GUIDE ON

TROPICAL VEGETABLE SEED PRODUCTION

Compiled and Edited by

Dr. MINI, C
Dr. KRISHNAKUMARY, K.

KERALA AGRICULTURAL UNIVERSITY
KAU (P.O.) - 680 656, THRISSUR

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FOREWORD

Availability of good quality seed is a major concern of farmers, world over. Improved seed is a catalyst for making other inputs cost-effective. Seed production techniques for each crop varieties and hybrids need to be developed and disseminated as soon as they are released. Popularization of these techniques necessitates extension activities including the availability of adequate publications.

This book provides technical information to produce quality vegetable seeds and also to store them properly up to next sowing season. To make this book practical and more useful, detailed cultural hints are given on seed production practices of different tropical vegetables. Nutritional and weed management, control of pests and diseases, including storage pests, seed invigoration treatments etc. are being fully dealt with. Floral biology and pollination of important tropical vegetables are included in this book along with hybrid seed production techniques. The colour photographs have been provided to make the subject explicit and illustrative. This compilation would prove to be a useful and comprehensive reference guide for all those who are involved in tropical vegetable seed production programme.

This compilation is brought out under the project on "Commercial production of hybrid vegetable seeds" awarded to Dr. Mini, C , Assistant Professor, from National Horticulture Board, Gurgaon, Haryana.

I take this opportunity to congratulate Dr. Mini, C, Assistant Professor (Hort.), Cashew Research Station, Madakkathara and Dr. K. Krishnakumary, Assistant Professor (Hort.), Department of Olericulture, College of Horticulture, Vellanikkara for their efforts in bringing out this publication.

I am sure this work is comprehensive enough to attract the attention of a wide variety of readership including teachers, students, extension personnel and professional seed producers of the State.

Vellanikkara
26-3-05

Prof. K. V. Peter
Vice Chancellor

PREFACE

Seed has been regarded as the most vital, basic and critical input in agriculture for increasing and sustaining agricultural production. Use of quality seed is of utmost importance in order to realize the maximum utilization of other inputs viz., fertilizers, irrigation, pesticides and other improved agronomic practices. To keep pace with the availability of quality seeds of high yielding varieties and hybrids, considerable progress has been made in the technologies of seed production, processing, quality control, seed treatment, storage etc.

An attempt has been made to give a simple account of seed production techniques of different tropical vegetables. Different management practices like nutrient management, weed control, pest and disease control measures followed in seed production are discussed in detail. Floral biology, pollination and hybrid seed production techniques of important tropical vegetables are included.

Seed storage is a major problem in warm humid tropics of Kerala. Different seed problems and the possible control measures are covered along with management of stored pests. This book also contains chapters dealing with economics of vegetable seed production and some indigenous practices followed by vegetable seed growers of the State.

We are thankful to Dr. Jose Mathew, Associate Professor & Head, Cashew Research Station, Madakkathara for providing the necessary support, without whose help, this work would not have been materialized. We take this opportunity to express our sincere gratitude to Dr. T.E. George, Associate Professor, who has permitted us to take photographs from the vegetable seed production unit of the Department of Olericulture.

We record our sincere thanks to Smt. Radha and Ms. Ajitha for the help in DTP works, Mr. Vijayanarayanan and Mr. Ajayan for the help rendered in photographic works, all the staff members of Department of Olericulture for the help given during various stages and for providing photographs, all the teachers who have contributed in this book and Kerala Agricultural University for publishing this book.

We are grateful to Prof. K.V. Peter, Vice-Chancellor for writing a foreword to this book.

The financial assistance provided by the National Horticulture Board is gratefully acknowledged.

Vellanikkara

26-3-05

Mini, C and Krishnakumary, K

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PROBLEMS AND PROSPECTS OF VEGETABLE SEED PRODUCTION IN KERALA

Gopalakrishnan, T R

Diverse climatic conditions prevailing in different parts of Kerala result in the cultivation of a variety of vegetable crops differing in temperature requirement, cultivation practices, parts used etc. Absence of a distinct winter climate, as in other states, provides ideal situation for growing summer season crops throughout the year. Cool season vegetables are also grown in districts of Idukki, Wayanad and high altitude panchayaths of Palakkad. Cultivation of bitter gourd, snake gourd, bottle gourd, cucumber, ash gourd, ivy gourd, pumpkin, ridge gourd, cowpea, okra, amaranth, chilli, brinjal, coleus, colocasia, amorphophallus, potato, garlic, cabbage, carrot etc. is mainly market oriented. Minor vegetables like sword bean, dolichos bean, chekkurmanis, bird pepper, drumstick, winged bean, curry leaf, clove bean etc. are grown in the home gardens, mainly for family use. Cultivation of vegetables for marketing is confined to rice fallows during summer season and hill slopes and garden lands during rainy season. Riverbed cultivation in the beds of Bharathapuzha river and basins of Pamba and Manimala rivers during December- April also supports the vegetable production in the State.

The varieties grown and their cultivation practices, whether intensive or extensive, vary with a number of factors like availability of land and labour, type of soil, consumer and market preference in each locality etc. The crops and varieties, cultivation practices, problems encountered, consumer preferences etc. of vegetables in Kerala are different from rest of the states in the country. High rainfall, warm humid climate with high relative humidity, increased cost of production resulting from high wage rate, scarcity of suitable land for cultivation etc. make the vegetable culture very distinct in the state.

Performance of varieties is found to vary from season to season, soil to soil and from location to location depending on the micro climate prevailed in the locality. So selection of varieties suited to specific agro climatic zone/soil/location is very important for successful cropping.

Vegetable Seed Production in Kerala - Present scenario

Being seasonal crops, correct statistics on area, production and productivity of vegetables in the state are not available and the figures are found to vary from source to source of the information. As per the Farm guide, 2004 the area under vegetables including tuber crops and tapioca is 1.89 lakh ha. Area under seasonal vegetables including chilli is 28,309 hectares for which the average seed requirement is 142 tonnes. Considering a per capita requirement of 125 grams per day the annual requirement of vegetables in the state is 14.5 lakh mt and its major share is met from the neighbouring states like Tamil Nadu, Karnataka etc.

A survey conducted in the central and southern parts of Kerala by the R&D Unit of KHDP in the Kerala Agricultural University (KAU) revealed that lions share of vegetable seeds used for cultivation are from home saved seeds of farmers. Inability of the Govt. Organizations or Public Undertakings to supply the required quantity of seeds of improved varieties, that too, at the right time is mainly responsible for the low spread of improved varieties.

