbendazin, or benomyl 0.025% and these chemicals provide good protection too.

Bacterial leaf spot

The disease is caused by the bacterium Pseudomonas cyamopsicola. Minute water soaked lesions appear on the leaves which coalese to produce larger patvhes. The infected leaves shrivel, dry up from tip downwards and defoliate prematurely. Severe infection results in extensive defoliation, stunting and lowered yields.

Bacterial leaf blight

This disease is caused by the bacterium *Xanthomonas campestris* pv. *cyamopsidis*. The initial symptoms are olive coloured leaf spots which later become black in color and coalese to form large necrotic patches surrounded by chlorotic haloes. The infection proceeds through the petioles to the entire length of the main stem thus incolving the entire plant. The stem shows blackening along the entire length. The stem gets cracked and breaks at several points. The stem blight becomes aggravated at high temperature coupled with high humidity.

The bacterium is inernally seed borne. The pathogen remains viable in dried leaf, stem or pods. Glabrous and branched pubescent types are more resistant to the disease. The varieties GP 590B, Brookes, PLG4 and G 255 are resistant to the disease. Seed treatment with 500 ppm streptocycline or 1000 ppm streptomycin prevents the disease incidence in seedlings. Foliar spraying with streptocycline 100-250 ppm checks the spread of the disease.

Top Necrosis

This is a viral disease caused by the virus *Annulus tabaci* Holmes var. *Cyamopsidis*. The initial foliar symptoms includes chlorosis and stunting with vein clearing or oak leaf pattern. The leaflets often exhibit rugosity. As the disease advances general necrosis of the stem and the growing point accompanied by abscission of the foliage. The virus is sap transmissible. Its TIP is 10 minutes at 78°c.

COWPEA AND LAB LAB

Powdery Mildew

This disease assumes serious proportions during the dry periods and frequently covers a larger host surface leading to heavy losses. The disease assumes maximum intensity as the crop attain maturity with heavy pod infection. Early varieties are less susceptible to infection and those varieties maturing by January usually escape infection. When an entire field is infected, the loss in pod numbers is estimated to be approximately 21 to 31 per cent and reduction in pod weight about 24 to 27 per cent. Most of the cultivated legumes are prone to infection by powdery mildew.

The disease is initiated on the leaves and later on spreads to other plant parts. White, powdery patches develop on all affected plant parts and is found on both sides of leaves. Powdery masses of conidia of the pathogen becomes visible as infection progresses. Finally large areas of leaf surface gets covered with the powdery masses which causes reduction of photosynthetic activity.

The disease is caused by an ascomycetous fungus, <u>Erysiphe polygoni</u> DC.

The disease is seed borne and the infected pods carry the disease from season to season. The cleistothecia which remain in the infected plant debris also aid in the inception offield infection. The secondary spread of the disease is brought about by the wind blown conidia. Heavy application of nitrogenous fertilisers tend to favour the disease. Fungicides like Karathane (0.2%), Mildex (0.2%), Milstan (0.8L1./ha), Calixin (0.51 L/ha), thovit (5kg/ha) or Morocide (0.1%) can effectively control the disease.

Rust

This disease occurs during the cool, wet conditions causing very heavy yield losses. Yield loss up to 36.7% have been recorded. Most of the cultivated legumes are infected by the rust pathogen.

A general yellowing of the leaves is the most common early symptom of rust. This is due to the presence of yellow patches of aecia in dusters and later these turn brown when the uredia are formed, the telia are produced mainly on the stem and petèoles and are dark brown to black in colour.

The disease is caused by an autoecius rust pathogen, <u>Uromyces</u> <u>fabae</u> which infects peas, lentil, cowpea, broad bean and several species of <u>Lathyrus</u> which grow as weeds.

In India, the rust survives on weed hosts like <u>Lathyrus</u> sp and causes infection in the cultivated crops. Therefore proper control of these weed hosts can help a lost in reducing the disease. Fungicidal sprays with Dithane M.45 (0.2%) or Calixin (0.2%) at periodic intervals can help in reducing the disease.

Fusarial wilt

This disease causes general yellowing of lower leaves and wilting of plants at mid season leading to serious crop losses. The infection may set in at the time of first flowering. The plant growth is stunted with yellowing ofleaves and downward curling ofstiples and leaflets. The loss of turgidity initially manifests in the lower leaves. The xylem elements of roods and rootlets turn yellow to orange brown which often leads to the death of feeder roots.

The causal pathogen is <u>Fusarium</u> <u>oxysporum</u> <u>f</u>. <u>pisi</u>. The pathogen is seed and soil borne. The fungus concentrates in xylem vessels leading to clogging of the conduction system; therefore inducing wilt.

Ascochyta Foot Rot and Blight

The disease is manifested by the occurrence of small, purple spots on the leaves. These spots enlarge and become Zonate with a distinct margin. Such leaves usually dry up but remain attached to the plant. The lower leaves are infected first and later spreads to the upper leaves. The basal portion of the stem gets infected turning blackish brown with elongate lesions and causes weakening of stem. Samll dot like spots appear on flowers leading to blossom blight. Infected flowers may shed prematurely. Pod infection causes shrunkage of pods due to the irregular spots formed and the deformed pods have a stained appearance.

The disease is caused by Ascochyta pisi. The fungus produces conidia inside pycnidia which are immersed on infected plant surfaces.

The pathogen survives in the infected crop debris and is also seed brone. Cool weather with high moisture content is conducive for disease development. Heavy rains help in the spread of the spores from plant to plant.

Seed treatment with captan or organomercurials reduces inoculum load and prevents preemergence seed rot. Fungicidal sprays to protect leaves and pods are not usually economical.

Anthracnose

The disease appears soon after the plants are established in the field, about 3-4 weeks from sowing. Plants of all ages are susceptible to infection.

Elongate angular spots are produced on the veins on the ventral surface of the leaves. Lessions on the stem are dark brown and scattered on different parts including the pods. As the infected tissues dry up, depression develop in the centre which contain pink spore masses when moist. The disease is caused by the fungus Colletotrichum Iindemuthianum.

Humidity favours disease development and the best temperature for infection is 20 to 24°c. Periodic spraying with Zineb or Maneb (0.2%) can control the disease.

Rhizoctonia Web blight

Most of the cultivated legumes are affected by Rhizoctoria during warm, humid conditions. Under continuous wet spells, the disease assumes serious proportion.

When the plants are attacked at the time of emergence a damping off may occur. When collar infections occur sunken reddish brown lesions form at the soil line. Foliar lesions appear as prominent leaf scalds. Initially the lesions turn light green and later they turn greyish brown. The dead leaf portions are found to harbour the fungal mycelium and sclerotia.

The causal organism is *Rhizoctonia solani* which has its basidial state in *Thanatephorus cucumeris*.

The fungus thrives well in a wide temperature regime (15°c-34°c) with an optimum of 29°c. The fungus is soil borne and can exist for years together as sclerotia in the soil. As this pathogen can cause sheath diseases in cereals, especially rice, it is not advisable to use cowpea crop for rotation in rice fallows where the pathogen is prevalent. The application of PCNB or Thiram in the beds at the time of sowing can reduce the seedling damage while field infection can be controlled by spraying 0.1% carbendazim.

Dry Root Rot or Charcoal Rot

This disease is also known as ashy stem blight, *Macrophomina* rot, etc. It is prevalent in the humid tropics and found widespread in India.

When the seedlings are attacked the pathogen causes damping off or collar rot depending on the crop. The collar rot symptoms seen in beans include formation of dark, sunken cankers below the cotyledonary node leading to the death of the plant. Adult plants are prone to infection when growing under stress. Initially the leaves turn yellow and later on these dry up leading to the death of the plant. The dried up plants may exhibit dark lesions on the stem base. When uprooted, the infected plants will exhibit decortication of stem base and the main rots. The affected portions may exhibit large numbers of dark sclerotia of the pathogen. The disease is caused by the fungus *Macrophomina phaseolina*. The sclerotial stage of the fungus is known as *Rhizoctonia bataticola*.

The disease assumes serious proportion only during warm, dry periods. The furrow application of PCNB or thiram (8kg/ha) at planting time gives good control of the disease.

Bacterial blight

This disease has been reported to occur all over India since 1950. The disease causes complete destruction of the plant.

Initial symptoms occur on the cotyledons of emerging seedlings. The affected cotyledons turn dark and are malformed. The foliage is covered with necrotic lesions. When the bacterium becomes systemic in the plant, the vascular bundle are blocked and the growing tip of the plant is killed. Often cankers develop on the collar region, weakening it and the plants break down during strong winds. The diseased pods are crinckled and shrivelled and produce infected seeds.

The disease is caused by the bacterium, Xanthomonas vignicola. This is a gram negative bacterium with a single polar flagellum.

The primary source of inoculum is the infected seed and the secondary spread is through wind splashed rains, insect feeding and implements. The only available means of control is the use of disease free seeds.

Cowpea Mosaic

The vegetable cowpea grown in parts of India is prone to a number of mosaic diseases. Most of these diseases have overlapping symptoms and are caused by related viruses. The virus infects other crops like urd bean, soybean, limabean and sunhemp.

General yellowing of young leaves is the initial symptom. This is followed by chlorotic mottling and appearance of a mosaic pattern. Leaf puckering and reduction ofleaf size is noticed in cases of severe infection.

The virus is seed and sap transmissible. The common insect vectors include *Aphis medicaginis*, *A. gossypii*, *A. craccivora*, and *Myzus persicae*. The TIP of thevirus is 10 m. at 66°c. One way to reduce infection is use seeds from disease free plants. The application of systemic insecticides (Dimethoate 0.03% or Monocrotophos 0.05%) is good for controlling the insect vector and thereby reducing the disease.

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Diseases of cucurbits and their management

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Cucurbitaceous vegetables are affected by various diseases incited by fungi, bacteria and viruses which reduce both quantity and quality of the produce (Appendices 1 and 2).

A. Fungal diseases

1. Seedling blight and damping off :

Many fungi are reported associated with seed decay, seedling blight and damping off of cucurbits.

Symptoms

Water-soaked minute lesions appear on the stem near the soil surface, soon girdling the stem and spreading up and down. Within a short period, the stem may rot causing the seedlings to topple.

Causal organism

Pythium aphanidermatum, *P. irregulare*, *P. ultimum*, *Rhizoctonia solani*. *Phytophthora* sp. and *Fusarium* sp. are the fungi associated with seedling blight and damping off in cucurbits (Hammouda, 1988).

Control

The disease can be controlled by shallow planting and adjusting planting time so that the soil temperature is high. Seed dressing with Fernasan D (25% thiram + 20% Gamma - HCH) at 3g/kg seed is recommended against damping off of vegetable marrow. (Hammouda, 1988). Biological control of damping off of cucumber by *Pythium aphanidermatum* using *Penicillium stipitatum* and *Trichoderma harzianum* was equivalent to that obtained with Ridomil (metalaxyl) (Sharif *et al*, 1988). Wolffhechel (1989) found *Trichoderma harzianum*, *Chrysosporium* spp. and a number of *Penicillium* spp. and *Aspergillus* spp. were able to suppress *P. ultimum* on cucumber seedlings.

In a study using fungivorus and entomogenous nematodes for

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control of soil-borne diseases and pests of cucumber, Choi et al (1988) found that incorporating *Aphelenchus avenae* suppressed the pre-emergence damping off of cucumber seedlings due to *R. solani*.

2. Root rots

Root rots occur in cucurbits at all stages of growth and are incited by many soil-inhabiting fungi like *Pythium irregulare*, *P. aphanidermatum*, *Phytophthora capsici* and *Fusarium Solani* f. *cucurbitae*.

Symptoms

The affected plants are dwarfed and leaves become yellow. The plant may show wilting symptom followed by complete collapse. Roots of the affected plant appear water-soaked and flaccid and there are sunken darkened lesions on the larger fleshy roots. On uprooting, the underground parts also are found similarly disintegrated.

Causal organism

Root rot of watermelon, squash and cucumber caused by *P. irregulare* and *P. ultimum* occur only when soil temperature is comparatively low, whereas root rot of muskmelon incited by *P. aphanidermatum* occur during the warm season when the soil temperature is high.

The organisms which attack watermelon, squash and cucumber are most destructive in poorly drained soils that have previously been cropped with cucurbits or other plants, such as peas and spinach which tend to increase soil populations of *Pythium*. Well drained soils previously cropped with cereals, crucifers, lettuce and some other crops which do not support a large population of *Pythium* sp. in the soil will usually yield satisfactory crops of watermelon, squash or cucumber.

F. solani f. *cucurbitae* causing fusarium root rot attacks pumpkin and squash primarily, it seldom attacks watermelon or cucumber.

Control

Seeds may be disinfected by soaking for 10-15 minutes in a 1 : 1000 solution of mercuric chloride, then rinsing with water. As the fungus is relatively short lived (2-3 years) it can be controlled by rotation, combined with seed treatment.

3. Fusarium wilt

In India, fusarium wilt was first reported in 1955 from Maharashtra.

Symptoms

The plant is attacked at all stages of its growth. Characteristic wilt symptoms appear on older plants when leaves show flagging down during hot period of the day. Wilt symptoms usually appear first at the tips of runners which is followed by a gradual wilting and eventually death of the entire plant. Fusarium wilt is more severe when soil temperatures are comparatively high. Seedling injury is high at 20 to 30°C and wilt development is favoured by a temperature of about 27°C. No infection occurs at temperature below 15°C and above 35°C. The fungus survives in the soil many years and it will multiply rapidly when the respective hosts are grown.

Causal organism

It is demonstrated that fusarium wilt of watermelon, cucumber, muskmelon etc. are caused by different biological races of the same species of Fusarium. Wilt of watermelon is caused by *Fusarium oxysporum* f. sp. *niveum*. Wilt of cucumber is caused by *F. oxysporum* f. sp. *cucumerinum*. Muskmelon wilt is incited by *F. oxysporum* f. sp. *melonis*. The pathogen isolated from muskmelon did not attack watermelon. But Hendrix *et al* (1948) obtained isolates with duel pathogenicity. Eide and Makila (1952) isolated a number of strains, which differed greatly in their pathogenicity on different cultivars of muskmelon.

The fungus is seed borne and is a persistent soil inhabitant. In the presence of the host, the chlamydospores of the fungus germinate and cause infection of the fibrous roots. The pathogen concentrates in the xylem vessels.

Control

Seed borne inoculam can be reduced by treating the seed with Benlate or Bavistin (2.5g/kg seed).

Biles and Martyn (1989) found that in watermelon, cultivars differentially resistant to fusarium wilt, when preinoculated with *F. oxysporum* f. sp. *cucumerinum* or avirulent races of *F. oxysporum* f. sp. *niveum* 24 to 72 hr prior to challenge inoculation with a virulent race of *F. oxysporum* f. sp. *niveum* significantly reduced wilt symptoms. Avirulent races of *F. oxysporum* f. sp. *niveum* induced higher level of resistance than did *F. oxysporum* f. sp. *cucumerinum*, thus giving cross protection to the cultivars. Disease incidence in watermelon seedlings inoculated with sub leathal heat treated conidia of *F. oxysporum* f. sp. *niveum* (at 36-42°C) was reduced by 35.82%. A similar trend was observed with *F. oxysporum* f. sp. *melonis* in muskmelon seedlings also. (Freman and Katan, 1988).

While isolating and identifying the antagonistic rhizosphare micro-organisms to cucumber wilt pathogen, Kim and Jee (1988) found that *Pseudomonas fluorescens* and *Trichoderma harzianum* were the best antagonists and when they were introduced into the field soil there was significant reduction in disease incidence.

Iida *et al* (1985) in glass house tests found that the fusarial wilt of cucumber caused by *F. oxysporum* f. sp. *cucumerinum* was reduced by amendment of the soil with ground crab shell, the effect appearing after 30 days. Production of CO_2 in the natural soil was accelerated by crab shell amendment and the pH in the amended soil became alkaline thus making the situation unfavourable for development of pathogen.

4. Verticillium wilt

This occurs in most of the areas where cucurbits are grown. The wilt attacks many of the cultivated cucurbitaceae.

Symptoms

Verticillium wilt is similar to fusarium wilt in general symptoms, although the yellowing and killing of crown leaves are more pronounced with *Verticillium*.

Causal organism : *Verticillium albo-atrum*

Control

Verticillium wilt can best be controlled by planting cucurbits in soils that are free from the fungus if possible.

5. Downy mildew

This affects especially spongegourd, ridgegourd, muskmelon and cucumber which are more severely affected. The disease is fairly common in North India during rainy season.