Unlike in other states, a Seed Certification Directorate is not established in Kerala and certification of vegetable seeds is not yet started in the state. This restricts the seed supplying agencies from the distribution of either foundation seed or certified seeds. Instead, distribution of truthfully labeled seeds (TLS) is in vogue in the state.

KAU has so far developed 44 improved vegetable varieties in different annual vegetable crops and it has the mandate to produce and supply nucleus and breeder seeds of the above varieties to the Development agencies. Development agencies should produce foundation seeds for the multiplication of certified seeds. In addition to nucleus seed and breeder seed, KAU is also multiplying and supplying truthfully labeled seeds to the farmers through its regional stations located in different parts of the state. By utilising breeder seeds from KAU, Vegetable and Fruit Promotion Council of Keralam, Kochi (Formerly known as KHDP), District farms and Regional farms of the State Department of Agriculture, National Seed Corporation etc. are also multiplying and distribute truthfully labeled seeds to the public. Private seed companies like Maharashtra Hybrid Seed Company (Mahyco), Indo American Hybrid Seed Company etc. also distribute vegetable seeds to a limited extent. Private seed companies are also playing a key role in the supply of seeds of cool season vegetables for the Idukki district. Unauthorized seeds sold mainly on the road sides and exhibitions also cater the need of the public in Kerala.

Future prospects and action plan for vegetable seed production

Stakeholders

Due to the shrinking resources, the Govt. Organizations like Kerala Agricultural University, State Department of Agriculture and VFPCK are unable to fulfill the entire seed requirement of the state. A model followed by VFPCK will be a viable proposition. Utilizing the breeder seeds from KAU, VFPCK is multiplying seeds of selected vegetable varieties in the fields of registered growers. The seeds so produced will be taken back by VFPCK and will be distributing to the public as TLS. The National Seeds Corporation is also following the same procedure for multiplication of seeds in bulk. In order to tackle the problems associated with the seed production, an efficient research support is highly essential.

In the absence of a Seed corporation in the state, the Kerala State Seed Authority may be entrusted with the multiplication and distribution of vegetable seeds. At present the Authority is confined to paddy seeds only.

Taking advantage of high literacy and favourable atmosphere for cooperative ventures in the state, Self help groups (SHG) should be promoted to take vegetable seed production especially for certified seeds of cultivars having local acceptance. Seeds of locally acceptable cultivars may be included in the research programmes of KAU, and may be refined, if warranted, before taking up large scale multiplication by SHGs. The local cultivars should be registered in order to protect claim of the farmers.

Ideal locations

Vegetable production in the state is confined to selected villages due to availability of congenial soil and climatic conditions. Vegetable seed production programmes also should be limited to selected districts and tracts. Availability of extensive area for growing the varieties in isolation, cheap labour for field operations, hot and dry climate suitable for seed drying and processing, low relative humidity etc. makes Chittoor taluk of Palakkad district ideal place for vegetable seed production. Certified seed production can also be undertaken through the registered seed growers in selected villages in all districts.

Due to unique consumer acceptance and climatic conditions, the varieties found popular in other states of the country are not preferred in Kerala. This indicates scope for production of high yielding but locally acceptable varieties for Kerala. Varieties developed by Kerala Agricultural University are best suited in this regard. However depending on the preference for colour, shape, size etc. of vegetables and also depending on the suitability to specific agro climatic conditions, the varieties should be selected (Table 1&2).

Hybrid seeds

Through out the country, F_1 hybrid seeds are in great demand especially in crops like tomato, cabbage, capsicum, brinjal, water melon etc. KAU has developed one bacterial wilt resistant and high yielding brinjal hybrid, Neelima. Large scale seed production of Neelima is also not satisfactory at present. Selected farmer groups like SHGs can take up the seed production programme, after attaining sufficient experience through training programmes on hybrid seed production. Nearly 40% of the total cost of hybrid seed production is incurred on labour employed for emasculation and pollination. Use of male sterile lines, gynoecious lines and growth regulators facilitate hybrid seed production by cutting cost of hand emasculation. Efforts are, therefore, needed to isolate/develop male-sterile/gynoecious lines in important vegetable crops for hybrid seed production.

Maintenance of genetic purity

Maintenance of genetic purity should be given utmost priority during seed production and it can be achieved by:

a). Use of approved seed, that too from an authorized source, for seed multiplication. In case of highly cross pollinated crops it is advisable to use breeder or foundation seed for certified seed production. Fresh breeder seed may be used every time for foundation seed production. Spatial and temporal isolation may be insisted to maintain purity. Only a few varieties may be allotted to a farm or station to avoid crossing/mixing. Depending on the demand/programme, targets are to be fixed every year during January-February (to produce seeds from April to March). It is advisable to provide indent atleast one year in advance.

b). Inspection and approval of fields prior to planting. Care should be taken to avoid disease prone areas and seasons for specific crops.

c). Field inspection and roguing at critical stages for verification of genetic purity.

d). Sampling and sealing of cleaned lots.

e). Growing of samples of potentially approved stocks for comparison with authentic stocks.

Inspection and reporting should be done by certification agency or other than the multiplication agency.

Vegetative propagated crops

Seed production of tuber crops can be undertaken in the farms, for which breeder/ tubers/clonal materials of the promising and released varieties are to be obtained from the CTCRI, Sreekaryam. Multiplication process in vegetatively propagated vegetables like drum stick, amorphophallus, coleus, colocasia etc. are very slow. Tissue culture technique can be followed in mass multiplication of improved varieties especially in the newly released ones. Attempts should be intensified to standardize protocol for mass multiplication of individual vegetative propagated vegetable crops.

Storage and distribution of seeds

Seeds produced are to be pooled, and to be brought to the Pooling centers of each district for grading, processing and seed treatment. At present Seed Processing Plant of VFPCK at Alathur is equipped with imported machines capable of processing large quantity of seeds. In other places machines suited to our conditions and with less capacity will be advisable. The processed seeds have to be stored at selected Regional Centres and will be distributed to the farmers through Sales counters of the Agriculture Department or Krishi Bhavans. The hot humid tropical climate of Kerala is not congenial for seed storage. Seed viability and vigour deteriorate at a faster rate in this climate. Cold storage facilities at 4.8°C are to be provided in the Regional Centres for this purpose.