Symptoms

First symptoms on the leaves resemble those of mosaic mottling. Pale green areas are seen separated by islands of darker green. Soon the spots become well defined. They are angular, yellow and often restricted by the veins on the upper surface. On the lower side of these spots a purplish downy growth appears in moist weather. Occasionally the purplish colour is lacking and lower side of the spots look white to almost black. The entire leaf dies quickly. Usually the central leaves are attacked first and are followed by other leaves until entire plant is wilted or weakened. Young leaves are less susceptible than older ones. Infection occurs more readily on lower surface than on upper surface. On infected vines the fruits are few and small with poor taste.

Causal organism : Pseudoperonospora cubensis. It is an obligate parasite.

Control

Fungicides like Dithane M-45 (mancozeb), Dithane-Z.78 (zineb) and Tricop 50 are usually used as spray against this disease. Only protective sprays provide significant disease control. The former two fungicides protect the leaves for 9 days and Tricop 50 for 5 days after spraying. (Bains and Jhooty 1978). Mixtures of cymoxanil with mancozeb or mancozeb with oxadixyl were effective in controlling the disease. Removal of the badly infected vines followed by chemical spraying prevent spread of the disease.

In India, the cucumber cultivar 'Bangalore' has some tolerance to the disease. 'Palmetto' a cultivar released in 1948 has resistance to downy mildew. Recently, on studying the relative resistance of introduced cucumber cultivars in Bulgaria, Neykov and Dobrev (1988) found that the most resistant cultivar was "Simo si radzu' from Japan. Some of the Asian and Netherland cultivars were also showing relative resistance.

Suhag *et al* (1988) found that the downy mildew of spongegourd can be successfully controlled by Apron seed treatment at 2g a.i./kg seed followed by two sprays of metalaxyl (0.2%) or Blitox (2.0%).

6. Powdery mildew

Powdery mildew is especially destructive on pumpkin, and bottlegourd. Bittergourd is comparatively less affected.

Symptoms

Powdery mildew on the foliage and green stems is characterised by the appearance of tiny white to dirty grey spots sometimes with a reddish-brown tinge. On leaves the symptoms first appear as round white spots on the under surface of the older leaves. The spots enlarge, increase in number, coalesce, appear on the upper surface of the leaves and eventually cover both the surfaces. Severely affected leaves turn brown and shrivel. The superficial powdery mass may ultimately cover the entire green surface of the host. In India, the disease has been found only during the winter months. The effect of severe infection may be premature defoliation and death of the vines. Fruits also sometimes get covered with the white powdery mass, but this is not common. The fruits on infected plants ripen prematurely and lack the usual texture, flavour etc.

Causal organism

Three species of Erysiphae are identified as the cause of powdery mildew of cucurbits, viz. *Erysiphae cichoracearum*, *Sphaerotheca fuliginea* and *Leveillula taurica*. Of these, the former two are the frequent and predominant ones, the latter being noted in indoor cucurbits. (Khan and El-Ammari, 1987). The superficial growth of *E. cichoracearum* is white while that of *S. fuliginea* is rusty brown.

Two races 1 and 2 are reported in *S. fuliginea* in which race 2 is more virulent. (Cohen and Eyal, 1988).

Control

The diseased crop debris should be destroyed by burning. Spraying of fungicides regularly control powdery mildew effectively. Sulphur dusting @ 15 to 30 kg/ha was recommended earlier. But different species and cultivars differ in their sensitivity to sulphur. It can be safely used on some cultivars of muskmelon and cucumber but not in others. Elasol (0.5%) had been used as a substitute for sulphur. Other effective fungicides are Karathane (0.2%), Sulfex (0.2%), Calixin (0.1%), Bavistin (0.1%) etc. The fungicides Karathane (0.1%), Bavistin (0.1%), -Calixin (0.1%) and Sulfex (0.2%) were compared for the control of Sphaerotheca fuliginea on bottlegourd, summer squash and pumpkin; where the disease is seen reduced by all the four fungicides. Calixin was found the best. Mukesh Mathur and Daftari (1985) found Bavistin and Topsin-M as the most effective fungicides against powdery mildew.

Under green chamber conditions two species of Stephanoascus viz. S. flocculosus and S. rugulosus had antagonistic effect on Sphaerotheca fuliginea. (Jarvis et al, 1989) and a hyperparasite Tilletiopsis albescens on Erysiphae cichoracearum (Heijwegen, 1988).

7. Anthracnose

Muskmelon, bottlegourd and cucumber are the most susceptible hosts while bittergourd is the least affected. It rarely affects pumpkin. In temperate regions heavy losses occur on fruits of watermelon. The disease is especially severe in areas where summer rainfall and higher humidity is experienced.

Symptoms

The fungus attacks all the aerial portions of the plant at all stages of development. Symptoms usually seen first on the older leaves at the crown of the plant. The spots appear as small yellowish or water-soaked areas that enlarge rapidly and turn brown in most cucurbits and black on watermelon. On cucumber (Kheera leaves the spots commonly start on a vein and expand into brown spots which are angular or roughly circular. Growing leaves may be distorted and coalescing spots may cause scorched appearance leading to death of the entire leaf. Elongated narrow, slightly sunken, water-soaked lesions often appear on the stems and petioles. These lesions may turn brown or yellow. Anthracnose is most characteristic on fruits reaching maturity. The spots on fruits are roughly circular, water-soaked with dark borders and of considerable size. The infected areas become elevated above the surface of the fruits giving a bumpy appearance in the initial stages. These raised areas later become sunken and pitted, creamy to black in colour. In the centre of these spots pin-point, black stromata bearing pink masses of spores can be seen in humid weather. Red gummy exudate appears on lesions. Infected fruits may be destroyed by soft rot organisms that gain entrance through the broken rind.

Causal organism : Colletotrichum lagenarium

The fungus is chiefly soil-borne. It may be seed borne if fruits are attacked and mycelium has reached the seed. It is disseminated by wind, rain, cultural implements, beetles and by persons working in the field. If moisture is present, spores germinate and penetration occurs effectively within 3 days. Disease development occurs at temperatures between 20 to 30°C, under 100% relative humidity existing for at least 18 hours. The fungus occurs in epidemic form only when there is more than average rainfall.

Control

Crop rotation, proper drainage, destruction of wild and weed hosts and seed treatment are the important steps in the control of the disease. As the pathogen lives for at least one season in the diseased plant refuse left on the soil, a two-year crop rotation is essential. Mercuric chloride (0.1%) or any organomercurial or Thiram may be used for seed treatment (2.5 g/kg seed). Bavistin or Benlate (2.5g/kg seed) can also be used for seed treatment. Spraying with mancozeb (2 kg/ha); or Difolatan (0.2%); or Copper oxychloride (0.2%), or Benlate or Benomyl (0.05 to 0.15%) is effective in controlling the disease. Spraying should be started at two-leaf stage and repeated at 10 days interval. While copper oxychloride and Difolatan are effective for both foliage and fruit infection, Benomyl is effective only against foliage infection.

8. Alternaria blight and fruit rot

Several species of the fungus Alternaria attack the foliage of cucurbits causing leaf spots and blight and some attack the fruits, causing usually dry rot.

Blight due to A. cucumerina in watermelon was reported from India. It was later noted on muskmelon, cucumber, bottlegourd and vegetablemarrow.

Symptoms

In watermelon the disease appears as yellow or brown spots of 0.2 to 0.5 mm diameter, surrounded by pale green to bright yellow halo on the upper surface of the leaves. Lesions become 1 to 10mm in diameter with frequent zonation and marginal necrosis. In other hosts the size and colour of lesions may vary.

Causal organism

Alternaria cucumerina is one of the main species that causes leaf spot.

9. Cercospora leaf spot or Blotch

Several species of Cercospora are reported on cucurbits. Most common is C. citrullina which attacks snakegourd, bittergourd, pumpkin and muskmelon. Other species are C. trichosanthes var. anguinae, C. momordicae, C. laginariae, C. cucurbiticola & C. melonis.

Control

Precautions taken to ward off anthracnose will be effective for the control of leaf spot diseases also.

10. Fruit rot or cottony leak of cucurbits

It occurs in almost every locality and every field during summer when there is excess moisture and during the rainy season (July to August). It is not only a field disease but market and transit disease also. Fruit may rot in storage also.

Symptoms

The disease appears as a luxuriant cottony mycelial growth on the affected fruits. Fruits which are in contact with the soil suffer the most. Before the cottony growth of the fungus appears, the fruit skin shows soft, dark green, water-soaked lesions which gradually develop into a watery soft rot. On this rotting region, the cottony mycelial growth develops abundantly in high humid atmosphere. In watermelon, the decay frequently starts at the blossom end. On the margin of the cottony growth, in fruit, skin looks dark green and water soaked. This area which is without any aerial growth of the fungus indicates the 'killing in advance activity of the pathogen. The tissues in the interior of the fruit become watery and soft and the decaying matter emits a bad odour due to secondary invasion of bacteria.

Causal organism

Pythium aphanidermatum and P. butleri are the main causes of the disease. Other species of Pythium, Fusarium, Rhizoctonia and Phytophthora may also be involved. Frequently Sclerotium rolfsii has been found growing on fruits affected with cottony leak.

Abundance of moisture, high temperature and juvenile tissues of the host are factors determining the development of the disease. On the fruits, infections always occur when there is some injury to the skin by soil particles, excessive wetness around fruits or insect bites.

Control

It is not advisable to recommend application of fungicides to prevent infection of fruits. The fruits should be kept away from the soil so as to avoid the chances of contact with soil and infection. The garden soil can be drenched with 0.25% Copper oxychloride solution.

B. Bacterial diseases

1. Angular leaf spot

Symptoms

Disease occurs on leaves, young green stems and on fruits. On leaves the spots appear as water-soaked, irregular or angular lesions. The spots enlarge and become brown. Later, the tissues dry and may fall out leaving irregular holes in the leaf. On fruits the lesions are superficial and cause cracking.

Causal organism

The disease is caused by Pseudomonas syringae p.v. lachrymans. The bacterium is seed-borne, it can survive in soil and also in crop debris. Seeds from diseased fruits carry the bacteria in the seed coat. Cotyledons are invaded after germination of the seed.

Dispersal of the bacterium from the ooze exuded from the affected parts takes place with the help of rain. Penetration occurs through stomata. The disease is favoured by rain and a temperature range of 24 to 26.5°C. High nitrogen content in the plant increases its susceptibility.

Control

The bacterium in the seed is killed by hot water treatment, but this method reduces germinability of the seed. Soaking seeds in mercuric chloride solution (0.1%) for 5 to 10 minutes, rinsing in water and dry quickly is an effective method. Spraying the plants with 400 ppm solution of streptomycin sulphate or copper fungicide reduces the spread of the disease in the field.

2. Bacterial wilt

Symptoms

The affected leaves wilt and turn dark green. Eventually all the leaves wilt and the entire plant dies. Occassionally an exudate is seen in the affected fruits. When the wilted stems are cut in cross-section, a viscid, sticky, white ooze appears which can be pulled out in strands.

Causal organism : Erwinia trecheiphila

The bacterium over winters in the bodies of the adult cucumber beetles, Diabrotica vittata Fab. and D. deodecimpunctata Oliv. The pathogen is spread exclusively, these beetles. This is one of the rare cases where an organism is completely dependent upon the associated insect for survival and dissemination.

Primary infection is produced when the beetles feed on the plants. After infection, the bacteria invade and move through the vessels. The capsular material of the organism provides the viscid matrix and is believed to cause wilt by mechanical plugging of the xylem.

Control

Doolittle and Porte (1939) suggested that resistance might be increased by breeding. As the pathogen is completely dependent on the beetle for perpetuation and dissemination, control is directly related to restriction of the insect population. Williams and Lockwood (1956) claimed that the incidence of the disease is reduced and some degree of control attained by the use of antibiotic sprays.

3. Bacterial stem rot

Symptoms

The diseased plant had soft watery and pulpy stems, roots, leaves and fruits. Affected parts collapse and convert into a mass of mushy, slimy, semisolid material which emit putrid odour.

Causal organism

The disease is caused by the bacterium *Erwinia carotovora* var. *carotovora*.

Control

Destruction of the affected plants will check the further spread of the disease.

4. Bacterial leaf spot

Symptoms

The leaf spots appear as water-soaked areas on the under surface. The upper surface opposite to these areas look yellow in colour. These spots appear as interveinal and with age, they enlarge and become angular. The colour of the spots change to brown in the advanced stages with a chlorotic zone around them. Under favourable conditions several spots may coalesce to form large spots. Later, the tissues dry. The lesions on the stems and petioles are linear or streak-like in appearance and are brown in colour.

Causal organism : *Xanthomonas campestris* pv. *cucurbitae*

The bacterium is seed borne and also persists on diseased crop debris. Infection of seeds occur internally in the seed coat and after germination as cotyledons emerge they got infected. The optimum temperature for growth of the bacterium is 25-30°C.

Control

Same as for angular leaf spot.

5. Bacterial soft rot

Symptoms

Mainly a fruit disease and occurs due to injury to fruits and poor transit and storage conditions.

Causal organism :

Erwinia carotovora and E. aroideae are the main bacteria associated with this disease.

C. Virus diseases

The list of viruses reported from different cucurbits are appended (Appendix 2).

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Appendix I. Diseases of Cucurbits and causal organisms

Name of disease	Causal organism
Fungal diseases	
Seedling blight	Pythium apanidermatum (Eds.) Fitz. P. ultimum Trow. P. irregulare Buis Rhizoctonia solani Kuhn.
Root rot	Pythium aphanidermatum P. irregulare Phytophthora capsici Lean Fusarium solani f. cucurbitae Snyder and Hansen (Perfect Stage : Hypomyces solani Reinke and Berth)
Fusarium wilt	Fusarium oxysporum f.sp. niveum (E.F.Sm) Snyder and Hansen. F. oxysporum f.sp. cucumerinum Owen

Name of disease	Causal organism
	_F_. _oxysporum_ f. sp. _melonis_ (Leach and Currence) Snyder and Hansen.
Verticillium wilt	_Verticillium_ _albo-atrum_ Reinke and Berth
Downy mildew	_Pseudoperonospora_ _cubensis_ (Berk and Curt.) Rostow.
Powdery mildew	_Erysiphae_ _cichoracearum_ De. Candolle. _Sphaerotheca_ _fuliginea_ (Schlechtendal) Pollacci. _Leveillula_ _taurica_ (Lev.) Arnaud.
Anthracnose	_Colltotrichum_ _lagenarium_ (Pass.) Ellis and Halsted.
Cercospora leaf spot	_Cercospora_ _citrullina_ Cooke _C_. _annamalaiensis_ Rang and Chand. _C_. _chidambarensis_ Rang and Chand _C_. _cucurbiticola_ _C_. _lagenariae_ Rang and Chand _C_. _melonis_ Cooke _C_. _momordicae_ Mc Rae _C_. _trichosanthes_ var. _anguinae_ Rang and Chand.
Alternaria bligh (Brown spot)	_Alternaria_ _cucumerina_ (Ell. and Ev.) Elliott
Fruit rot or cottony leak	_Pythium aphanidermatum_ _P_. _butleri_ Subram. Other species of _Pythium_, _Phytophthora_, _Fusarium_, _Rhizoctonia_, & _Sclerotium_ _rolfsii_ Sacc.
Leaf spots	_Diplodia_ _natalensis_ Evans. _Septoria_ _cucurbitacearum_ Sacc. _Phyllosticta_ _cucurbitacearum_ Sacc.
Leaf bligh	_Ascochyta_ _cucumeris_ _Stemphylium_ _cucurbitacearum_ Osner _Corynespora_ _melonis_ (Cooke) Lindau.

Name of disease	Causal organism
Scab	Cladosporium cucumerinum Ell. and Arth
Blossom blight (Choanephora wet rot)	Choanephora cucurbitarum (Berk and Rev.) Thaxt.
Grey mould	Botrytis cinerea Pers.
Brown rot	Phytophthora capsici Lean
Charcoal rot	Macrophomina phaseolina (Tossi) Goud.
Soft rot of fruits	Phomopsis cucurbitae Mckeen
	Curvularia lunata (Wakker) Boed.
	Phytophthora drechsleri
	P. butleri
	Fusarium equisetti (Corda) Sacc.
	Rhizopus oryzae Went and Prin Greel
	Myrothecium roridum Tode ex Fr.
	Aspergillus flavus Link ex Fries
	A. nidulans (Ediam) Wint
	Curvularia ovoidae (Hiroe and Watanabe)
	Geotrichum conidium Link ex Person
	Diplodia gossypina Cooke
Southern blight	Pellicularia rolfsii (Sacc.) West
Gummy stem blight	Didymella bryoniae
Stem rot	Sclerotium rolfsii Sacc.
Dry rot	Rhizopus sp.
Mycosphaerella black rot	Mycosphaerella melonis (pass) Chiu & Walker
Bacterial diseases	
Angular leaf spot	Pseudomonas syringae p.v. lachrymans (Smith and Bryan) Young, Dye and Wilkie
Bacterial wilt	Erwinia tracheiphila (E.F. Sm) Holland.
Bacterial soft rot	E. carotovora
	E. aroideae
Bacterial leaf spot	Xanthomonas campestris p.v. cucurbitae (Bryan) Dye.
Bacterial stem rot	Erwinia carotovora var. carotovora
Physiological disorders	
Pillowy disease	Ca deficiency

Appendix 2. List of virus diseases reported in Cucurbits

Name of disease
Cucumber mosaic
Cucumber stunt mottle
Cucumber necrosis
Cucumber mottle mosaic (Cucumber green mottle)
Cucurbit mosaic
Cucurbit latent
Melon mosaic (Watermelon mosaic) (Muskmelon mosaic)
Muskmelon necrotic ring spot
Muskmelon vein necrosis
Pumpkin mosaic
Pumpkin yellow vein mosaic
Squash mosaic
Bottlegourd mosaic (Tobacco mosaic strain)
Tobacco ring spot (Cantaloupe mosaic)
Cucumber ring spot
Watermelon mosaic (Virus I & II)
Cucumber vein yellowing
Cucumber (wild) mosaic
Squirting cucumber mosaic
Benincasa mosaic
Bittergourd mosaic
Kakri mosaic
Tori mosaic
Pumpkin enation mosaic & Pumpkin mild mosaic
Cucumber yellow
Zucchini yellow mosaic & Zucchini yellow fleck
Melon necrotic spot
Papaya ring spot
Tomato enation leaf curl

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Seed Production of Solanaceous Vegetables

Sreelathakumari, I*

The total demand for vegetable seeds in India is about 29,500 t. annually, of which 25 to 30% is met by private companies, 10 to 15% by public sector and the remaining from seeds saved by farmers themselves. Area under vegetable crops in India is about 4.5 million ha. with a production of 41.2 million t. Consumption of vegetables/capita/day in India is only 130 g which is far below the recommended dietary standard of 280g. It is estimated that by 2000 A.D., requirement of vegetables in the country would be about 123.6 million t. Both area and productivity need to be increased to meet the national requirement of vegetables. Expansion and strengthening of seed industry on modern scientific bases would, therefore, be necessary for production of the required quantity of quality seeds (Vishnu Swarup, 1990).

Annual requirement of certified seeds and area and production of Solanaceous vegetables are given in Table 1.

Table 1. Quantity of certified seeds required annually (1988) and area and production of Solanaceous vegetables

Vegetables	Area (000 ha)	Production of vegetables (000 tonnes)	Requirement of certified seeds (t)
Tomato	83	500	42
Chillies	826	511	826
Brinjal	40	600	16

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Standards of seed production

The first step in a scientific seed production programme is the selection of site. The specific requirement for Solanaceous vegetables are given in Table 2.

Table 2. Land requirements for Solanaceous vegetables for seed certification

Crops	Land requirements
Solanaceous Vegetables	1. The land must be free of volunteer plants 2. The land should be fertile, rich in organic matter and well drained

The agronomic practices recommended for Solanaceous vegetables are as follows: Table 3.

Table 3. Agronomica practices recommended

Operations	Brinjal	Chilli	Tomato
Time of sowing	Feb-March June-July Oct - Nov	May - August Sept.-Dec	August-Jan
Seed rate	375-500 g	1 kg	400 g
Spacing	60cm x 75cm 75-90cm x 60-70cm	45cm x 45cm 60cm x 45cm	60cm x 60cm
Mannures and fertilizers	FYM - 25t/ha N - 75 kg P - 40 kg K - 25 kg	FYM 20-25t/ha N - 75 kg P - 40 kg K - 25 kg	FYM 20-25t/ha N - 120 kg P - 60 kg K - 60 kg
After cultivation a) Irrigation	3 to 4 days interval during summer	Same as brinjal	On alternate days
b) Weeding and earthing up	2 times, One and two months after planting along with top dressing	Same as brinjal	25 to 30 days after trans-planting along with top dressing

Regulations on seed production specify minimum isolation distance for crop growing (Table 4.). The seed regulation also specifies stages of inspection for Solanaceous vegetables (Table 5). Solanaceous vegetables are affected by a number of pests and diseases. The control measures recommended are given in Table 6.

Table 4. Minimum isolation requirements

Crops	Foundation seed	Certified seed
Brinjal	200 m	100 m
Chilli	400 m	200 m
Tomato	50 m	25 m

Table 5. Stages of Inspection

	Brinjal	Chilli	Tomato
Roguing	Remove off types before blossoming and plants affected by phomopsis blight and little leaf	Remove off types and plants affected by leaf blight, anthracnose and viral diseases	Remove off types and plants affected by early blight, leaf spot and mosaic (TMV)

Table 6. Recommended pest and disease control measures

Crops	Name of pest/disease	Recommended control measures
Brinjal	Shoot and fruit borer	Carbaryl (0.15%) at 15 to 20 days interval
Chilli	Mealy bugs and lace wings	Quinalphos (0.03%)
	Mites, aphids and other sucking insects	Dimethoate (0.05%)
	Damping off	Drench (0.1%), Agallol - 3 or Cheshunt compound
Tomato	Damping off	Drench with cheshunt Compound or Agallol-3 (0.1%)
	Early blight	Dithane M - 45 (0.2%)
	Mosaic	Rogor (0.05%) or Dimecron
	Fruit borer	Carbaryl (0.2%)

The specific crop standards for certification of Solanaceous vegetables are given in Table 7. The off types should not exceed 0.1% in a foundation crop. The specific seed standards are given in Table 8.

Table 7. Specific crop standards for certification

Crops	Off types (%)		Plants affected by designated disease (%)	
	F	C	F	C
Brinjal	0.1	0.2	0.1	0.5
Chilli	0.1	0.2	0.1	0.5
Tomato	0.1	0.5	0.1	0.5

Table 8. Specific seed standards

	Brinjal		Chilli		Tomato	
	F	C	F	C	F	C
a) Purity (%) (mini.)	98.0	98.0	98.0	98.0	98.0	98.0
b) Inert matter (%) (max.)	2.0	2.0	2.0	2.0	2.0	2.0
c) Other crop seeds (%) (max.)	-	-	0.05	0.1	0.05	0.1
d) Weed seeds (%) (max.)	-	-	0.05	0.1	-	-
e) Germination (%)	70.0	70.0	60.0	60.0	70.0	70.0
f) Moisture (%) (max.)	8.0	8.0	8.0	8.0	8.0	8.0

Weather parameters - Temparature and photoperiodism - their role in seed set.

Among the environmental factors, temperature is one of the important factors influencing vegetable production. In general, high temperature induces male tendency, while low temperature enhances female tendency. Night temperature is a limiting factor for fruit setting in tomato, more or less regardless of day temperature. In tomato, fruits set freely when day temperature ranges from 21°C to 32°C but they abort above 32°C. Similar view was expressed by Sugiyama et al, (1962) who reported that fruitset was markedly low at temperature above 50°C because of poor pollen germination. Pollen liberation was low in dull humid weather. Sticking of pollen to the stigma was unfavourably affected by dry sunny weather. Both rate and speed of germination depend largely on temperature. Charles and Harris, (1972) studied effect of 10°C, 12.8°C, 18.3°C and 26.7°C temperatures on flower production, fruit set and fruit size, pollen viability, stigma receptivity and stigma height in the antheridial cone in tomato lines selected for their ability to set fruit at high or low temperatures. They found that low fruitset at 10°C and 12.8°C was due to poor pollen viability and germination and to a lesser extent to a high stigma position in the antheridial cone. At 26.7°C, stigma elongation was the main factor reducing fruit set, but low stigma receptivity was also a factor in a few selections. Flowering and fruit set were optimum at 15°C to 18°C.

Nothman et al, (1979) studied flowering pattern, fruit growth and colour development of brinjal during cool season in sub-tropical climate. Plants of brinjal cvs. Black Queen, Black Oval and Money Maker were grown during May to November (hot season) and December to April (cool season). During warm season, when growth and flowering were normal, almost all fruits developed from the basal flowers and additional flowers, borne on a separate axis on the same inflorescence as the basal flower and having shorter styles were shed. In cool season, growth was a slow process and fruit quality was poor both in size and colour. Takahashi et al (1979) studied relationship between temperature and flower formation in capsicums. Flower bud differentiation was the earliest and number of flower buds was the greatest in plants kept at 30°C receiving high NPK rates. These indices diminished with temperature drop and with decrease in the NPK rate. Light is essential for growth and development of vegeta crops. Light plays an important role in sex expression. Beerk (19 observed in an American tomato variety that relative lengths of gynoecium and androecium at anthesis were affected by photoperiod light intensity. Short days of eight hours produced flowers in wh pistil substantially exceeded stamens in length and long days of 1 hours produced flowers in which stamens exceeded the pistil. Howl (1939) found, in addition, that pollen fertility was also diminished in plants grown under short days of winter. In plants flowering i February and March, pistil and stamen length ratio would be at its highest. In successive inflorescences produced during the lengthe days of spring, this ratio would decrease reaching its lowest valu in mid-summer. Conversely, in plants producing inflorescence in succession during the shortening days of autumn and winter, the ratio would progressively increase.

Two flowering periods were recorded in hot pepper from June t early August and early to mid-September. Flower abscission was increased under shortdays (12 hours) and high temperature (28°C to 33°C). In chilli, number of flowers/plant fell with decreasing li intensity but the fall was evident only 10 days after shading was applied. It was marked after 20 days but indiscernible after 40 d Decreasing light intensity also increased fruit and blossom drop a the effect was evident within the first five days of shading of the flowers and the fruits which dropped, 83% had done so within eight days after end of flowering. When light intensity was reduced by 25%, fruit yields fell by 58.5% as per Park and Jeong, (1977).

Seed extraction techniques

Chauhan,(1965) reported that seeds can be produced in North and South India during rabi and kharif. Fruits are harvested when they turn red in colour. For extraction of seeds, the following methods are used.

a) Fermentation method

Fruits are pulped and the pulp along with seed are kept for fermentation for 24-48 hours. Then it is washed thoroughly to remove the mucilaginous material around the seeds and then dried under shade.

b) Acid method

First pulp the ripe fruits and add Con. HCl at the rate of 100ml/ 10kg pulp. Keep the mixture for 30 minutes and then wash with water and dry. Ritchie(1971) reported that at a temperature of 15°C, very good seed cleaning could be achieved with 1% Hcl and 0.1% pectinase in 24 hours and it was quite capable of cleaning within six hours. Satisfactory germination could be obtained with both tall and compact cultivars when the treatment time was extended to 48 hours.

c) Alkali method

Sodium hydroxide or washing soda at the rate of 17 oz. in 1 gallon (1:8) of water is mixed with equal quantity of pulp. Keep it for one night (10-12 hrs) and wash and dry.

d) Mechanical

De-seeding machine is used. Seed and juice are seperated from pulp. From seed and juice moisture, seed is separated and dried to 8% moisture before storage. Vadivelu et al (1983) studied seed quality of tomato cv. CO2 extracted from fruits harvested at different picking . Seed quality assessments revealed usefulness of restricting number of harvests for extracting seeds of tomato. Quality of fruits from the first seven harvests were of high order with more seed weight, seed recovery, 100 seed weight, laboratory germination, field emergence, dry matter production, vigour index and less processing loss. Seed quality assessments made with the seeds extracted from large, medium and small fruits of the tomato varieties Co 1 and Co 2 indicated increased vigour and germination potential of the seed extracted from large and medium fruits over small fruits.

In brinjal, the fruits are harvested at full ripe stage when colour changes to bright yellowish. Seed is extracted by simple mechanical crushing. Crushed fruits are mixed with water. Sedimented seeds are seperated and dried to 8% moisture level. Recovery of brinjal seeds was always higher from medium sized fruits. Quality seeds are recovered in about eight pickings. Fruits are pulped in an electric pulper and treated with commercial Hcl at 1:40 ratio (25 cc/kg of pulped fruit), stirred for 25 to 30 minutes and washed well and dried to 8 to 10% moisture content. A maximum seed recovery of 5% to the total weight of fruits was registered by acid method. The seed yield ranges from 360 to 400 kg/ha.

In chillies fruits are harvested at fully ripe red stage. Seeds are extracted from fresh fruits or from dried fruits. 8% moisture is retained before storage. In K_2 chillies, storing of dried fruits as such prolonged seeds viability much longer than stored extracted seeds. Seeds stored in fruits with stalk showed less germination compared to fruits without stalk. In K_2 chillies, recovery of quality seeds was 55%, 55%, 51%, 50% and 46% from fruits harvested in the first, second, third, fourth and fifth pickings respectively. Recovery of seeds from fruits of 5 to 6 cm long was maximum ranging from 51% to 68% in different pickings.

At TNAU Coimbatore, different methods of drying were tried and the results revealed that drying fruits under direct sun improved quality of seeds. Seeds extracted from fruits dried under sun recorded 11% increased germination over the fruits dried under shade.

Seed storage - Storage structures, seed treatment - factors affecting storage life of seeds.

Vadivelu <u>et al</u> (1983) reported that tomato seeds of the variety Co 2 thoroughly cleaned and dried to 7% moisture level can be stored in fresh gada cloth bag without any seed treatment for 15 months, with thiram (335g/100kg) and captan (225g/100kg) treatment for 21 months and in paper aluminium foil and polythene laminated pouches for 18 to 27 and 30 months respectively.

Soak tomato seeds (if untreated) in warm water (55°C) for 30 minutes or acetic acid (0.5% to 0.8%) overnight and then sun dry before sowing. This helps in getting rid of externally seed borne fungi as well as acts as a good control of Tobacco Mosaic Virus (TMV).

In brinjal, seed yield ranges from 360 to 400kg/ha. Seed is treated with 4g of captan or Thiram/kg of seed. Seeds can be stored upto one year in paper bags and upto three years in aluminium foil.

It is observed that 2% reduction in seed moisture will double seed storability. Seed life is halved for each 5°C increase in seed storage temperature between 0°C to 50°C.

Factors deciding storage life of seeds

1. Identification of place of storage.

Locating places where the climate favours long term seed survival is the cheapest and the most practical storage method. Average monthly limit of Rh is 70% and temperature not exceeding 30°C as critical for seed storage.

2. Storage environment

The important environmental factor affecting seedlife in storage are humidity and temperature.

a) If the sum of Relative humidity (Rh%) and temperature (°C) is 80 or higher, seeds will commence to deteriorate in 1 to 9 months depending on the species and the initial seed quality (Short term storage).
b) If it is 70, the safe storage period is extended to about 18 months (Intermediate term - storage).
c) If it is reduced to 30 to 45, most seeds will survive for 3 to 5 years.

3. Storage building

A good seed storage building should exclude moisture, lower the temperature and provide adequate ventilation and air circulation. It should be completely weather proof to keep out rain. Roof and walls must be free of holes and cracks.

4. Quality of seeds entering storage is important in deciding the longivity during storage. If the seeds are spoiled due to weather, mechanical means and are immature they cannot be stored safely under ambient condition.

Seed borne diseases and their control.

Seed borne pathogens cause significant yield losses, decrease germination, serve as the most important source for the perpetuation of pathogens, cause symptoms on seeds such as discolouration and shrivelling, result in biochemical deterioration and change in the quality of seed nutrients. Economically important seed borne diseases and their control in solanaceous vegetables are given below. (Table 9.)

Table 9. Seed borne diseases and their control

Crops	Diseases	Pathogen	Control measures
Tomato	Early blight	*Alternaria solani*	Dithane M-45 (0.2%)
	Bacterial canker	*Corynebacterium spp.*	Long rotation with crops not affected by the disease should be followed.
	Mosaic	Tobacco mosaic virus	Rogor (0.05%) or dimecron
Chilli	Anthracnose	*Colletotrichum capsici*	Difoltan 80 WP (0.2%)
	Ripe fruit rot	*Macrophomina phaseolina*	Dithane M-45 (0.2%)
	Bacterial leaf spot	*Xanthomonas vesicatoria*	Agrimycin-100 at 200 ppm plus Copper Oxychloride 0.3%

(contd.)

Table 9. contd.)

Crops	Diseases	Pathogen	Control measures
Brinjal	Fruit rot	*Phomopsis vexans*	1. Use resistant varieties 2. Long rotation 3. Weekly spraying of nursery and field with fungicides 4. Hot water treatment of seeds at 50°C for 30 minutes 5. Seed treatment with Captan @ 4g/kg of seeds.