HRD training programmes

Short term trainings on varietal characteristics, seed production seed processing, seed treatment, quality control etc. should be given to all officials involved in seed production. Trainings are also to be imparted to farmers and labourers of farms of State Department of Agriculture and KAU since their involvement is equally important for the success of seed production programmes. They should be given training before starting the production programme.

Intensification of seed research

Chance for loosing the viability and longevity of seeds is more and rapid at high temperature conditions. High relative humidity prevailing in Kerala aggravates the situation by offering favourable condition for stored pest and diseases. Information on seed viability, storage, invigoration etc. of tropical vegetables are very much limited. Hence research on seed processing, storage and quality should be intensified to cater the demand of seed industry. Specific packaging technologies are to be standardized.

Inspite of shrinking resources, large scale seed production programmes, as a commercial enterprise, should be taken up in the University farms and Department farms. This will, not only increase the farm revenue but also, expose the scientists and Development officers to the actual field problems during the cropping. Agriculture as a profession, in the future, can sustain only by doing, not by preaching.

Table 1. High yielding vegetable varieties of KAU

Crop	*Variety*
Chilli	Jwalamukhi, Jwalasakhi
Ash gourd	KAU Local, Indu
Bitter gourd	Priya, Preethi, Priyanka
Oriental pickling melon	Saubhagya, Mudicode, Arunima
Pumpkin	Ambili, Suvarna, Saras,
Ridge gourd	Haritham, Deepthi
Snake gourd	Kaumudi, Baby
Coccinia	Sulabha
Yard long bean	Malika, Sharika, Vyjayanthi, Lola, KMV 1
Bush Cowpea	Bhagyalakshmi
Semi trailing Cowpea	Kanakamani, Anaswara
Winged bean	Revathy
Amaranth	Arun, Mohini
Okra	Kiran, Salkeerthi, Aruna

Table 2. Disease resistant vegetable varieties from KAU

Crop	*Variety*	*Special attributes*
Brinjal	Surya, Swetha, Haritha, F_1 Neelima	Resistance to bacterial wilt
Chilli	Ujwala, Anugraha	Resistance to bacterial wilt
Tomato	Sakthi, Mukthi, Anagha	Resistance to bacterial wilt
Cowpea	Kairali, Varun	Resistance to mosaic
Okra	Susthira	Tolerant to mosaic

PROGRAMME PLANNING AND POLICY IMPLEMENTATION IN SEED PRODUCTION

Rajan, S

Seed is a critical input and plays a vital role in agriculture production. A good quality seed along with other input and improved agronomic practices can improve the production and productivity. High quality seed is as important as an improved variety and quality seed must accompany cultivar improvement.

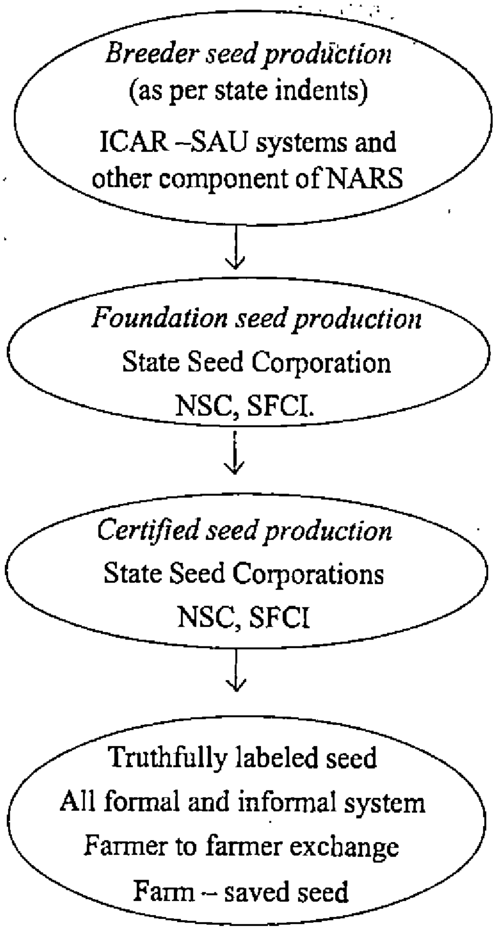
The growth of food grain production and that of seed production happened simultaneously which clearly establishes the linkage between the two and the dependence of agriculture production on seed production and its distribution. It is true that food grain production increased from 50 million tonnes in 1950-51 to 200 million tonnes during 2001 – 02 and availability of quality seeds to farmers which was only 1.83 lakh quintal during 1953-54 increased to 114 lakh quintal during 2001 – 02 in the country.

More than 40,000 quintals of breeder seed of different crops are produced annually in our country. The breeders seed is sequentially multiplied to result in foundation and certified seeds.

Seed generation system

In India we follow three generation systems viz. breeder seed, foundation seed and certified seed. After the release of a variety, its seed has to be multiplied in sufficient quantity, which takes three to four generation, before it can be made available to the farmers for commercial use. During these multiplication cycles, required care has to be taken so that the variety does not degenerate. The production of breeder seed is the mandate of ICAR and SAUs while the production of foundation and certified seed is the mandate of the seed industry. In the recent past the production of breeder seed has been liberalized to be taken up through sponsored breeder seed programme by the State Seeds Corporation and NGOs, monitored by specialized breeders.

The sequential seed generation system is depicted below.



The ICAR – SAU system makes available breeder seed of all notified varieties as per indents, received from the states and other organizations through the Dept. of Agriculture and Co-operation (DAC), Govt. of India.

Seed supply systems in India

The seed supply systems in India can be classified into formal and informal. The formal sector consists of public sector organization and private companies. The formal supply system corresponds to organized seed sector in the country where seed production is undertaken by national government agencies, state government agencies, government assisted and other co-operatives, multi national (MNCs) or transnational companies (TNCs), domestic private sector companies etc. The public sector produces bulk of self pollinated crops of which wheat and rice accounts for 60 percent. The private sector on the other hand deals mostly in hybrid vegetables and flowers accounting about 50 percentage of total quality seed in India, which is said to be low volume high value seeds.

The informal seed supply systems are traditional, informal, operating mainly under community level through exchange mechanism and involving limited quantities per transaction. This system lacks functional specialisation. The informal system includes farm saved seed and farmer-to-farmer exchange, farmer's co-operatives, community groups, seed growers' associations, non-governmental organization etc.

The Indian seed industry and its development

The Indian seed industry at present consists of two national organization (NSC and SFCI), 13 State Seeds Corporations, 19 State Seed Certification Agencies, 63 notified seed testing laboratories and about 200 large private seed companies. Several private seed companies are multinational and have their own R&D.