7. Important varieties/hybrids released, their sources, characteristics and parentages.

Tomato

Pusa Early Dwarf - Plants are dwarf, 50-55cm in height; fruits are flattish, medium - large, uniformly red, ribbed; mature in 60-70 days after transplanting and yield 20-50t/ha.

HS 101 - A very promising variety bred at HAU, Hissar. It is the product of hybridisation of 'Sel-2' with an exotic variety of tomato. Plants determinate, dwarf, multi branched and sturdy; fruits medium-sized, borne in clusters of 2-3, round; suitable for both seasons in the northern regions; partly tolerant to leaf curl virus and yields 25 to 30 t/ha.

HS 102 - This is a selection from the cross 'S 12' and Pusa Early Dwarf made at HAU, Hissar. An early bearing variety, plants determinate, fruits small, round, juicy, attractive, plants withstand considerable rains and set fruits at high temperature.

HS 110 - Plants semi-determinate, potato leaf type, late, fruits large, fleshy, round with meaty texture, suitable for table purpose.

Hisar Arun (Sel 7) - A very potential variety developed at HAU, Hisar from PED x Kt. Plants determinate, compact, dwarf, concentrated flowering and fruiting, extremely early-bearing, fruits medium to large, red round; fleshy: Yields 35t/ha.

Hisar Lalit (NT 8) - Developed through hybridisation of the nematode resistant Bangalore x HS 101 at HAU, Hissar, it is resistant to root-knot nematodes. Plants determinate, early bearing, fruits medium-sized, round and red.

Pant T_3 - Developed at Pantnagar by Pure line selection, plants are semi-determinate with large foliage, suitable for the winter season, fruits round, red, smooth-surfaced; suitable for processing; average yield 20t/ha.

Pusa Ruby - It is an early and hardy variety evolved at IARI, New Delhi. Plants are medium and semi determinate. The fruits are medium-sized, lobed, uniformly red when ripe and yield 33 t/ha around Bangalore. Pusa Ruby was evolved by crossing Sioux with Improved Meeruti.

Arka Vikas - A selection from a variable population of the American variety 'Tip-Top'. Plants indeterminate, fruits medium-large with uniform deep red colour.

Arka Saurabh - Developed through selection made from the variable breeding line 'V 685' at IIHR, Bangalore. Plants semi-determinate in growth, fruits firm, round, medium large, deep red and nipple-tipped; suitable for both fresh market and processing; yields 30t/ha.

Punjab Chouhara - The variety is developed through hybridization of EC 55055 x Punjab Tropic at PAU, Ludhiana. Plants dwarf, bushy, fruits pear-shaped, firm fleshy, bilocular, suitable for transportation.

F_1 hybrids

Karnataka Indo Hybrid and Vaisali are produced by Indo-American seeds co. Bangalore. Karnataka Indo hybrid is indeterminate and yields 60t/ha. Vaisali is semi determinate and yields 50t/ha.

Brinjal - So far, 14 brinjal varieties were identified for the 8 agro climatic zones.

Pusa Purple Long - Fruit are long (20-25cm). Purple, glossy and tender, grown as summer and autumn crop, average yield is 28.1t/ha and released from IARI.

Pusa Purple Cluster - Fruits are 10-12 cm long, deep purple in colour and borne in clusters of 4-9. It is a medium-early variety, moderately resistant to bacterial wilt and released from IARI.

'PH 4' - A derivative of Hyderpur x PPL, fruits are medium to long and thin, dark purple in colour.

Pusa Kranti - Variety developed at IARI, fruits are oblong 15-20cm long, dark purple with shining green calyx and less seeded. The average yield is 28t/ha.

Pant Samrat - A selection from the local collection at Pantnagar, Resistant to phomopsis blight and bacterial wilt, less infestation of shoot and fruit borer and Jassids.

Kt 4 - This variety is from the IARI Regional Station Katrain. Fruits are borne in clusters of 3 to 5, are cylindrical, tender or firm of purple colour, resistant to wilt, average yield is 37t/ha.

ARU.2c - This variety was bred at Almora, fruits are cylindrical long, bright violet in colour, borne in clusters of 4 to 6, average yield is 32t/ha, it is field resistant to bacterial wilt.

Azad Kranti - A variety identified from Kalianpur, fruits uniformly thick, oblong, 15-20 cm long, dark purple with a shining green colour, less seeded.

K 202 - 9. A variety from Kalianpur, which has the ability to withstand mild frost.

Pant Rituraj - A derivative of T 3 x PPC from Pantnagar. Fruit is almost round, attractive purple in colour, soft, less seeded and endowed with good flavour. Average yield is 40t/ha, possesses field resistance to bacterial wilt.

T 3 - It was developed at Kalianpur, fruits round, light purple with whitish green colour at stigmatic end. T 3 is moderately resistant to little leaf and bacterial blight.

Jamuni Gola - A variety developed at Ludhiana. Fruit is plump and shining purple in colour. Early maturing, first harvesting in 65 days after transplanting.

Arka Kusumkar - An improvement over the local collection (IIHR 193) from Karnataka. Fruits, small, borne in clusters of 5 to 7, average yield is 33 t/ha.

Arka Navneet (F_1) - A cross between IIHR 22-1 x 'Supreme' from Bangalore, fruits oval and free from bitterness, skin attractive, deep purple, flesh soft, white with a few seeds. Yield is 65 to 70 t/ha.

Pusa Anmol - It is a hybrid with alternative dark purple oblong fruits.

Chilli

K 1 Chilli - This is a selection from an Assam type chilli, B-72-A. The plants are tall and compact. The mean length of the fruit is 6.6 cm with 3.8 cm girth. It yields 1900 kg of dry pods with a crop duration of 215 days.

K 2 chilli - This is a hybrid derivative B-70-A and Sathur Samba. The plants are tall and compact, fruits are 7.3 cm in length and 5.5 cm in girth. It gives a yield of 1,500 kg of dry pods/ha.

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Seed Production Techniques of Okra

Sreelathakumary, I*

It is estimated that by 2000 AD, the requirement of vegetable in the country would be about two to three times more than the present production. Expansion and strengthening of seed industry on modern scientific basis would, therefore, be necessary for production of the required quantity of quality seeds,(Vishnu Swarup, 1990).

Table 1. Quantity of certified seeds required annually and area and production of Okra

Vegetables	Area 000'ha	Production of vegetables 000' tonnes	Requirement of certified seeds (t.)
Okra	750	3000	15000

Standards of seed production

Land requirement - select a field where the same crop was not grown in the previous season unless the crop was of same variety and was certified. Soil should be fertile, well drained and free from soil borne diseases.

Isolation requirement

Seed field must be isolated from fields of other varieties, fields of the same variety not confirming to the varietal purity requirements for certification and from wild Abelmoschus species, at least by 400 m for F.S. and 200 m for C.S.

Time of sowing

June - July and October - November

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Vishnu Swarup 1990. Vatika 1 (1) : 33 - 36.

Seed rate - 7kg/ha.

Spacing - 60 cm x 45 cm.

Manures and fertilizers

Apply FYM or compost as basal dose @ 12t/ha. At the time of sowing, apply ammonium sulphate (125 kg/ha), Superphosphate (50kg/ha) and muriate of potash (50 kg/ha). Ammonium sulphate (125 kg/ha) may be applied in two splits 15 and 45 days after sowing.

Irrigation - Give pre-sowing irrigation, if necessary. During non rainy periods, irrigate the crop at 5-6 days interval.

Interculture - Conduct regular weeding, give two earthing up after 15 and 45 days of sowing.

Plant protection - control jassids by spraying Quinalphos, Fenthion or Fenitrothion at 0.05% concentration. For controlling aphids, spray dimethoate (0.05%). For controlling fruit and shoot borers, remove all dropping shoots and damaged fruits. Spray carbaryl (0.05%) at intervals of 15-20 days.

Roguing - All the yellow vein mosaic affected plants should be uprooted and destroyed soon after they are noticed. This should be done upto the fruit stage. Further roguing of off types and wild *Abelmoschus* species should be done before flowering. This should be done during flowering stage also.

Seed standards

Seed standards	F.S.	C.S.
Pure seed (minimum %)	99	99
Inert matter (Maximum %)	1	1
Other crop seeds (maximum)	none	0.05
Total weed seeds (maximum)	none	none
Objectionable weed seed (maximum)	none	none
Germination (%)	65	65
Moisture (ordinary container) (maximum %)	10	10
Moisture (Vapour proof container %)	8	8
Specific requirement for certification		
Off types (%)	0.10	0.20
Inseparable other crop plants	-	-
Objectionable weed plants	none	none
Plants affected by designated diseases	-	-
Plants affected by yellow vein mosaic	0.10%	1%

Yellow vein mosaic has not been found seed borne but affected plants must be removed.

Seed extraction

Dried pods are harvested leaving the pods at the top of the plant. To avoide shattering of seeds, pods may be picked periodically before the fruit bursts. These are then threshed, seeds separated, cleaned and dried to a moisture content of 10%. Seed yield of bhindi is 1200 kg/ha.

Grewal et al (1974) reported that under Punjab condition, early sowing (20^{th} June) and close spacing of (30 cm x 30 cm) and no picking of green pods resulted in the highest seed yield, the largest seed size and the highest percentage germination. The experiment was conducted using Pusa Sawani.

Shukla and Tewari, (1973) reported that increase in fruit length, weight and number of seeds, size of seeds by the application of growth retardants namely chlorophonium (100 or 1000 ppm) or with chloromequat chloride (1000 or 5000 ppm), the greatest effect being obtained with chlorophonium (100 ppm).

At TNAU, Coimbatore, investigations were carried out with bhindi Cv. 'Pusa Sawani' to determine effect of time of sowing and spacing on crop growth, seed yield and quality, and to study influence of seed size and weight or seedling vigour in 15 cultures. Crop sown during March, April and May had recorded better plant growth, higher seed yield and better seed quality than the crop sown during other months. Spacing of plants had significantly influenced days to flower, number of flowers and fruits/plant, fruit size and seeds/fruit. Wider spacing (60cm x 30cm) resulted in the production of more flowers and fruits/plant and increased fruit size, seeds/fruit, 100-seed weight and seed vigour. Closer spacing (60 cm x 20 cm) had however, increased the total seed yield by 20.9%. Seeds obtained from the first picking were heavier than those from subsequent pickings.

Seed weight was increased with increase in seed size. A close association was evident between seed weight and seedling vigour and upgrading the seeds both on the basis of size and the weight would further improve the seed quality in all the bhindi cultivars.

Details of varieties of Okra available in India and their sources and salient features

Variety	Source	Salient features
Pusa Sawani	IARI	High yielding, good adaptability
Sel-2	NBPGR, New Delhi	High yielding
Punjab Padmini	Punjab Agrl. University Ludhiana	High yielding, resistant to yellow vein mosaic virus
Vaishali Vadhu	Sabour, Bihar	High yielding, multiribbed pods
Lam Hybrid	Lam, Guntur Andhra Pradesh	F_1 hybrid, High yielding
Sel-4	IIHR, Bangalore	High yielding, medium long pods. Resistant to YVMV
Sel-10	IIHR, Bangalore	High yielding, long pods. resistant to YVMV

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Seed production in legumes

Meagle Joseph, P*

The seed production requirement of leguminous crops are similar, as regards to their soil and climatic requirements. The details regarding their cultural practices, field and seed standards are discussed below.

Standards for seed production of legumes

	Cowpea		Dolichos bean		Cluster bean		Winged bean
Isolation distance	FS - 50m CS - 25m		FS - 50m CS - 25m		FS - 50m FS - 25m		FS - 50m CS - 25m
Seed Standards							
	FS	CS	FS	CS	FS	CS	
(min) pure seed	98	98	98	98	98	98	
Inert matter (maxi)	2	2	2	2	2	2	
Other crop seeds (max)	None	0.05	None	0.10	0.10	0.20	
Total weed seeds (max)	None	0.10	None	0.10	None	None	
Objectionable weed seeds	-	-	-	-	-	-	
germination	75	75	75	75	70	70	
Moisture (ordinary container) Maximum	9	9	9	9	9	9	
Vapour proof (maximum)	-	-	7	7	-	-	
Specific requirement for certification							
Off types	0.10	0.20	0.10	0.20	0.10	0.20	

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plants affected by designated deseases	0.10	0.20	0.10	0.20	0.10	0.20

Planting requirements

Select a field where the same crop was not grown in the previous season or the crop was of the same variety and was certified. The field should have a light well drained soils. The best time for sowing varies with the crop. In the case of cowpea it is 2nd week of June, dolichos bean August-September, Cluster bean June-July and winged bean August-September.

Seed rate and spacing

	Cowpea	Dolichos bean	Cluster bean	Winged bean
Seed rate - Bush type	20kg/ha	15-20 kg/ha	10-12kg/ha	15-20kg/ha
Poletype	10-12kg/ha			
Spacing- Bushtype	25x15cm			
Poletype	45 x 15cm	75x50cm	45-60x20-30cm	75x 50 cm

Staking should be done for pole types of cowpea, dolichos bean and winged bean.

Roguing

Cowpea

To maintain genetic purity Careful roguing should be done. Characters like foliage colour, plant type, flower and pod characteristics should be noted at pre-flowering, flowering and maturity stage and offtypes should be removed. Plants affected by ashy stem blight, anthracnose, Ascochyta blight and cowpea mosaic should be removed.

Dolichos bean

Rogouing should bedone at 3 stages ie. pre-flowering and maturity stage based on vegetative, floral and pod-characters. Plants affected by bacterial blight, Anthracnose and aschochyta blight should removed.

Cluster beans

Roguing should be done at 3 stages ie. preflowering flowering and maturity stage based on vegetative, floral and pod characters. Plants affected by bacterial blight and anthracnose should be removed.

Winged bean

It is same as above.

Harvesting and seed extraction

The pods are picked when they are fully dried. To avoid shattering, harvesting may be done when two-third of pods have matured. They should be dried fully. Threshing is done by beating with a stick. Seeds should be cleaned and dried under shade to a moi moisture content of 9%.

Seed yield

Cowpea - 15 - 20 T/ha
Dolichos bean- 3 - 6 T/ha
Cluster beans- 6 - 10 T/ha
Winged bean - 15 T/ha

Seed production in cucurbits

S. Rajan*

Cucurbits form a distinct group of species with many similiarities in botany, agronomy, ecological requirements and susceptibilities to insect pests and diseases. They grow well at day temperature between 20-35°C and do not tolerate frost and strong wind. They may show slight photo reaction to short days for flowering.

The important crops in the cucurbitaceae family are listed below:

	Common name	Botanical name
1.	Cucumber (Kakri, kheera)	Cucumis sativus
2.	Pumpkin (Sitaphal, Kaddu, Lalbhopla)	Cucurbita moschata
3.	Ashgourd (Wax gourd, Petha, Bhatua)	Benincasa hispida
4.	Bittergourd (Karela)	Momordica charatia
5.	Snakegourd (Padwal)	Trichosanthes anguina
6.	Bottlegourd (lanki, ghia)	Lagenaria sicerania
7.	Ridgegourd (Nasdhar tori, Kalitori)	Luffa acutangula
8.	Spongegourd (Chiknitori, ghia tori)	Luffa cylindrica
9.	Pointed gourd (Parwal)	Trichosanthesa dioica
10.	Watermelon (Tarbuz)	Citrullus lanatus
11.	Muskmelon (karbuza)	Cucumis melo var reticulatus
12.	Longmelon (kakri)	Cucumis melo var. utilissimus
13.	Oriental pickling melon (Kanivellari)	Cucumis melo var conomomum

Floral biology, pollination and sex mechanism

Inflorescences are axillary, solitary or clustered or racemose. Flowers are mostly unisexual, large and showy and mostly monoecious as in lagenaria, cucurbita, citrullus, Luffa. Momordica and

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Trichosanthes. Andromonaecious forms are found in (dessert) muskmelon. Dioecious forms are seen in pointed gourd, Ivy gourd and in *Momordica dioica*. Monoecious and gynoecious forms are found in cucumber.

Staminate flowers are mostly singly but clusters in *cucumis* and in recemes in Luffa. Pistillate flowers are borne singly in short peduncle. Staminate and pistillate flowers are borne in different axils while in *sechium* and *Luffa* on the same node. Fruit is a (inferior) berry eventhough called a pepo. Seeds are borne with parietal placentation. The edible portion is placenta in cucumber and watermelon while in muskmelon and pumpkin, moslty pericarp. In ridge and sponge gourds, endocarp is edible which later becomes fibrous and spongy. In ashgourd, endocarp is fleshy and edible. In chow-chow it is monocarpillary, single seeded and viviparous. Seeds are usually exendospermous.

Pollination

Anthesis, pollen dehiscence and fruit set are affected by environmental factors. In many cucurbits, anthesis and pollen dehiscence take place between 4 am to 10 pm. However in spongegourd and ridgegourd, it is from 3 pm to 7 pm, in bottlegourd 4 pm to till midnight and in *Momordica dioica*, 6 pm to 10 pm.

Pollen productions in different genera are variable. It is abundant in watermelon, pumpkin, bittergourd etc. while it is scanty in muskmelon. Since cucurbits are insect pollinated - mostly by bees, beetles and moths - they are essential for good yields. Inadequate pollination results in poor fruitshape and excessive blossom drop.

Sex forms

Sex forms in cucurbits show wide range of variation. Primarily hemaphrodite sex form is considered primitive (this is observed in satputia in ribbed gourd) while hermaphrodite genetic stocks in cucumber and muskmelon are recorded. The advanced form is monoecious. In muskmelon, pistillate flowers are replaced by perfect flowers and the sex form is called andromonoecious (dessert type). Similarly andromoniecious forms are met with in watermelon and gynoecious form are seen in cucumber. Sex forms can be modified by exogenous application of plant growth regulators. High ehtylene level promotes femaleness. Gibberellins is antagonistic to ethylene, which induces malencess. Silver nitrate at 300-400 ppm will also induce male flower production.

In order to promote female flowers, MH (50-100 ppm), GA(5-10 ppm), ethrel (150-250 ppm) are sprayed.

Sex ratio is highly influenced by environmental and endogenous factors. Low temperature and high relative humidity stimulate the development of female flowers. High nitrogen, high temperature and long day conditions generally produce more male flowers. The developing fruits determine the production of further pistillate flowers. If fruits are allowed to ripe, the female flower production and further fruit set are restricted.

Isolation

Monoecious nature of most of the cucurbits imposes cross pollination. However natural self-pollination also takes place. The minimum isolation distance between varieties/species for foundation seed production is 800 M and that for certified seed production is 400 M. The following groups of crops should not be grown together for seed production.

- Pumpkin with summer and winter squash
- Sponge gourd and ridgegourd
- Snap melon and long melon
- Muskmelon and long melon

When isolation facilities are not available and where seeds of two or more cultivars of the same variety are to be multiplied, a kind of barrier system, with 3 or 4 cucurbits can be adopted providing minimum isolation as suggested by Seshadri (1986).

In this system, in an area of 1.5 acres, 16 plots are divided with minimum area of 9 m x 30 m for each cultivar as shown below:

Sowing of each of the four cultivars of the four cucurbits has to be done in such a manner that it ensures full stand at the time of flowering without any gap in any plot. Further, adjustment in sowing has to be carefully done so that the all the four cultivars in all the species flower simultaneously.

Cucumber - 1	Bittergourd - 1	Watermelon - 1	Pumpkin - 1
Watermelon- 2	Pumpkin - 2	Cucumber - 2	Bittergourd-2
Cucumber - 3	Bittergourd - 3	Watermelon - 3	Pumpkin - 3
Watermelon- 4	Pumpkin - 4	Cucumber - 4	Bittergourd-4

The main principle here is that when bees or insects carrying pollen from one cultivar of one species fly to the next plot they will have a barrier of another species and the pollen of the flower is wasted. The barrier between the cultivars of the same species is effective if full stand and simultaneous flowering are ensured. Under this system natural selfing takes place without the need for hand pollination. This is a practical method which ensures a large number of fruits available for selection at the same time avoiding crossing between two cultivars of the same species. The population of each cultivar should be large and the plot size should be big enough so that the bees shall not skip or overfly from one cultivar to another of the same species. Even if occasional cross pollination were to take place it could not exceed more than 1%. To eliminate this a row of plants on the outer periphery of each plot may be taken as border plants to discard their fruits.

Climatic requirements

Frost free warm condition for 120-150 days duration with ample sunshine and low humidity are prefered. Excessive rainfall has got an adverse effect.

In Andhra Pradesh and Karnataka rabi and summer seasons are suitable for bittergourd and watermelon. In north Feb-May are good for watermelon, muskmelon and tinda for seed production. In south, summer and winter are found suitable for seed crop.

Soil

Well drained clay loam is essential. A neutral pH 6-7 is good. However, watermelon can come up under slight alkaline condition.

Sowing time

N. India - Feb-March

S. India - January-March and Septeimber-December

Seed rate and crop spacing

Crops	Seed rate kg/ha	Spacing (mxm)
Cucumber	0.5 - 0.75	2 x 1.5
Pumpkin	1.0 - 1.5	4.5 x 2
Bittergourd	5.0 - 6.0	2 x 2
Snakegourd	3.0 - 4.0	2 x 2
Ashgourd	0.75 - 1.0	4.5 x 2
Bottlegourd	3.0 - 4.0	3 x 3
Ridgegourd / Spongegourd	2.5 - 3.0	2 x 2
watermelon	1.0 - 1.5	2 x 3
Muskmelon	1.5 - 2.0	3.6 x 0.6
Long melon	2.0	1.8 x 0.8

Manures and fertilizers

Apply organic manures @ 30-35 t/ha and NPK as mentioned below:

Crops	NPK kg/ha	Recommended by
Cucumber	90-100 : 80-120 : 40-60	Dutta, (1984)
Pumpkin	80 : 80 : 40	do
Bittergourd	90-100 : 90-100 : 40-50	do
Snakegourd	do	do
Ashgourd	90-100 : 80-100 : 40-60	do
Bottlegourd	100 : 90-100 : 40-50	do
Ridgegourd & Sponge gourd	90-100 : 80-10 : 40-60	do
Watermelon	100 : 60 : 60	AICVIP Annual report (1987)
Muskmelon	100 : 80-120 : 40-60	Dutta (1984)
Longmelon	100 : 80-120 : 40-60	do

Special requirements

Land requirement

There is no requirement as to the previous crop, but the land shall be free from Volunteer Plants.

Field inspection

A minimum of three inspections shall be made, the first before flowering, the second during flowering and the immature fruit stage and the third during the mature fruit stage.

Field Standards (NSC, 1985)

Specific requirement

Factors		Max. permitted (%)	
		F.S.	C.S.
i)	Off types	0.10	0.20
ii)	Objectionable weed plants	None	None
iii)	Plants affected by seed borne disease in muskmelon (Mosaic)	0.10	0.20
iv)	Plants affected by viral diseases	0.10	1.0

(max. permitted at and after flowering in the case of off types and at final inspection in case of objectionable weeds, seed borne diseases and virus diseases).

Roguing

Three times at the time of field inspection

Harvesting and seed extraction

Cucumber

Fully ripe fruits are harvested for seed extraction which is indicated by change of colour from yellow or golden yellow. Seeds are extracted by treatment with acid or alkali or by fermentation. If acid is used Con. HCl. is used @ 8.5 ml/12 kg of pulp. In alkali method 25% technical grade ammonia is used @ 12 parts per 100 parts of fruit material. After 30 minutes, seeds settle down. Upper portion is decanted and seed is washed and taken. In fermentation method, keep the crushed material for 2-3 days till fermentation is over. Wash and dry the seeds.

Pumpkin, bittergourd, snakegourd and ashgourd

In pumpkin fruit colour turns from green to yellow or greyish yellow depending on the variety and in ashgourd the colour changes from green to ashy white and fruit stalk dries up coinciding with seed maturity. In bittergourd and snakegourd the tip of fruit turns to yellow in colour as seeds mature.

The seed along with fleshy part are scooped out and washed over screen. Keeping seeds alongwith pulp overnight facilitates easy removal of mucilage.

Watermelon

On maturity, the fruit surface touching the ground turns to yellow tinge, the tendrils dry up and the fruit emits a dead sound on thumping. The seeds are removed from the flesh either mechanically or through mannually.

Muskmelon and Longmelon

On fruit maturity the colour between nets changes from green to yellow and full slip stage is attained so far as muskmelon is concerned. Cut fruits into two pieces and scoope out seeds and wash it over screen.

The washed seeds are dried first under shade and then in mild sunlight. The seed moisture level is brought to 7% before storage.

Bottlegourd, Spongegourd and Ridgegourd

Dry fruits are harvested for seeds extraction. Seeds are extracted by breaking open the fruits. The extracted seeds are dried for 1-2 hours in sun before storing.

Fruit and seed yield

If pistillate flowers are more in early stages more seeds could be obtained. The number of fruits in a seed crop will be less than in a vegetable crop as the developing fruits restrict further fruit set. The fruit yield and seed yield vary with different species of cucurbits as shown below:

Crops	Fruit yield t/ha	Seed yield kg/ha
Cucumber	25-30	150-200
Pumpkin	25-35	250-300
Bittergourd	15-20	200-250
Snakegourd	25-35	200-250
Ashgourd	50-60	250-300
Bottlegourd	40-45	250-300
Ridgegourd & Spongegourd	20-25	100-150
Watermelon	50-80	150-200
Muskmelon	15-20	100-150
Longmelong	35-40	150-200

Seed standards for certification

Factors (%)	Foundation seed	Certified Seed
Pure seed	99	99
Germination (mini.)	60	60
Moisture (ordinary storage)	7	7
Inert matter	1	1
Other crop seed (max.)	0.05	0.1
Weed seeds	None	None
Other distinguishable varieties	0.1	0.2

Hybrid seed production

Methods

1. Emasculation and hand pollination (eg. muskmelon)
2. Hand pollination where male and female flowers are separate
3. By use of gynoecious lines. In this natural pollination is allowed for crossing two gynoecious lines after spraying $AgNO_3$ or hand pollination is resorted to (Expected seed yield would be 10 t/ha. But in glass house conditions upto 30t/ha can

be produced). In this method resistance can be incorporated in F_1.

4. Hybrid seeds can also be produced by sex modification. By spraying ethrel in female line, to hasten pistillate flower production in the first phase. Ethrel (200 ppm) at 2 to 4 leaf stage is sprayed to get pistillate phase first. Alternatively GA3 (1500 ppm) or Silver nitrate (200-300 ppm) can be sprayed to produce staminate flowers in female lines.

5. Prospect of male sterility

   Male sterility has not been much significance as it is genic - single gene recessive and can be recognized only at flowering (male sterile - msms; male fertile - Msms). On crossing male sterile with male fertile (msms x Msms -- 1 msms : 1 Msms) for maintenance, 50% of plants go waste.

Some of the popular hybrids that are being cultivated in large scale are listed below:

Crops	Hybrids
Watermelon	Arka Jyothi, Pusa Badana, Madhu, Milan, MHW - 4, MHW - 5.
Cucumber	Pusa Sanyog
Muskmelon	Punjab Hybrid, HC-5, HC-6
Bittergourd	MDU-1
Snakegourd	MDU-1
Bottlegourd	Pusa meghdoot Pusa Manjari

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Amaranths - Seed production techniques

Meagle Joseph*

Among vegetable crops, a few are easy to grow as amaranths. Starting from the tiny seed, these species produce greens in 4-5 weeks or even less, and then continues to produce for upto 6 months. Further it produces thousands of seeds which guarantee their survival. In favourable locations, they can reseed themselves and continue to produce a useful crop without much attention. In addition to the greens, which is obtained throughout the year, the seeds are also highly nutritious with high protein. Although it is not commonly used now in India, it was the primitive food of the tribal people. In four locations at Himachal Pradesh and Uttar Pradesh, small trial plots were selected and trials laid out with the land races. The yield recorded was 3000 kg/ha. of grains.(Anonymous, 1984). This results therefore gives the suspecion that the yield of grain amaranth will match the yields of other cereals. Therefore scope of seed production of amaranths both grain and vegetable type, is very high and the actual production is far below the requirements. Still the cultivation of amaranths has not been taken up in a big way in all India level, and hence seed production too is very less.

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Standards for seed production

Specific crop and seed requirements in the field for certification are :

	Foundation seed (F.S.)	Certified Seed (C.S.)
Off types (%)	0.10	0.20
Inseparable other crop plants	-	-
Objectionable weed plants (%)	0.10	0.10
Plants affected by designated disease	-	-
<u>Seed Standard</u>	<u>F.S.</u>	<u>C.S.</u>
Pure seed (minimum)	95	95
Inert matter (maximum)	5	5
Other crop seeds (maximum)	0.10	0.50
Total weed seeds (maximum)	0.10	0.20
Objectionable weed seeds (maximum)	-	-
Germination	70	70
Moisture (ordinary container)	8	8
Moisture (Vapour proof)	6	6

Factors influenzing flowering and seed production

Season and weather parameters influenzed flowering in amaranths. Early bolting is one of the limitations in the cultivation of amaranths. There are day-neutral and short-day types of amaranths - short day types are being obligatory in nature and day neutral types are being affected by various factors like temperature (Zabka, 1957), soil factors (Grubben, 1976) height of cutting on harvest (Kaufmann and Gilbert, 1981) nature of cutting (Grubben, 1976 and Deutsch, 1977) density of population Enyi, 1965) C/N ration (Grubben, 1976) mode of planting (Mohideen and Rajagopal, 1975) and age of plantlets (Sulekha, 1980).

Photoperiodism

Investigations on photoperiodic response of different species of amaranths indicated that, there is precocious flowering with increase in photoperiod in *A. hypochondriacus*, *A. dubius* and *A. spinosus*, whereas flowering was delayed with more light in *A. caudatus* and *A. tricolor* while *A. cruentus* and *A. viridis* were photo-insensitive (Mallika, 1989). Devadas, (1982) screened the vegetable amaranth germplasm belonging to four botanical species, *A. tricolor*, *A. dubius*, *A. viridis* and *A. spinosus*. Among the 25 genotypes, two lines belonging to *A. tricolor* namely A_{22} (yield 736 - 36g/0.45m^2 and bolting:59 days) and A_{13} (yield 740.46g/0.45m^2 and bolting : 56 days) are high yielding and stable for bolting, hence they are recommended for seed production purpose. The line A_6 (*A. tricolor*) (769.09g/0.45m^2) was high yielding and late to flower (75 days) but was not stable for days to flowering. This line flowers only during the short-day conditions available during October-November, hence this line is considered as a short-day type. Because of this it was not suitable for seed production throughout the year but only during short-day periods. Mario and Ricardo (1987) also reported that under Guatemala conditions amaranthus is susceptible to the numbers of light hours, it needs for developing and producing seeds. In that particular condition, where the day length is 13.5 to 14h from March to September, June is the best time for planting. From October to February the day length is significantly shorter (11 to 11.5 hrs) with cooler temperatures and it is suitable for seed production.

Temperature

The effect of weather elements (weekly mean) during the first 18 weeks, on days to flower was not significant. Hence Devadas (1982) worked out the total heatunits of each genotype under study and correlated with days to flower. There was high significant correlation in this respect for *A. dubius* and *A. tricolor* genotypes, but the influenze was practically nil for *A. viridis* and *A. spinosus*.

Pruning

Delayed flowering was observed when plants were cut for vegetable purpose (Devadas 1982) compared the overall mean for days to bolting in the control rows as well as unicut rows (first cutting done on 30^{th} day after sowing, uniformly at 10 cm. height). The delay observed in bolting in unicut rows was significant, when compared to the control rows in all 25 genotypes in the trial. Martinez and Muy (1988) also studied the effect of pruning on the seed yield in amaranths. Five cultivars belonging to *A. caudatus* and *A. cruentus* were subjected to the treatments like pruning at 35 days of post emergence, pruning at the beginning of the flowering stage with the cutting of the plant at 10 cm from the soil and with the elimination of the central inflorescence and a fourth treatment which served as control. It was also seen that the cultivars respond differently to different environmental conditions. At an altitude of 1500m. MSL, when pruning was done on 35^{th} day of post emergence, the seed yield surpassed 36% over control. In contrast, pruning done at the beginning of the flowering stage, with the cutting of the plant 10 cm from the soil, seed yield exceeded only 19.5% over the control. At 1740 m. MSL also pruning at 35 days surpassed control by 32% in seed yield which confirms that pruning does have a positive effect on seed yield. Rajan and Meagle (1990) also studied influenze of vegetable harvest on seed yield and quality in *A. tricolor*. First cutting for greens was done after 30 days of transplanting. Subsequent cuttings were given for 2^{nd} and 3^{rd} treatment at an interval of 15 days, where as the control was with no cuttings at all. The highest seed yield was obtained from the treatment with no cuttings, but the yield was statistically on par with unicut treatment. As the number of cuts increased there was a gradational decrease in seed yield. The benefit : cost ratio of taking two green harvests was the maximum as 6:1, followed by one cut (5.8 :1) and no cut (5.3 L 1).