National seed project

The National seed project was started in 1979-80 as an all India Co-ordinated Project with 14 centres on seed technology research along with an equal number of breeder seed production units at various SAUs / ICAR institutes.

A separate NSP on vegetables was established in 1994. Indian Institute of Vegetable Research, Varanasi has been co-ordinating the NSP & BSP of such 14 units dealing with vegetables (excluding potato)

A seed section is functioning in ICAR with ADG (seeds) level post.

NSP Mandate.

- To conduct, coordinate and monitor research on different aspects of Seed Science and Technology.
- To produce adequate quantity of nucleus and breeder seeds of high quality as per the national requirements.
- To generate basic information on seed certification standards including seed health.
- To disseminate information and impart training on seed production, processing, storage and packaging, quality control and seed health.
- To make linkage with crop improvement projects, seed industry, seed certification agencies, seed trade, NGO's/KVK/KGK etc.
- To establish national and international linkages for strengthening seed research.
- To augment seed research/seed programme to make it relevant to the needs of farming community specially of marginal and small farmers.

The project has progressed very well during the last two decades creating required infrastructure, man power and scientific aspects. The project has now 35 centers for production of breeder seed and 22 centers for seed technology research in the country at various State Agricultural Universities and ICAR institutions.

Seed legislation

Seeds Act 1966:- To ensure the quality of seed put on the market, Government of India, desired to arm itself and state governments with statutory powers. In the year 1966, the Indian Parliament passed the seed legislation viz., Seeds Act 1966.

The essential features of this enactment are :-

1. Constitution of various committees to advise the Govt. of India and State Govts, to carryout the purposes of the Act-(Section-3).
2. Establishment of seed testing laboratories both at central and state level (Section-4).
3. Notification of kinds or varieties of seeds (Section-5).
4. Specifying minimum limits of purity and germination (Section-6)
5. Regulation of sale of seeds of notified kinds/varieties (Section-7)
6. Establishing of seed certification agencies and certification procedures (Sections 8 & 9)
7. Establishing law enforcing agencies and procedures (Sections 12, 13, 14, 15)
8. Imposition of penalty for contravention of Act (Section-19)
9. Forfeiture of property (Section-20)
10. Offences by companies (Section-21).

Seeds Rules 1968.

For giving effect to the provisions of Seeds Act 1966, Seeds Rules 1968 were framed and issued by Govt. of India. The Seeds Act 1966 and Seeds Rules 1968 were enforced with effect from October 1969. The most important rules, which invite the attention of personnel in seed marketing, are indicated below:-

Rule-7	Marking or labelling
Rule-8	Contents of mark or label.
Rule-9	Manner of marking or labelling the container under Clause-(c) of Section-7 Clause (b) of Section -17.
Rule-10	Mark or label not to contain false or misleading statement.
Rule-11	Mark or label not to contain reference to the Act or Rules contradictory to required particulars.
Rule-12	Denial of responsibility for mark or label, content prohibited.
Rule-23	Action to be taken by the Seed Inspector if a complaint is lodged with him.

Seeds Control Order 1983.

The Seeds Act 1966 was mainly aimed at specifying and regulating the quality of the seeds of the notified kinds and other related activities. But due to entering of Private Seed Industry in the fields of Research and Development many private bred hybrid varieties of various crops have been evolved and released for crop production. This necessitated the Government of India to declare seeds as an essential commodity to bring all the crop seeds, whether notified or not and regulation by issuing the Seeds (Control) Order 1983.

1. Obtaining of Seed Licence to deal in the seeds byway of purchase/sales import and export of seeds and notifying the authorities for grant of licence (Clause-3).
2. Making available the seeds wherever they are required (Clause-10)
3. Notifying the Law enforcing/Regulating authorities (Clause-11 and 12)
4. Making compulsory issue of bills, display of stock and price list, maintenance of records and submission of returns to notified authority (Clause-8, 9 & 18).

Necessary forms have been prescribed for various purposes namely,

(1) Application to obtain Dealers Licence – Form-A.

(2) Licence to carry on the business of a Dealer in seeds – Form-B.

(3) Application for renewal of Licence to carry on the business of a Dealer in seeds – Form-C.

(4) Submission of Monthly Return – Form-D.

Thus it could be observed that the Government acquired all the powers to ensure the quality of seed placed in the market and regulate the trade.

New (Liberalised) Policy on Seed Development 1988

To encourage further development of seeds, a new liberalised seed policy was issued by Govt. of India in 1988 with the objective of providing the best planting materials to the farmers and encouraging seed production on commercial lines, incentives, domestic seed industry, import, and export of seeds and on quarantine.

Taking advantage of the New Seed Liberalised Policy-1988 the Private Seed Industry has taken several initiatives to make the quality seed available throughout the nook and corners of the country in addition to the efforts of the Public sector. Presently the volume of business turn-over is approximately Rs. 4000 crores.

The Protection of Plant Varieties and Farmers Rights' Act 2001.

India having ratified the agreement on trade related aspects of Intellectual Property Rights should *inter-alia*, make provisions for giving effect to sub-paragraph- (b) of paragraph (3) of article 27 in Part-II of the said Agreement relating to Protection of Plant Varieties and to provide for the establishment of an effective system for protection of Plant Varieties, the Rights of Farmers and Plant Breeders and to encourage the development of new varieties. The Government of India, has formulated the legislation based on UPOV 1978 namely, "The Protection of Plant Varieties and Farmers' Rights Act, 2001". This act provides for the establishment of an effective system for protection of plant varieties, the rights of the farmers and plant breeders and to encourage the development of New Plant Varieties for accelerated agricultural development in the country.

The main features of the Act are:-

Definition: Some of the definitions of important words and expression are:

I. " Breeder "

No academic qualifications are prescribed for a Breeder.

A Breeder means:-

a) A person or group of persons.

b) Any Institution

c) A farmer or a group of farmers who have bred, evolved or developed any variety.

II. "Extant Variety".- means a variety available in India which is

a) Notified under Section-5 of Seeds Act 1966.

b) A farmers variety, or

c) A variety about which there is common knowledge, or

d) Any other variety which is in public domain.