Planting density

The high density planting showed earlier initiation of flower primordia, where as low density planting were slow to flower and gave more number of harvests. Spacing of 20 cm x 20 cm (50 plants/m^2) gave more number of harvests (Sulekha,1980).

Seed extraction techniques

Land requirement and cultural practices

While selecting a field, care should be taken to see that, the same crop was not grown in the previous season. Or the crop should be of the same variety and was certified. The soil should be fertile and well drained.

Isolation distance for the foundation seed is 400m and certified seed is 200m. The time of sowing normally comes during June-July for a seed crop. Seed rate requirement is 1 kg/ha.

and planted at a spacing of 30-20cm x 20-10cm.

Apply 50 tonnes of FYM/ha. Nitrogen, phosphorous and potash is applied @ 50:50:50 kg/ha as basal dose. Apply 50 kg/ha N at regular intervals.

Irrigation should be given at an interval 5-6 days if there is no rain. Regular weeding should also be done. The off types should be removed in three stages. (1) At planting out — check that the plants are true to type (2) Before flowering - check for the height and degree of branching. (3) At start of flowering - Inflorescence and flower colour (George, 1985). For controlling leaf webber, Malathion (0.1%) spraying should be done.

Harvesting and threshing

Seed crop is harvested when grains attain maturity. This is marked by colour change of glumes. When the glumes turn brown and seeds turn to black, it can be harvested along with stem. These are then dried in sun for a few days. Seeds are further extracted by beating with sticks. Seeds are cleaned and dried till a moisture level of 7% is reached.

Seed yield ranges from 180-280 kg/ha, according to variety and season.

Seed storage

Seeds should be stored with maximum security to minimize entry of insects and micro organisms. To ensure maximum storage time, care should be taken during following stages:

1. Post maturity drying
2. Seed extraction/threshing
3. Seed cleaning
4. Holding storage (containers)
5. Packaging.

Although the longevity of seed is primarily dependent on its inherent keeping quality which varies with species in amaranthus, it is 10-12 months, under ambient conditions.

Seed borne diseases

The two main seed-borne pathogens of Amaranths are *Alternaria amaranthi* causing blight and strawberry latent ringspot virus (George, 1985).

Important varieties

Name	Source
CO 1 (*A. dubius*)	Tamil Nadu Agricultural University
CO 2 (A. tricolor)	do
CO 3 (*A. tristis*)	do
Pusa Chhoti chaulai (*A. blitum*)	IARI, New Delhi
Pusa Badi chaulai (*A. tricolor*)	do
Kannara Local (*A. tricolor*)	Kerala Agricultural University

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Inheritance of clusterness, destalkness and deep red colour in chilli (*Capsicum annuum* L.)

T.R. Gopalakrishnan*

Abstract

The research project "Inheritance of clusterness, destalkness and deep red colour in chilli (*Capsicum annuum* L.)" was carried out at the College of Horticulture, Kerala Agricultural University, Vellanikkara, Trichur from July 1979 to September 1983. Preliminary evaluation of 38 chilli lines during 1979 and 46 lines during 1980 revealed considerable variation for most of the economic characters. Phenotypic coefficient of variation was the maximum for fruits/plant followed by fruit length and main stem length. High heritability coupled with high expected genetic advance was observed for fruit length and main stem length. Earliness measured as days to flower and days to red chilli harvest, though having high heritability, had only a very low expected genetic advance.

Six F_1 hybrids developed by crossing four specific chilli lines - Jwala, Pant C-1, CA 33 and CA 23 - exhibited heterosis for earliness. Four F_1 hybrids manifested relative heterosis for plant height. Among the hybrids Jwala x CA 33 had the longest fruits (7.9 cm) with the maximum average fruit weight (2 g). Taking into consideration of the yield in terms of the number and weight of fruits and the extend of heterosis, Jwala x Pant C-1 was the best hybrid yielding 201 g/plant (fruits/plant, 121) followed by Jwala x CA 23.

Combining ability analysis and generation mean analysis revealed the gene action of economic characters. Combining ability analysis stressed the importance of additive gene action for fruit girth, average fruit weight, fruits/plant and fruit yield/plant. Preponderance of additive gene action for leaf laminar length, locules/fruit, capsaicin content and colouring matter of fruits expressed as total carotenoid contents was indicated in the generation mean analysis. The dominance effect was higher than additive effect for main stem length, primary branches/plant and days to flower. The type of gene interaction governing

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expression of characters varied with specific parental combinations. All the three types of interactions - additive x additive, additive x dominance and dominance x dominance - were observed. In most cases epistasis was of duplicate type.

The parental lines Jwala, Pant C-1, CA 33 and CA 23, along with their F_1s, F_2s, BC_1s and BC_2s were grown during May-September 1983 to study the inheritance of clusterness, fruit orientation and destalkness. The transfer of clusterness to cultivated varieties would reduce the cost of harvesting of fruits and offers possibility for mechanical harvesting. Clustered fruiting habit was recessive and monogenic. The genotypes of clustered accession CA 33 and solitary varieties Jwala and Pant C-1 were proposed as cl_1cl_1, cl_1cl_1 and Cl_1Cl_1 respectively. Determinate type of branching was pleiotropic to clustered fruiting habit. The pendulous fruit was dominant to upright and two genes 'up_1' and 'up_2' operated with a specific dominant and recessive epistasis for the control of upright fruit orientation in chilli. The genotype of pendulous lines Jwala and CA 23 for fruit orientation was postulated as $up_1+up_1+up_2up_2$ while that of erect fruited lines Pant C-1 and CA 33 was $up_1up_1up_2+up_2+$. Destalkness in chilli was recessive and digenic. Destalked genotype CA 33 differed from stalked varieties Jwala and Pant C-1 at a single locus 'ds_1' while it differed from CA 23, a stalked line, at two loci 'ds_1' and 'ds_2' with duplicate gene action. The genotype of CA 33 was proposed as $ds_1ds_2ds_2$.

The study resulted in the development of destalked, clustered and deep red chilli lines which are under advanced trials.

Selection efficiency and genetic and biochemical bases of resistance to bacterial wilt in tomato*

S. Rajan and K.V. Peter

An investigation was conducted to study the selection efficiency and genetic and biochemical bases of resistance to bacterial wilt in tomato (line - LE 79) at the College of Horticulture, Vellanikkara during September 1981 to December, 1983.

Of the four methods of selection, single seed descent method improved fruits/plant (19.87 to 52.53), locules/fruit (3.4 to 3.9) and yield/plant (0.63 to 1.82 kg) significantly. Average fruit weight was significantly improved from 29.9 g to 62.4g. The SSD method of selection improved resistance to bacterial wilt from 77.87 to 90.14%. The improved material was subsequently released as a variety, SAKTHI.

The cross between LE 79 and Pusa Ruby indicated a monogenic incompletely dominant gene action to bacterial wilt resistance. The reported association of yellow jel colour around seed and a low locules/fruit with bacterial wilt resistance was not indicated.

A higher level of α -tomatine, O.D. phenols and Vitamin C was maintained in the roots of LE 79 as compared to Pusa Ruby (the susceptible) on infection and development of the disease.

*Ph.D. thesis submitted by the first author to the Kerala Agricultural University, Vellanikkara.

A high ratio of α -tomatine : total phenols, α - tomatine : C.D. phenols, α -tomatine : Vitamin C and a low ratio of total phenols : O.D. phenols were found in the roots of LE 79 compared to the susceptible variety Pusa Ruby.

The artificial inoculation studies divulged that LE 79 was resistant to Vellanikkara isolate of *Pseudomonas solanacearum* E.F. smith. Grafting of susceptible scions on resistant root stock (LE 79) delayed wilting of susceptible scions on infection.

Through SSD method of selection, five promising cultures, viz., LE 79-1, LE 79-2, LE 79-3, LE 79-4, and LE 79-5 were identified. They are being evaluated for resistance to bacterial wilt and other horticultural traits.

Studies on Genetic Resistance to bacterial wilt (*Pseudomonas solanacearum* E.F. Smith) and root knot nematode (*Meloidogyne incognita* Kofoid and White, 1919) Chitwood, 1949) in tomato (*Lycopersicon esculentum* Mill)*

S. Nirmaladevi[1] and S.K. Tikoo[2]

Abstract

Bacterial wilt caused by *Pseudomonas solanacearum* and root-knot disease caused by *Meloidogyne incognita* are major factors limiting tomato production in the traditional areas of tomato cultivation. Development of varieties resistant to the disease is the economical and environmentally safe means of control. Hence the present study was undertaken at the Indian Institute of Horticulture Research, Bangalore to study the inheritance of combined resistance to bacterial wilt and root knot nematode; to study the interaction of these soil borne pathogens on the resistance genes present in the host genotype and to identify a broad spectrum resistant source to wilt amongst known lines/varieties.

The experimental material consisted of 6 lines resistant to bacterial wilt and 12 cultivars/lines resistant to root-knot nematode. Each of the six bacterial wilt resistant (BWR) lines was crossed with all the nematode resistant (NR) lines to obtain F_1s for studying the yield and reaction to bacterial wilt and root-knot nematode. Based on their performance, 6 F_1 hybrids were selected (3 were resistant to

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*Ph.D. thesis submitted to University of Agricultural Sciences, Bangalore, India.

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both bacteria and nematode; 2 were resistant to nematodes and susceptible to bacteria and 1 was resistant to bacteria and susceptible to nemetodes). The hybrids were crossed with their respective male and female parents separately.

Peptone casein hydrolysate agar containing 0.005 per cent 2, 4,5 triphenyl tetrazolium chloride (Kelman, 1954) was used for isolation of bacterial wilt pathogen from infected tomato plants.

The plot selected for conducting the study was sick with P. solanacearum (10^8 colony forming units/g soil) and M. incognita. At the time of planting 100g of nematode infested soil containing about 1000 M. incognita larvae were put in the planting holes to ensure sufficient nematode inoculum. When the plants started flowering, P. solanacearum culture containing. 10^7 cfu (colony forming units) per ml was inoculated on the third leaf axil from the top to ensure the presence of sufficient inoculum. The experiment was laid out in a randomised block design with three replications. Observations were recorded on percentage survival of plants, ooze index, gall index, fruits/plant and fruit yield.

The results showed that F_1s of parents having dominant sources of resistance to wilt and root knot nematode were resistant to both the diseases in the field. The combined resistance to root-knot nematode and bacterial wilt is inherited digenically in the crosses of BWR 1. It was also found that the interaction between pathogens has modified the genetic ratios in the crosses. The wilt resistance in CRA 66 sel A was found to be controlled polygenically. The sequential inoculation of both pathogens has shown that the digenic ratio is modified to 9:3:4 ratio irrespective of the sequence. It was found that there is significant correlation between ooze index and gall index and the root-knot nematodes do predispose the plants to bacterial wilt.

The lines selected for resistance to P. solanacearum in Hessaraghata were studied for their reaction to the same pathogen from Maharashtra, Kerala and Chethalli (Karnataka). The lines showed differential response to these isolates. The differential response may be due to difference in races or biotypes. The necessitates testing of lines for wilt resistance in different geographic localities.

Evaluation for processing characteristics in tomato and their expression in a bacterial wilt resistant genetic background*

Alice Kurian[1] and K.V. Peter[2]

Abstract

The investigations on evaluation for processing characteristics in tomato and their expression in a bacterial wilt resistant genetic background were carried out during September 1986 to January 1990 at College of Horticulture, Vellanikkara. Sixty four tomato accessions were evaluated for processing traits leading to high case yield, quality and shelf life of products - ketchup and paste. The selected processing genotypes were crossed with 'Sakthi' and two other resistant lines to develop processing lines possessing resistance to bacterial wilt. Parental combinations which resulted in heterotic F_1 hybrids for different character(s) were identified and type(s) of gene action governing processing traits were studied. The genetic bases of resistance to bacterial wilt were studied and the promising F_2 segregants were selected for further improvement.

Evaluation of the tomato genotypes revealed considerable variations in morphological and qualitative characters. AC 238 and Pusa Early Dwarf were the earliest genotypes during 1st and 2nd seasons (91.20 and 87.40 days respectively). In terms of economic earliness, LE 206 was top ranking (1.34). Sioux produced the biggest fruits (101.83 g) but the fruits were a fewer in number (5.70). AC 142 having small fruits had the maximum number of fruits (55.70). Fruit shape index was the highest (1.95) for Veepick characterised by long

* Ph.D. thesis of first author. Kerala Agricultural University, Vellanikkara, Thrissur.

oval fruits and the lowest (0.71) for AC 2301 having an oblate shape. Thirty nine genotypes had fruits with elongate shape with shape index $>$ 1. Fruits with elongate shape had a fewer locules (range 2.0 to 4.9) and high pericarp thickness (4.16 mm to 7.52 mm) whereas round fruits had more locules (2.8 to 6.3) and a low pericarp thickness (2.77 mm to 5.93 mm) Ohio 832 had the highest pericarp thickness (7.42 mm), H 722 (33.20 days) and St 87 (34.00 days) were the least perishable during the first and second seasons respectively. Thirty genotypes produced fruits which did not crack.

Fruits with high pericarp thickness were firm also. These fruits had high total solids, pulp content, insoluble solids and consistency. The acidity was low and the PH was high. The TSS, reducing sugar and acidity were also low in these firm fruits. HW 208 F recorded the highest total solids (8.16%), insoluble solids (1.25%), pulp content (34.25%) and consistency (0.34). Ohio 8129 (6.36 mg/100 g) and E 6203 (6.62 mg/100 g) were the high lycopene lines during first and second seasons. EC 129355 was the highest yielder (1287.23 g/plant). Veeroma had the highest TSS (6.7%) and LE 214 the highest ascorbic acid content (40.93 mg/100 g).

Among the components of yield, index to earliness recorded maximum variability (gcv - 71.06; pcv - 105.28). Genetic advance as % of mean was the highest (98.83) but the heritability was only moderate (0.6%). Fruit cracking recorded maximum variability (gcv-65.09; pcv - 83.60) and genetic advance as % of mean (104.42) among fruit characteristics. Insoluble solids showed the highest gcv (30.98) and pcv (32.06) among fruit juice characteristics. High heritability (0.93) coupled with high genetic advance of % of mean (61.67) was also observed.

Positive correlation was observed between fruit shape index and consistency (rg = 0.64), pericarp thickness (rg = 0.62), insoluble solids (rg = 0.50), Iycopene (rg - 0.35), total solids (rg - 0.33), PH (rg - 0.26) and TSS (rg - 0.09). Somatic analyses further confirmed the results that fruits with high shape index have a fewer locules, thick pericarp, high total solids, insoluble solids, consistency, lycopene and pH but low acidity and reducing sugar.

Pulp and total solids content determine the product recovery. The ultimate product yield depended on juice yield from a unit area also. Total solids and pulp content also determine the excess water to be evaporated and the cost involved in concentrating the product to a fixed solids level. Content of insoluble solids was critical for consistency whereas lycopene was crucial for colour of product. HW 208 F with the highest total solids (8.16%) yielded maximum ketchup (10.95 t ha^{-1}) and paste (6.93 t ha^{-1}) and the least quantity of water to be removed saving considerable energy cost. HW 208 F with the highest consistency of ketup (0.52) scored maximum (85.80) for Grade I standard, even with a moderate colour. Ohio 8129 and St 64 also scored for Grade I standard.

For tomato paste, colour is more important since high lycopene genotypes Ohio 8129 and St 64 scored high (88.60 and 87.60 respectively) but the paste yield were only moderate. HW 208 F and St 87 also had Grade I standard. St 87 had the added advantage of fairly high yield of paste (5.85 t ha^{-1}). Hunt's tomato paste from USA was exceptional in its deep red colour with high lycopene content (25.44 mg/100 g) and high consistency (0.98). Ohio 8129 (25.37 mg/100g) and St 64 (24.79 mg/100g) were comparable to Hunt's paste in lycopene.

The acidity of the products from all the genotypes was within limits prescribed. The selection index worked out on the basis of processing qualities also revealed superiority of HW 208 F (11.44), Ohio 8129 (10.26) and St 64 (9.86) for processing. Veeroma which was top ranking in the selection index based mainly on high TSS, did not score in the sensory rating due to low consistency and low colour of product.

Considering physical appearance of products, a few genotypes showed balackneck formation and phase separation. Genotypes showed varied response in retention of quality components during processing and storage. Progressive decrease in acidity (2.18 to 1.80%) and concominent increase in pH (3.71 to 3.86) were observed during storage. The reducing sugar content increased slightly (17.66 to 17.70%) with advanced storage life. TSS was not changed significantly during storage (38.0 to 37.57%).