III. Essentially derived variety

a) is predominantly derived from such initial variety, or from a variety that itself is predominantly derived from such initial variety, while retaining the expression of the essential characteristics that result from the genotype or / combination of genotypes of such initial variety.

b) is clearly distinguishable from such initial variety.

c) conforms (except for the differences which result from the act of derivation) to such initial variety in the expression of the essential characteristics that result from the genotype or combination of genotypes of such initial variety.

IV. Farmer's Variety means:-

a) A variety which has been traditionally cultivated by the Farmer in their fields or

b) Is a wild relative or land race of a variety about which the farmers possess the common knowledge.

V. "Seed" mean a type of living embryo or propagule capable of regeneration and giving rise to plant, which is true to type.

VI. "Variety" means a Plant grouping except microorganism within a single botanical taxa of the lowest known rank

a) Which can be defined by the expression of the characteristics resulting from a given genotype of that plant grouping.

b) Distinguished from any other plant grouping by expression of atleast one of the said characteristics.

c) Considered as a unit with regard to its suitability for being propagated which remains unchanged after such propagation and includes propagating material of such variety, extant variety, transgenic variety, farmers' variety and essentially derived variety:

VII. "Registrar" means a Registrar of Plant Varieties appointed under Sub-Section-(4) of section 12 and includes the Registrar General.

New seeds policy 2002

The new Seeds policy Review Group formed in 1997 under the Chairmanship of Padmasri.Dr.M.V. Rao, recommended comprehensive and far reaching suggestion to be introduced in the seed sector of the country. Based on the recommendations the Government of India has proposed the New Seeds Bill 2004 which will replace the Seed Act 1966 and the Seed Control Order 1983 on its enactment by the Parliament. The new seed bill envisage for regulating seed business and registration of a kind or varieties of seeds, their production, processing, quality control and law enforcement.

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PRINCIPLES OF QUALITY SEED PRODUCTION

Mini, C

Seed is the cheapest but most vital input, which contributes to 30 per cent of total production potential of any crop. Production of high quality seed is of paramount importance in development of horticultural industry both in national and international perspective.

Qualities of good seed

1. Trueness to variety
2. Damage free
3. Germinating ability
4. Free from physical mixture
5. Free from seed borne diseases and pests
6. Vigour
7. Moisture content within safe limits

It is not possible to achieve 100 per cent of these attributes. Therefore, in seed production, minimum levels are fixed for these important attributes.

1. Genetic purity

This factor is given prime importance in any seed production programme. Based on purity level, seeds are of different classes.

a) Breeder seed

Breeder seed is the seed or vegetative propagating material directly produced or personally supervised by the plant breeder or the institution, which gives out a particular variety. Hundred per cent genetic purity is essential for this seed. .

b) Foundation seed

Foundation seed shall be the progeny of breeder seed or be produced from foundation seed which can be clearly traced to the breeder seed. Production shall be supervised and approved by the certification agency and so handled to maintain specific genetic identity and purity and shall be required to conform to certification standards specified for the crop being certified.

c) Certified seed

Certified seed shall be the progeny of foundation seed and the production shall be so handled as to maintain specific identity and purity according to standards specific for the crop. Certified seed shall be the progeny of certified seed, provided this reproduction shall not exceed two generation beyond foundation seed and provided further that it is determined by the certification agency that the genetic purity will not be significantly altered.

Seed production is rather a specialized field of vegetable growing, where adequate knowledge of the crop growth habit, mode of pollination etc. are necessary. Floral biology and pollination of important tropical vegetables are dealt in separate chapter.

1. Location and season of seed production

Selection of site is done on the basis of suitable ecological niche which favour production of high quality seed with the risk of crop failure. Soil, climate and disease free conditions are factors influencing location of seed production areas. As vegetable hybrids have high potential, well drained and fertile soils having medium texture with optimum pH are considered to be the best.

A field, where the same crop was not grown in the previous season, is to be selected for seed production. It should be free from volunteer plants, which arise from accidentally sown seed or from seed produced by earlier crops. Fields for producing seeds of a particular variety should not have grown with a potentially contaminating variety for a number of preceding years.

Occurrence of rains and prevalence of high humidity during seed maturation cause substantial reduction in seed quality due to mould development, discolouration and sprouting of seed, thus lowering their viability and storability. Therefore, wherever possible, seed sowing should be so planned that rains do not occur during seed maturity stage.

2. Use of approved seed only

Breeder/Foundation seed should be collected from a source approved by the seed certification agency.

3. Isolation distances

The genetic purity of a seed crop can be viallated due to pollination by foreign pollen. Spatial isolation of seed production fields is useful in preventing contamination.

Isolation is done,

a) To prevent crossing with a different but related variety.

b) To prevent crossing with a related species with which the variety is crossable.

c) To prevent mechanical mixing during harvest.

Isolation is a primary factor in the seed production of plants, cross pollinated by wind or insects. The required distance specified by seed regulating agencies varies with the class of seeds produced. Greater distance should be given for seeds in which a high degree of genetic purity is desired.

The minimum distance between varieties depends upon a number of factors, such as

1. the degree of natural cross pollination
2. the pollination agency
3. the direction of prevailing winds and
4. the number of insects present

In general, greater the isolation distance, lesser the possibility of contamination. But it is difficult to get complete isolation for seed production plots of a given variety. Therefore, the need is that seed production plots should be at a specified distance from fields of other varieties, where an acceptable level of contamination is expected.

The isolation distances, as prescribed in the Indian Minimum Seed Certification Standards (IMSCS), have been fixed on the basis of the standards followed in western countries, mode of pollen dispersal, pollination biology and mode of reproduction of a given crop species, rather than on actual studies on isolation.

4. Roguing

The high quality requirements necessitate monitoring at different stages of production. Inspection and roguing of seed crop of parental lines and hybrid at critical stages, based on stable diagnostic morphological characters, are to be routinely done to maintain genetic purity of parental lines and to produce hybrid seed of high genetic purity.

Roguing is the removal of off type plants of other varieties, weeds and plants affected by certain diseases (designated diseases) from the seed production plot. Rouging is done minimum thrice at vegetative phase, flowering phase and fruiting stage. A thorough knowledge on the morphological and floral characters of a variety is a must for effective roguing.

Usually three field inspections are done by the certifying agency, first at pre-flowering stage, second at flowering stage and last at harvesting stage.

5. Minimum standards

In the field, certain minimum standards are fixed for each crop, which is envisaged in the seed production. There are field as well as seed standards, different for different classes of seeds.

1. Field standards :

1. Land requirement
2. Minimum isolation
3. Minimum crop standards
   a) Off types
   b) Inseparable other crop plants
   c) Objectionable weed plants
   d) Plants affected by designated diseases

2. Seed standards

a) Pure seed (minimum %)
b) Inert matter (max.%)
c) Other crop seeds (max.%)
d) Total weed seeds (max. %)
e) Objectionable weed seeds (max. %)
f) Germination % (minimum)
g) Moisture %

1. Ordinary container
2. Water proof container

A satisfactory germination percentage of seeds and good crop stand are essential for successful cultivation of any crop. Germination of seeds is a complex phenomenon influenced by various internal (biological) and external (environmental) factors.

6. Seed harvest and processing

The stage of harvest and technique of processing have a bearing on seed quality. Seeds should be harvested at their physiological maturity, when maximum dry weight is attained.

Seeds of different varieties must be kept separate during harvest. Careful cleaning of the harvesting equipment when a change is made from one variety to another is required. Like wise, sacks and other container used must be carefully cleaned to remove any seed which may have remained from previous lots.

The details of harvesting, processing and storage are dealt in separate chapters.

SEED PRODUCTION IN SOLANACEOUS VEGETABLES

Sadhankumar, P G

Tomato, brinjal and chilli are the three important solanaceous vegetable crops grown in the tropical region. The seed production requirements are almost similar in these crops.

BRINJAL *(Solanum melongena* L.)

Land requirement

There is no specific requirement with respect to previous crop but it should be free from volunteer plants. Soil should be fertile, rich in organic matter, sandy loam and well drained.

Isolation requirement

Brinjal is partially self pollinated and partially cross pollinated. The extend of cross pollination is 0-48%. For seed production, seed fields should be isolated from other varieties of brinjal and also from same variety not conforming to varietal purity standards for certification. Accordingly, the isolation distance for brinjal is 200 m foundation seed and 100 m for certified seed.

Time of sowing

February- March, June- July and October- November

Seed rate

375- 500 g/ha.

Nursery preparation and transplanting

Seeds are sown in raised nursery beds (10 to 15 cm high) in rows spaced at 5-10 km. Usually beds of 1m width and convenient length are prepared using 1:1:1 potting mixture. When the seedlings are 30-45 days old, they are transplanted to the main field, preferably in the evening.

Spacing

Seedlings are transplanted at a spacing of 75-90 x 60-70 cm.

Manures and fertilizers

Apply well rotten farm yard manure at the rate of 20-25 tonnes/ ha. Apply NPK at the rate of 75:40:25 kg/ha.

Irrigation

Irrigate the crop once in three to four days depending upon the moisture content of the soil.

Inter culture

Weeding should be done twice along with earthing up of the crop. First weeding and earthing up are done one month after transplanting and the second at two months after transplanting.

Roguing

Remove off type before flowering based on vegetative characters. Second roguing should be done at fruit formation stage based on fruit characters. Plants affected by phomopsis blight and little leaf are to be removed.

The characters of brinjal varieties and hybrid released from Kerala Agricultural University is shown below.

Name of variety	*Characters*
Surya (SM 6-7)	Non- prickly stem and leaves, green leaves with violet tinged vein. Glossy, oval and medium sized fruits. Average fruit length is 8.16 cm and fruit weight is 90.0 g. Resistant to bacterial wilt.
Swetha (SM 6-6)	Bushy growth habit, semi erect, green leaves with purple tinge on the leaf stalk, non prickly stem, purple flowers, white and medium long fruits which are born solitary with occasional clusters. Average fruit length is 12.67 cm and weight is 43.0 g Resistant to bacterial wilt.
Haritha (SM 141)	Long duration, spreading habit, Non prickly stem, green leaves and vein, white flowers, light green, long and fleshy fruits with less seeds. Average fruit length is 18.0 cm and weight is 123.0 g Resistant to bacterial wilt.
Neelima (F_1 hybrid)	Spreading habit, non prickly stem, green leaves with violet tinge, purple flowers, large, oval to round, glossy violet fruits. Average fruit length 12.0 cm and weight is 176.0 g Resistant to bacterial wilt.

Plant protection

Adopt proper plant protection measures to control pests and diseases.

Harvesting and seed extraction

Harvest the fruits at full ripe stage when the colour of the fruit changes to yellow. The fruits are then cut into pieces and soaked in water. If the material is allowed to stand over night, the separation of seed from the pulp becomes easier. Frequent stirring should be done. The seeds will settle down and those, which float, are removed. Then the seeds are dried to moisture content of 8%.

Seed yield

100-120 kg per hectare.

Field standards

	F.S	C.S
1. Off types (max %)	0.1	0.2
2. Diseased (max %)	0.1	0.5

Seed standards

1. Purity (min %)	98	98
2. Intermatter (max %)	2	2
3. Other crop seeds (max %)	-	-
4. Weed seeds (max %)	-	-
5. Germination (%)	70	70
6. Moisture (max %)	8	8

CHILLI *(Capsicum annuum* L.*)*

Land requirement

There is no land requirement with respect to previous crop but the land should be free from volunteer plants. The soil should be fertile and well drained.

Isolation requirement

The seed fields must be isolated from other varieties of chilli and also from same variety not conforming to varietal purity standards for certification. The isolation distance is 400 m for foundation seed production and 200 m for certified seed production.

Time of sowing

May- August and September- December

Seed rate

1 kg/ha.

Nursery preparation and transplanting

The nursery is raised as in brinjal and the seedlings are ready for transplanting at 30-45 days after sowing.

Spacing

45 x 45 cm – 60 x 60 cm

Manures

Apply farm yard manure at the rate of 20-25 tonnes/ ha and NPK at the rate of 75:40:25 kg/ha.

Irrigation

Irrigate the crop at an interval of 3 - 4 days depending upon the moisture content of the soil.

After cultivation

Weeding and earthing up should be done twice, at one and two months after transplanting along with top dressing.

Roguing

Remove off types and plants affected by leaf blight, anthracnose and viral diseases.

The characters of varieties released from Kerala Agricultural University is shown below.

Name of variety	*Characters*
Jwalamukhi	Annual with moderate branching, fruits pendulous, green, medium long with thick skin. Average fruit length is 9.6 cm and weight is 6.5 g High yield, protracted fruiting, low pungency.
Jwalasakhi	Annual, moderate branching, fruits pendulous, tapering from stalk end, smooth, sulphur coloured, medium long, less pungent and thick skinned. Average fruit length is 7.6 cm and weight is 5.2 g High yield, protracted fruiting, low pungency
Ujwala	Determinate growth, clustered, linear and erect fruits which are dark green at immature stage turning deep red on ripening. Resistant to bacterial wilt.
Anugraha	High yielding (27 t/ha), bacterial wilt resistant variety with medium pungency.