The genotypes varied in the retention of lycopene, B carotene and ascorbic acid during processing and ranged from 55.40% to 98.80%, 50.10% to 90.05% and 39.57% to 79.83% respectively. With advanced storage upto 12 months, retention of lycopene, B carotene and ascorhic acid dropped to 76.12%, 53.08% and 63.26% respectively. Consequent to reduction in quality components, the sensory scores also changed with genotypes and duration of storage. Ohio 8129 and St 64 were exceptional in retention of lycopene (94.83% and 94.69% respectively) without notable reduction after 12 months. HW 208 F, Ohio 8129, St 64, Ohio 7814, Veeroma and Rubyvee retained the initial consistency throughout storage.

Visible microbial infection was observed in three samples of ketchup. Micro-organisms which caused spoilage were identified as

Aspergillus flavus and *Aspergillus fumigatus*. The chemical components, acidity and pH of the product did not have a direct role in microbial spoilage.

The F_1 hybrids which had the highest *per se* performance were Sakthi x HW 208 F (0.91%) for insoluble solids, LE 206 x St 64 (7.0%) for TSS and for lycopene LE 206 x ohio 8129 (11.66 mg/100) and LE 206 x St 64 (11.38 mg/100g.) Considering yield/plant, Sakthi x TH 318 (1280.34 g) and for average fruit weight Sakthi x Fresh Market 9 (70.97 g) were promising. These hybrids had significantly high sca also. The hybrids produced fruits with intermediat acidity, reducing sugar and firmness. All the F_1 hybrids were crack resistant.

Good general combiners were identified for different characters. They were Sakthi (yield/plant), Fresh Market 9 (average fruit weight), TH 318 (fruit shape index) St 64 (pericarp thickness, TSS), HW 208 F (juice yield, total solids, insoluble solids, consistency, pH, ascorbic acid) and Ohio 8129 (reducing sugar, lycopene, storage life).

Additive gene action predominated for plant height, days to harvest, storage life, pericarp thickness, total solids, lycopene, ascorbic acid, juice yield, reducing sugar, consistency, shape index, acidity and pH. Except shape index (0.23), acidity (0.19) and pH (0.07) all the characters had a high heritability also. Non-additive gene action was observed for fruits/plant, yield/plant, average fruit weight, locules/fruit, TSS and insoluble solids.

Evaluation of F_1 hybrids for ketchup and paste revealed their superiority for high product yield due to increased solids and better colour through increased lycopene. Sakthi x HW 208 F had the highest yield (40.33% and 25.08% respectively) and consistency (0.48 and

0.71 respectively) for ketchup and paste. LE 206 x Ohio 8129 and LE 206 x St 64 were promising for enhanced colour of products. Sakthi x HW 208 F, Sakthi x Ohio 8129, LE 206 x St 64, and LE 206 x Ohio 8129 were rated for Grade II standards for ketchup and paste and Sakthi x St 64 for ketchup alone. These F_1 hybrids had improved product quality over Sakthi and LE 206 which did not reach even Grade II standard.

Reaction of tomato genotypes to bacterial wilt indicated that all the processing lines were highly susceptible to wilt. Crosses using Sakthi and LE 206 with selected processing types, revealed a recessive and monogenic inheritance with Sakthi and recessive, ~~di~~ digenic and supplementary gene interaction for wilt resistance with LE 206. The F_2 segregants elicited uniform fruit colour and elongated fruit shape. All the F_2 segregants were free from fruit cracking.

Breeding for virus resistance in Bell pepper (*Capsicum annuum* L.)

T.E. George*

The cultivation of highly profitable and vitamin-C rich vegetable, bell pepper (*Capsicum annuum* L.) has not picked up momentum in our country due to a conglomeration of factors, the vulnerability to virus infection being the most important among them. To overcome the adverse effects caused by viruses on the growth and yield of bell pepper, development of resistant genotypes is the only avenue open in the absence of any effective virus control measures. The present investigation was hence undertaken with the following objectives:

i. to isolate and identify major viruses which infect bell pepper;

ii. to quantify the adverse effect caused by viruses on growth and yield;

iii. to isolate sources of virus resistance;

iv. to unravel genetics of virus resistance;

v. to study variability in virus resistant segregating material; and

vi. to determine the genetic parameters of important quantitative characters so as to formulate a breeding strategy.

The results obtained are discussed under the following heads.

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Isolation and identification of viruses

Based on symptomatology, reaction on indicator plant, particle morphology and serology, the two major viruses that infect bell pepper were identified as potato virus Y (PVY) belongs to poty virus group and cucumber mosaic virus (CMV) belonging to cucumo virus group. Election microscopy of the purified virus preparations revealed flexuous rods measuring 694 x 12.5 nm in case of PVY and isometric particles with a diameter of 29 nm in case of CMV.

Quantification of adverse effects caused by viruses

Inoculation of PVY, CMV and both together drastically reduced the mean leaf area, fruit length, fruit diameter, average fruit weight and yield/plant of bell pepper cultivars, Arka Mohini and Arka Gaurav. Reduction of yield, ranged between 66.7% to 74.0% depending upon the virus and the cultivar. The severity of adverse effects was more pronounced when inoculated with CMV or both together than when inoculated with PVY alone there being no appreciable difference between combined infection and CMV infection. Thus, in bell pepper, more damage is caused by CMV infection that PVY and both these viruses act in a non-synergistic manner.

Isolation of sources of virus resistance

On screening one hundred and twenty genotypes belonging to eight different species of Capsicum, six chilli genotypes (IHR-243, IHR-328 - 9, IHR-384 IHR - 990, Puri Red and Pant C-1) and one wild accession (IHR-1252 - Capsicum chinense) exhibited resistance to both PVY and CMV, two bell pepper genotypes (IHR-993 and IHR-994) and one wild accession (IHR-1243 - *C. frutescens*) possessed resistance to PVY alone and one wild accession (IHR-1274 - *C. pubescens*) had resistance to CMV alone. The confirmatory tests viz., back inoculation, graft transmission, aphid transmission and multi-environment study clearly established that the reaction of the resistant genotypes was stable and could be considered as extremely resistant.

Combined resistance to both PVY and CMV was found only in chilli genotypes and not in bell pepper genotypes. This necessitates incorporation of genes for resistance to PVY and CMV from chilli to bell pepper. As no crossing barrier exists between chilli and bell pepper, this is feasible but for the delay in eliminating chilli characters like pungency, small fruit size and this flesh.

Genetics of virus resistance

Evaluation of parents, F_1, F_2, F_3 and back-cross generations of six cross combinations for resistance to PVY after artificial inoculation with pure PVY revealed that resistance to PVY was conditioned by a single recessive gene. Evaluation of parents, F_1,F_2,F_3 and backcross generations of four cross combinations for resistance to CMV after artificial inoculation with pure CMV revealed that resistance to CMV was conferred by a single dominant gene. Reciprocal F_1s behaved exactly similar as F_1s as regards their reaction to PVY and CMV thereby ruling out any cytoplasmic effects. Evaluation of parents F_1 and F_2 generations after combined inoculation of PVY and CMV revealed that the single recessive gene governing PVY resistance and single dominant gene conferring CMV resistance segregate independently and did not show any interaction.

Variability in virus resistant segregating material

Wide variability was observed for mean leaf area, percent fruit set, fruit length, fruit diameter, fruits/plant, average fruit weight and yield/plant in the segregating populations of chilli x bell pepper crosses in a virus - free environment. Selection for resistance to PVY/CMV narrowed down the spectrum of variability of these characters. The frequency of nonpungent fruits with high average fruit weight was as low as 8.1% in PVY resistant F_2 population and 8.7% in CMV resistant F_2 population.

Genetic parameters of quantitative characters

Hayman's six generation mean analysis revealed that all the three gene actions, additive, dominance and epistasis were important in the control of quantitative characters like plant height, plant spread, number of primary branches, number of secondary branches, mean leaf area, per cent fruit set, fruit diameter, number of fruits, average fruit weight and total yield. Yield/plant possessed positive association with average fruit weight and early yield and negative association with days to flower and pungency in F_2 of chilli x bell pepper crosses. Transgressive segregation was observed for yield in chilli x bell pepper crosses.

Breeding strategy

Taking cognizance of all the findings of the study, a backcross - intercross programme involving one chilli genotype resistant to both PVY and CMV as donor parent and three commercial but virus susceptible bell pepper cultivars as recurrent parents is formulated for developing multiple virus resistant, high yielding bell pepper varieties.

Genetics of Resistance to aphids (Aphis craccivora Koch) and Utility of line mixtures in Cowpea (Vigna unguiculata L. Walp)

Dr. K.V. Peter* and Dr. Salikutty Joseph**

Abstract

Direct damage caused by aphids by sucking plant sap and indirect damage caused by transmitting many viral diseases are serious havocs in cowpea. This constitutes a formidable obstacle in realisation of its yield potential, unless protected with insecticides. This, in turn, leads to high cost of production, serious health hazards and atmospheric pollution. In this context host plant resistance appears to hold great hope for cowpea production.

Experiments on "Genetics of resistance to aphids (Aphis craccivora Koch.) and utility of line mixtures in cowpea (Vigna unguiculata L. Walp)" were carried out during 1986-1990 at Department of Olericulture, Kerala Agricultural University at Vellanikkara to isolate cowpea line(s) resistant to aphids, to study mechanism of resistance, inheritance of resistance and to develop physical mixtures to manage aphids.

Three resistant and six moderately resistant lines were identified. The resistant lines are Vs 350, Vs 438 and Vs 452. The moderately resistant lines are Vs 306, Vs 307, Vs 147, Vs 456, Vs 457 and Vs 458.

The resistant lines were the least preferred for colonization. Growing tips of resistant lines were highly pubescent. Non preference and antibiosis mechanisms were the causes for observed resistance in cowpea.

Nitrogen, phosphorus, potassium and protein contents did not differ among resistant and susceptible lines. The resistant lines had more reducing sugars but less non-reducing sugars and total sugars when compared to susceptible lines.

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Fecundity of aphids were significantly higher (43.1-50.8) on susceptible lines when compared to resistant lines (9.0-17.6). Total phenol content was high in resistant lines (88 ppm-96 ppm) and low in susceptible lines (64 ppm-69 ppm). Orthodihydroxy phenols also were high in resistant lines (29 ppm-38 ppm) when compared to susceptible lines (23 ppm-27 ppm). Trypsin inhibitors were also observed in resistant lines.

Aphid population was the lowest during March, April and May which coincided with high temperature, low humidity and less rainfall.

Aphid resistance was governed by a single dominant gene. Level of resistance when considered as a quantitative trait, one 'factor' was estimated governing resistance.

All the physical mixtures expressed compensatory effects for level of aphid resistance. There was a positive correlation with level of aphid resistance and (%) obstruction created through physical blending. None of the mixtures exceeded the performance of their pureline components for pods/plot and yield/plot. The mixture Vs 438 + Kanakamony was promising in yield with 83.13% resistance under field conditions.

Two coccinellids - *Coccinella arcuata* and *Menochilus sexmaculatus* and one syrphid *Ischiodon scutellaris* were the most prevalent predators of aphids.

Climate, natural enemies and host plant effect are the major factors affecting development of aphids on cowpea.

Studies on virus (CGMMV) resistance in muskmelon (*Cucumis melo* L.)*

Rajamony, L[1] and V.S. Seshadri[2]

Abstract

An investigation on the virus resistance in muskmelon (*Cucumis melo* L.) was carried out in the Division of Vegetable Crops, Indian Agricultural Research Institute, New Delhi, during the period 1985-87 with special reference to the Cucumber green mottle mosaic virus (CGMMV).

Out of 196 collections (belonged to the dessert, semidessert and wild class) studied to identify the source of resistance, 15 viz., Phoot, Kachri, Papaya, Zolotistaja, FM-1, *C. myriocarpus*-1, 2,3, *C. africanus*-1,2, *C. figarei*, *C. dipsaceus*, *C. meeusii*, *C. ficicolius* and *C. zeyheri* were found to be symptomless under field screenings conducted twice. When the same 15 collections were screened under artificial conditions by mechanical sap inoculation with the purified CGMMV strain, only nine collections namely, *C. myriocarpus*-1,3,4, *C. africanus*-1,2, *C. figarei*, *C. meeusii*, *C. ficifolius* and *C. zeyheri* were found as symptomless. Two semi-dessert collections, Phoot and Kachri, one breeding line from the cornell University, USA, FM-1 and one wild collection of *C. myrio carpus* were found to be resistant to CGMMV with very mild symptom that too only in the early stages of growth. Later on they were confirmed as symptomless. Ninetten collections were classified

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as medium resistant wherein the plants showed only mottling with light and dark green colours without any further gradation towards the susceptibility. Studies on the symptom expression due to the CGMMV inoculation on the representative collections upto 50 days after inoculation revealed that scoring at 30 days was very authentic to categorize them into resistant, medium resistant or susceptible groups.

Back-inoculation experiments and Electronmicroscopy studies revealed that the wild species viz., *C. figarei*, *C. africanus*, *C. meeusii* and *C. zeyheri* were immune to CGMMV whereas Phoot, FM-1 and Kachri were found to be symptomless carriers with very low concentration of CGMMV particles.

Inheritance of resistance or tolerance to CGMMV in muskmelon was studied with three representative parents from each resistant, medium resistant and susceptible classes. Out of 15 cross combinations studied, 10 were found as interacting ones. Screening of P_1, P_2, F_1, F_2, BC_1, and BC_2 of all the crosses revealed that resistance (tolerance) to CGMMV in muskmelon is controlled by poly genes with recessive nature. On the other side, the susceptibility was found to be incompletely dominant over resistance. One resistant x resistant cross (Kachri x Phoot) showed heterobeltosis in F_1 and transgressive segregation in F_2 for resistance. Intermating of medium resistant lines did not improve the level of resistance higher than their parents. Additive genetic variance and additive x additive as well as additive x dominance interactions played predominant role in the expression of CGMMV symptoms. All the interacting crosses except one showed duplicate epistasis towards CGMMV incidence. It is indicated that the source of CGMMV resistance in Phoot, Kachri and FM-1 are different and accumulating these resistance genes to a single genotype would be worthwhile to have a higher level of resistance. The studies also projected the importance of CGMMV immune collection *C. figarei* in the interspecific hybridization programme by the application of embryoculture for getting highly resistant varieties in muskmelon.

Crop improvement in watermelon (Citrullus lanatus Thunb. mansf)*

P.C. Rajendran[1] and S. Thamburaj[2]

Abstract

Investigations were carried out to elicit information on variability, combining ability, nature and magnitude of inheritance, correlation and direct and indirect effects of component characters towards yield in 30 accessions of watermelon. The extent of variability was maximum in yield (67.60%) followed by sex ratio (60.68%). The heritability for yield of fruits was higher (59.00%) with the highest genetic advance as percentage of mean of 106.57%. The heritability was maximum for weight of 100 seeds (89.00%), ascorbic acid content in fruits (67.00%) and total soluble solids (60.00%). Six inbred parental genotypes were used to get a 6 x 6 diallel cross (direct and reciprocals) and further genetic analysis to identify a superior high yielding, early and quality hybrids.

The variance due to general combining ability was significant for most of the economic characters except crop duration, nodal position of first female flower and T.S.S. Variance due to specific combining ability was significant for all the characters except node number of first female flower. This indicated the involvement of both additive and non-additive gene action in the inheritance of most of characters. The parent P_1

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was the only general combiner for increased yield. Out of thirty hybrid combinations only two $P_2 \times P_4$ (Honey Island Yellow Flesh x Sugar Baby) and $P_4 \times P_6$ (Sugar Baby x H.W.I.) had better standard heterosis 27.13% and 6.18% respectively for yield/vine. These hybrids were also noted with maximum negative standard heterisis (-10.89% and -6-69% respectively) for days to first female flower production and maximum positive standard heterosis (14.71% and 5.88% respectively) for T.S.S. content of fruit. The hybrid $P_3 \times P_2$ (Asahi Yamato x Honey Island Yellow Flesh) recorded maximum negative heterosis of -10.00% for crop duration. Significant positive correlation of yield with average fruit weight, fruits/vine and seeds/fruit were observed. Among the various yield components, the average fruit weight had exerted maximum direct influence on fruit yield, while fruits/vine and seeds/fruit had greater indirect effects.

The estimates of genetic and graphic analyses disclosed presence of additive, non-additive and epistatic gene action in the inheritance of most of the traits under investigation. Based on the present investigations, it is suggested that heterosis breeding and reciprocal recurrent selection would be very effective breeding strategies to improve these economic attributes in watermelon.