Plant protection

Adopt proper control measures against pests and diseases.

Harvesting and seed extraction

Harvest at fully red ripe stage. Fruits are crushed, cut or macerated. Seeds are washed and dried to a moisture content of 8%.

Seed yield

100-150 kg/ha

Field standards

	F.S	C.S
Off types (max %)	0.1	0.2
Diseased (max %)(Seed borne)	0.1	0.5
(Virus)	0.5	0.2

Seed standards

Purity (min %)	98	98
Inert matter (max %)	2	2
Other crop seeds (max %)	0.05	0.1
Weed seeds (max %)	0.05	0.1
Germination (%)	60	60
Moisture (max %)	8	8

TOMATO (*Lycopersicon esculentum* Mill)

Among the vegetable crops, tomato ranks second in production after potato. In any seed production programme, it is important to know the ideal characters of the crop.

Important identifying characters for tomato varieties

At seedling stage	: Anthocyanin colouration of hypocotyle.
Growth habit	: Determinate/ indeterminate / semi determinate
Stem	: Pubescence, number of leaves under first inflorescence and internodal length
Leaf	: Size, shape, dark/ light coloured. In some varieties, the ribs are anthocyanin coloured.
Flowering	: Days to flower vary.
Fruit	: In the unripe stage, the basic green colour varies between dark and light green. Presence/ absence of green shoulder is another important character.
Fruit size	: Small to large
Fruit shape	: Flattened/ slightly flattened/ round/ heart shaped/ long cylindrical/ long pear shaped etc. Ribbing at the calyx end may be absent/ present.
Fruit colour	: Yellow to brown red. Green shoulder may be present/ absent. Pericarp may be thin/ thick.
Pedicel	: Short/ long. Pedicel area may be flat to strongly depressed.
Blossom end of fruit	: May be indented, flat or pointed.
Locule	: Number will be varying

Seed production

Land requirement

There is no specific land requirement with respect to previous crop. But the land should be free from volunteer plants. Land should be fertile, rich in organic matter and well drained.

Isolation requirement

In order to obtain true to type quality seeds of a particular variety, any chance of cross pollination should be avoided. So minimum distance to be maintained between any two varieties of a particular crop has been specified. Accordingly, the isolation distance for tomato is 50m for foundation seed and 25 m for certified seed. This distance should be given from other varieties of tomato and also from same variety not conforming to varietal purity standards for certification.

Time of sowing

August- January

Seed rate

400 g/ha.

Nursery preparation and transplanting

Seeds are sown in raised nursery beds (10 to 15 cm high) in rows spaced at 5-10 cm. Usually beds of 1m width and convenient length is prepared using 1:1:1 potting mixture. When the seedlings are 30-45 days old, they are transplanted to the main field. This transplanting is done preferably in the evening.

Spacing

Seedlings are transplanted at a spacing of 60 x 60 cm.

Manures and fertilisers

Apply well rotten farm yard manure at the rate of 20-25 tonnes/ha and NPK at the rate of 75:40:25 kg/ha.

Irrigation

Irrigate the crop once in three to four days depending upon the moisture content of soil.

Inter culture

Weeding and earthing up is done 25-30 days after transplanting along with top dressing.

Roguing

Remove off types and plants affected by early blight, leaf spot and mosaic (TMV)

The characters of varieties released from Kerala Agricultural University is shown below.

Name of variety	*Characters*
Sakthi (LE 79)	Semi determinate growth habit, fruits- flat round, medium sized, green shouldered with jointed pedicel, susceptible to cracking Average fruit length : 4.10 cm, Average fruit weight : 48.30 g Resistant to bacterial wilt.
Mukthi (LE 79-5)	Determinate growth habit, fruits - white, round, medium sized without green shoulder, jointed pedicel, susceptible to cracking Average fruit length 4.50 cm, Average fruit weight : 53.0 g Resistant to bacterial wilt.
Anagha	High yielding (30 t/ha), bacterial wilt resistant variety. Medium sized fruits with resistance to fruit cracking. Tolerant to leaf curl and mosaic.

Plant protection

Adopt proper plant protection measures to control pest and disease problems.

Harvesting and seed extraction

Fruits are harvested at red ripe stage seed extraction is mainly done by two methods

1. Fermentation method, 2. Acid method.

Fermentation method

In this method, the fruits are crushed by hand or in a seed extracting machine. Entire mass is kept in wooden / plastic containers for 24 -48 hours for fermentation. The time taken for germination depends on the prevailing temperature. Then the seeds are washed, dried initially in shade and later under sun avoiding the mid day period.

Acid method

The pulp with seed is treated with conc. HCl @ 100 ml for 10 kg pulp. Keep it for 30 minutes. Wash it and dry it.

Seed yield

100-120 kg/ha

Field standards

	F.S	C.S
a. Off types (max %)	0.1	0.5
b. Diseased (max %)	0.1	0.5

Seed standards

	F.S	C.S
a. Purity (min %)	98	98
b. Inert matter (max %)	2	2
c. Other crop seeds (max %)	0.05	0.1
d. Weed seeds (max %)	-	-
e. Germination %	70	70
f. Moisture content (max %)		
Ordinary container	8	8
Vapour proof container	5	5

SEED PRODUCTION IN CUCURBITACEOUS VEGETABLES

Nirmaladevi, S

Among the vegetable crops, the cucurbits belonging to the family Cucurbitaceae include ash gourd, bitter gourd, bottle gourd, cucumber, ivy gourd, muskmelon, pointed gourd, pumpkin, ridge gourd, smooth gourd, snake gourd and water melon. Of these, ivy gourd (*Coccinia grandis*) is propagated exclusively by vegetative means. A number of varieties have been developed and released for cultivation in these crops at state and national level (Table 1 and 2)

Table 1. Varieties of cucurbitaceous vegetables from KAU

Sl.No.	*Crop*	*Varieties*
1	Ash gourd (*Benincasa hispida*)	Indu, KAU Local
2	Bitter gourd (*Momordica charantia*)	Priya, Preethi, Priyanka
3	Ivy gourd (*Coccinia grandis*)	Sulabha
4	Oriental pickling melon (*Cucumis melo* var.*conomon*)	Mudicode, Saubhagya, Arunima
5	Pumpkin (*Cucurbita moschata*)	Ambili, Suvarna, Saras
6	Ridge gourd	Deepthi, Haritham
7	Snake gourd	TA- 19, Kaumudi, Baby