Homeostatic analysis of components of genetic variance and inheritance of fruit colour fruit shape and bitterness in bittergourd (*Momordica charantia* L.)*

M. Abdul Vahab and P.K. Gopalakrishnan

Abstract

The present investigation, "Homeostatic analysis of components of genetic variance and inheritance of fruit colour, fruit shape and bitterness in bittergourd (*Momordica charantia* L.)" was conducted at the College of Horticulture during 1981-85. The objectives were estimation of genetic divergence, gene action, inheritance of economic characters, identification of heterobeltiotic and stable F_1 hybrids and understanding crossability among related species of bittergourd (*Momordica charantia* L.)

The extent of genetic variability in 50 bittergourd lines was assessed. Ten diverse parents were selected, and 45 F_1s developed and evaluated along with the parents for three seasons. The combining ability and heterosis were estimated. The stability of these hybrids were worked out for commercial exploitation of the promising heterobeltiotic F_1 hybrids. Inheritance of fruit colour, fruit surface and bitterness using crosses of parents differing for these characters was studied. An attempt was also made to understand crossability among the three species of *Momordica* - *charantia*, *dioica*, and *cymbalaria*.

Significant differences were observed among the 50 genotypes for all the 18 characters studied, viz. branches/plant, vine length,

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*Ph.D. Thesis submitted by the first author to Kerala Agricultural University.

node to first female flower, days to opening of first female flower, female flowers/plant, percentage of female flowers, days to picking maturity, yield/plant, fruits/plant, fruit weight, fruit length, fruit girth, flesh thickness, seeds/fruit, 100 seed weight, T.S.S., Vitamin C content, and protein content. The genotype MC-34 was the earliest for first female flower formation (33.5 days). MC-79 had maximum fruits/plant (113.25), fruit size being small. Priya had the highest yield/plant (12.76 kg) which was on par with MC-84 (12.48 kg), MC-78 (12.25 kg) and MC-66 (12.17 kg). The highest phenotypic coefficient variation was observed for fruit weight (48.77) followed by yield/plant (39.91) and fruits/plant (31.82). It was moderate for fruit length (29.56), percentage of female flowers (28.56) and female flowers/plant (27.33). The pcv was low for node to first female flower formation (8.18) and days to first female flower opening (8.38). The genotypic coefficient of variation resulting in high heritability was of high magnitude for majority of the characters. High heritability coupled with high genetic gain was observed for fruit weight and yield/plant. Branches/plant and days to first female flower formation despite with high heritability had only low genetic gain.

Ten diverse bittergourd lines selected from the original germplasm were crossed in all possible combinations to develop 45 F_1 hybrids. Stability of these parents and hybrids was analysed by growing them continuously for three seasons. Pooled analysis of variance showed significant genotype x environment interaction for all the characters. The genotypes were significantly different in all the three seasons and the environments were also significantly different among one another. The pooled deviation was highly significant for all the characters except for node to first female flower, which indicated presence of interaction of the genotypes with the environment.

The linear components of genotype x environmental interaction was highly significant for yield and related characters indicating linear nature of interaction of genotypes with environments and presence of considerable differences among the genotypes themselves. The highest over all mean yield/plant was recorded by MC-78 x MC-66 (10.33 kg) followed by Priya x MC-66 (9.75 kg). Considering the regression coefficient approximately equal to unity (bi 1) and deviation from regression not significantly different from zero ($S^{2}d(i)$ 0), Priya x MC-84, MC-78 x MC-69, MC-84 x MC-66 and MC-84 x MC-49 were stable hybrids. Priya x MC-69, MC-78 x MC-84 and MC-78 x MC-34 were above average stable and Priya x MC-78, Priya x MC-66 and MC-84 x MC-34 were below average stable hybrids.

The 45 F_1 hybrids alongwith their 10 parents were evaluated for three seasons to study combining ability and heterosis. Analysis of variance for combining ability for separate environments showed significant gca variances for all the 15 characters in all the three seasons. The sca variances were also significant for all the characters excepting days to picking maturity, fruit girth and 100 seed weight in the second and node to first female flower in the third season.

Analysis over environments for combining ability variances showed significance of gca and sca variances indicating the role of both additive and non-additive gene action for control of majority of characters. The interaction of gca and with environments were high for all the characters excepting earliness indicating additive role of environments on combining ability of the parents. Significant sca x environment interaction for all the characters revealed inconsistent sca effects of the crosses. The parents Priya, MC-78, MC-84 and MC-66 which gave the highest yields found possessed significant gca effects. When parents with high gca effects were crossed, the F_1 hybrids gave best performance. The present study revealed importance of both additive and non-additive gene effects in the inheritance of majority of characters. Pedigreee system and diallel selective mating among the parents on the basis of gca would result in greater variability for recurrent selection to be resorted to for improvement in bittergourd.

Several hybrids recorded significant relative heterosis, heterobeltiosis and standard heterosis for majority of the characters in all the three seasons. Significant and negative relative heterosis, heterobeltiosis and standard heterosis were exhibited by several hybrids for days to first female flower. MC-66 x MC-49 (-14.97%) and MC-49 x MC-34 (-13.28%) in the first and Arka Harit x MC-82 (-11.76%) in the third season were significantly earlier for first female production than the standard variety Priya.

Priya x MC-49 (7.91%) and MC-49 x MC-34 (7.91%) and MC-49 x MC-69 (7.1%) were the important hybrids with high standard heterosis for percentage of female flowers.

Six hybrids in the first and two each in the second and third seasons exceeded their better parents for yield/plant. Arka Harit x MC-79 had high heterobeltiosis in the first and second seasons (117.17% and 43.09%). MC-78 x MC-66 (7.46%) and MC-78 x MC-84 (4%)

in first and MC-78 x MC-66 (17.14%) and Priya x MC-66 (5.04%) in the third season had higher yield than the standard variety Priya.

MC-78 x MC-49 (40.76%), MC-49 x MC-34 (17.07%) in first and MC-49 x MC-34 (40.54%), MC-49 x MC-69 (37.83%) and Arka Harit x MC-79 (37.6%) in second season were superior heterobeltiotic F_1 hybrids for fruits/plant.

Studies on inheritance of fruit colour and fruit surface using six crosses of four parents with contrasting fruit colour and surface revealed that both the characters are monogenic in inheritance, green and spiny fruits being dominant over white and smooth fruits respectively. Both colour and surface are independent in inheritance. Inheritance studies on bitterness using three crosses of highly bitter, and less bitter types of bittergourd showed quantitative inheritance of the character. Non allelic interaction was present in two crosses. Additive, dominance and additive x dominance types of gene action were involved in the inheritance of bitterness. Estimates of narrow sense heritability was high in two crosses and moderate in one.

Crossability studies using three species of _Momordica_ - _charantia_ _dioica_ and _cymbalaria_ showed complete incompatibility among the three species tried.

Genome analysis in the Genus Amaranthus

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Abstract

Amaranth, often described as a poor man's spinach, is a good source of carotene (of use against xerophthalmia), of iron (of use against anaemia), of calcium, Vitamin C, folic acid and other micronutrients. Amaranths include one of the ancient groups of crop plants having great potential for combating under and malnutrition in the World because of the high content and quality of proteins, vitamins and minerals in leaves as well as grains. Amaranth plants are also belayed with C_4 photosynthetic pathway, thus enabling them to produce more carbohydrates and to withstand adverse conditions like drought than C_3 plants. Interspecific relationship among Amaranthus species were worked out by many investigators but these studies were unsuccessful in establishing the relationship between the two sections of the Genus. The centre of origin, evolution and movement of vegetable species to Asia will be adding to our current knowledge on amaranths.

Cytogenetical studies on eight species of *Amaranthus* and their hybrids were undertaken at the Department of Olericulture, College of Horticulture, Vellanikkara in order to understand their genome relationship. This dissertation also embodies other aspects such as development of a provisional key or identification of *Amaranthus* species, classification of the forty accessions of *Amaranthus* available in the germplasm collection of the Department, analysis of reasons for low seed recovery in a promising vegetable type, studies on the photoperiodic response of the eight different species and studies on the content of antinutrient factors.

The eight species included in the present study are *A. tricolor*, *A. lividus*, *A. viridis*, *A. spinosus*, *A. dubius*, *A. hypochondriacus*, *A. cruentus* and *A. caudatus*, the former three belonging to the

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section Blitopsis and the latter five to section Amaranthus. Microscopic examination of the floral characters resulted in identifying a deviation in the pattern of development of flower cluster in *Amaranthus*. The floral development was found to be in a dichasial or polychasial scorpioid cymose pattern and not in a typical cymose pattern reported earlier. A simple provisional identification key for the eight species was developed using gross morphological features. Because of similarity in the nature of inflorescences, *A. spinosus* and *A. viridis* belonging to two different sections were brought together, and *A. dubius* a vegetable type was grouped along with grain amaranthus.

Meiosis in all the eight species were normal with regular formation of bivalents. Of the eight species, seven were diploids with n = 16 or 17 and one species *A. dubius* was a polyploid with n = 32. A preponderance of ring bivalents over rods was observed in all the species except the semiwild species *A. spinosus*. All the 3
species under section Blitopsis had n = 17 and maximum number of chiasmata was observed in *A. tricolor* the widely cultivated vegetable type. This species also had the largest chromosome in the complement. Under section Amaranthus, the polyploid species, *A. dubius* behaved as an allopolyploid with 32 bivalents. The lowest chiasma frequency/bivalent and per PMC and the highest number of rod bivalents was observed in the semiwild type A. spinosus, all indicating its primitive wild nature. Pollen fertility in all species was fairly high ranging from 83.4% in *A. viridis* to 93.8% in *A. lividus*. In all species pollen grains were not of the uniform size and included both macro (24 μm) and medium sized (12-24 μm) pollen grains. The percentage of each type of pollen differed in different species. Mean diameter of the pollen grains was the highest in *A. tricolor* among all species (31.4 μm).

In many of the unsuccessful interspecific crosses mortality of the hybrid seedlings were observed by the dissolution of the terminal buds. Seven interspecific hybrids were obtained which exhibited normal growth and flowering. These include hybrids within section Blitopsis, within section Amaranthus and also between sections Blitopsis and Amaranthus. These seven hybrids were subjected to detailed morphological and cytological studies.

The interspecific hybrid in the section Blitopsis *A. lividus* x *A. tricolor* resembled the male parent in most of the morphological features. Eventhough the hybrid was vigorous, it exhibited developmental abnormalities like shrivelling of the anthers and fasciation of the inflorescence. Cytological studies revealed the presence of two or more interchanges including 3 - 6 chromosomes and moderate frequency of bivalents at metaphase I. Subsequent meiotic irregularities led only to about 10% stainable pollen and seed sterility was also noticed. The multivalent associations, bridges and fragments in this hybrid indicated that interchanges and inversions are involved in the evolution and speciation within section Blitopsis. The moderate frequency of bivalents suggests homology of these chromosomes.

The interspecific hybrids obtained in the section Amaranthus include *A. spinosus* x *A. dubius*, *A. spinosus* x *A. hypochondriacus*, *A. spinosus* x *A. cruentus*, *A. spinosus* x *A. caudatus* and *A. cruentus* x *A. caudatus*. The arrested growth, peculiar twining of the stem and inflorescence axis and the stunted leaves in *A. cruentus* x *A. caudatus* simulated viral infection. This situation reflected a highly disharmonious interaction of parental genomes as combined in the hybrid nucleus. Generally in all other hybrids, there was an overall dominance of the female parent *A. spinosus*, characterised by the presence of spines, reduced leaf size, presence of slender terminal and few axillary clusters of flowers and distinct placement of male and female flowers. However the distinct arrangement of male and female flowers was not observed in *A. spinosus* x *A. dubius*. An overall reduction of male flowers was noticed in most of the hybrids. Normal anthesis of male flowers was observed only in *A. spinosus* x *A. dubius* and *A. spinosus* x *A. caudatus* while the male flowers failed to open in the other two hybrids *A. spinosus* x *A. hypochondriacus* and *A. spinosus* x *A. cruentus*. The presence of axillary clusters of flowers in the hybrid *A. spinosus* x *A. hypochondriacus* simulated the placement of axillary flowers in the *A. tricolor* species. Hence the plausible evolution of section Blitopsis from section Amaranthus by interspecific bybridization is suggested. The dominance of most of the *A. spinosis* characters in the hybrids indicated primitiveness of *A. spinosus* over other grain species.

Cytological studies in the hybrids of the section Amaranthus revealed that metaphase I was characterised by a high frequency of bivalents, one or two multivalents involving 3-4 chromosome and the rest univalents. The univalents failed to orient at metaphase plate, lagged at anaphase I and led to the formation of micronuclei at the end of the division. PMCs also showed abnormalities in the second meiotic division in the form of asynchronous orientation and disjunction at metaphase II and anaphase II respectively. These abnormalities often led to more nuclei than normal at telophase II and subsequently resulted in very high pollen sterility and micro-pollen. Meiotic abnormalities indicated that chromosome repatterning through inversions and translocations were involved in the evolution of the species within section Amaranthus.

The hybrid A. spinosus x A. viridis was the first success of hybridization between the two sections Amaranthus and Blitopsis. This hybrid was short and sturdy and inherited more of A. spinosus characters as in other hybrids including pentamerous symmetry of flowers. Cytological studies revealed that PMCs at metaphase I had an average of 14.35 bivalents and 5.25 univalents. Eventhough 38% pollen stainability was observed, the pollengrains were of medium size and the anthers failed to dehisce. The complete absence of multivalents, and the presence of only bivalents and univalents in the hybrid indicated the absence of structural changes in the cytogenetic differentiation of these two species, only cryptic structural differences between 2-3 pairs of chromosome differentiated these two species.

D^2 analysis based on chromosomal association at metaphase I in 6 hybrids grouped them into three clusters. The unidentified g genome in A. dubius complement may be responsible for the separate clustering of A. spinosus x A. dubius. A.hypochondriacus may be genetically distant from others. The clustering of hybrid A. lividus x A. tricolor along with hybrids of section Amaranthus questions the validity of the naturalness of the two sections under the genus Amaranthus.

Out of forty accessions available, 21 accessions were ascribed to A. tricolor 1 to A. dubius and 15 to A. hypochondriacus. Cytological studies revealed the formation of regular bivalents in all the forty accessions with 17, 32 and 16 pairs of chromosomes in the species *A. tricolor*, *A. dubius* and *A. hypochondriacus* respectively. All the accessions exhibited a reasonably high pollen fertility (>77%) and both macro and medium type pollen grains were noticed in each. Plant to plant variation was comparatively less in the species *A. dubius* and *A. hypochondriacus* while *A. tricolor* exhibited much variation in morphological features. The analysis of reasons for low seed recovery in the *A. tricolor* accession. A_6 revealed that the low seed recovery was due to long flowering span which leads to shattering of the earlier formed seeds, profuse vegetative growth which is negatively correlated with seed yield, the lower number of glomerules/leaf axil, the lower percentage of female flowers developing into mature utriculi and the apparently lower pollen fertility and seed size.

Investigation on photoperiodic response of eight species revealed that there is reduction in days to flower with increase in photoperiod in *A. lividus*, *A. hypochondriacus*, *A. spinosus* and *A. dubius*. A decreasing photoperiod induced precocity in *A. tricolor* and *A. caudatus*. In the species *A. viridis* and *A. cruentus* no definite relationship between flowering and photoperiodic treatments was observed.

The percentage of oxalate in the different species varied from 3.60 to 5.10% and that of nitrates from 0.295 to 0.695% on dry weight basis. Members of the section Amaranthus in general are characterised by lower content of oxalate and nitrate than section Blitopsis but *A. spinosus* the wild type was an exception having the highest content of both these factors. The three cultivated grain types did not show much variation in the content of these antinutrient factors.

The primitiveness of *A. spinosus* was evident from the cytomorphological and chemical studies on the species as well as its hybrids Cytological behaviour as well as pollen and seed fertility of the hybrids indicated that *A. spinosus* is closely related to *A. caudatus* and *A. viridis*. *A. spinosus* also contributed predominantly to one of the genomes of *A. dubius*. Hence the cosmopolitan weed *A. spinosus* has played a major role in the evolution of Amaranthus spp. Suppression of huge terminal inflorescences in all crosses of A. spinosus with grain types and production of dense axillary flower clusters in A. spinosus x A. hypochondriacus resembling A. tricolor of section Blitopsis were observed. Based on these results and the historical data on domestication and spread of Amaranthus species, the plausible evolution of section Blitopsis from section Amaranthus and also the evolutiin of vegetable amaranthus from grain types are hypothesised.