Table 2. Cucurbit varieties recommended at national level

Sl.No.	*Crop*	*Varieties*	*Source*
1	Bitter gourd (*M.charantia*)	RHRBG-4-1, KBG-16 PBIG-1 Priya, Preethi	MPKV, Rahuri, C SAUAT, Kalyanpur. GBPUAT, Pantnagar KAU, Thrissur
2	Bottle gourd (*Lagenaria siceraria*)	Pusa Naveen BG-L-C-2-1 PBOG-61 NDBG-132	IARI PAU Ludhiana GBPUAT, Pantnagar NDUAT, Faizabad
3	Cucumber	CHC-2	CHES, Ranchi
4	Muskmelon	NDM-15 Pusa Sharbati, Pusa, Madhuras Arka Rajhans, Arka Jeet	NDAUT, Faizabad IARI, New Delhi IIHR, Bangalore

Sl.No.	Crop	Varieties	Source
5	Pumpkin	CM-350, Ambili, NDPK-24 Pusa Viswas Arka Chandan Arka Suryamukhi	KAU,Thrissur, NDUAT, Faizabad IARI, New Delhi IIHR, Bangalore
6	Ridge gourd	CHRG-1, PRG-7, IIHR-7	CHES, Ranchi, GBPUAT, Pantnagar, IIHR, Bangalore
7	Watermelon	Sugar Baby, Durgapura Meetha	ARS, Durgapura

The cucurbits are highly cross pollinated crops. Hence seed production should be carried out under standardized and well organized conditions. Strict attention should be given to maintain genetic purity and other qualities of seed.

Land requirement

The area of seed production of a variety should preferably be the area of adaptation of that variety to minimize the chances for developmental variation/ genetic shift. The land must be free from volunteer plants. If the area selected was under cultivation with some other variety of the same crop, it should be irrigated at least three weeks before sowing and ploughed in to destroy germinating seeds.

Isolation distance

It is specified that minimum isolation distance should be maintained between fields of two varieties of the same crop to avoid genetic contamination and to reduce the spread of pests and diseases. The minimum isolation distance specified for foundation seed production of cucurbits is 800 m and that for certified seed production is 400 m.

Spacing

In the seed production plots, the seeds of cucurbitaceous vegetables are sown at the same spacing as recommended for the vegetable crop (Table 3.)

Table 3. Spacing recommended for curcurbits

Sl.No.	Crop	Spacing
1	Bitter gourd	2 m x 2 m
2	Bottle gourd	3 m x 3 m
3	Cucumber	2 m x 1.5 m
4	Oriental pickling melon	2 m x 1.5 m
5	Pumpkin	4.5 m x 2 m
6	Ridge gourd	2 m x 2 m
7	Snake gourd	2 m x 2 m
8	Watermelon	3 m x 2 m

Inspection and roguing

Inspection by seed certification agency is very essential in commercial seed production, especially for registered and certified seeds. During growing season, the standards for inspection include land requirement, previous crop, isolation requirement and maximum permissible off types. In cucurbits, minimum of three inspections should be done at pre-flowering stage, flowering to maturity stage and mature fruit stage. Off type plants and the plants affected by the designated diseases and objectionable weeds like wild *Cucurbita* sp. and *Cucumis* sp. also should be removed before flowering.

The salient features of certain important cucurbitaceous vegetable varieties are as follows.

i. Oriental pickling melon

a. Mudicode: The fruits are about 30cm long and oval. Average fruit weight is 1.8-2.5 kg. The number of fruits per plant varies from 5-7. Fruits are green at immature stage, turning attractive golden yellow on ripening. Average productivity is 30t/ ha.

b. Soubhagya: Less spreading, bears fruits in the lower nodes. The fruits are small to medium sized, oblong shaped,18-23 cm long and weighing 900-1400g. At immature stage, the fruits are green with light green lines from stalk end which turn attractive golden yellow colour on ripening. Average productivity is 17.1t/ ha.

c. Arunima: Bright green fruits with creamy spots at tender stage and orange yellow at ripening, Fruits are uniform cylindrical shape having 33.14cm length. Average fruit weight is 2.3 kg and average productivity is 27t/ha.

ii. Pumpkin

a. Ambili: Vigorously growing variety having flat round fruits of medium size with shallow grooves. The fruits are green at immature stage turning yellowish brown on maturity. The leaves are characterised by white spots on the upper surface of the lamina. Each fruit weigh 5-6kg and has a yield potential of 33 tonnes/ha.

b. Suvarna: The female flower anthesis starts by 48-50 days after sowing and fruit shape is flat round. The fruits are medium sized ad average fruit weight is 3.5 kg. The fruits are dark green in colour at immature stage and turn to reddish yellow at maturity. The flesh colour is orange and yield potential is 37 tonnes/ha.

c. Saras: Vigorous growth with elongated medium sized fruits. Average fruit weight is 2.7 kg. Yield potential is 37t/ha. Has orange coloured thick (5cm) flesh.

iii. Bitter gourd

a. Priya: The fruits are extra long (40cm) spiny, green in colour with white tinge at stylar end. Average fruit weight is 235g and yield potential is 20-30t/ha. Pre bearing period is 61 days.

b. Preethi: Medium long (30cm), white fruited variety with spines. Average fruit weight is 310g. Yield potential is 15t/ha. Pre bearing period is 55 days.

c. Priyanka: Highly productive and large spindle shaped uniform white fruits with smooth spines, thick flesh and less seed. Average fruit length is 25cm and average productivity is 28t/ha. Pre bearing period is 55 days.

iv. Snake gourd

a. TA-19: The fruits are light green in colour with white stripes. The fruits are about 60cm long and average fruit weight is 600g. The yield potential is 35 t/ha.

b. Kaumudi : The fruits are long (1.25m) and white in colour, weighing about 2 kg per fruit.

c. Baby: Trailing habit, having small (average fruit weight is 474g and fruit length is 36.5 cm), elongated and uniformly white coloured fruits. Tolerant to mosaic under field condition. Productivity is 50.76 t/ha.

v. Bottle gourd

a. Arka bahar: The fruits are long without crookneck. Each fruit weigh about 1 kg. The fruit colour is light green and shining. The average yield is 40-45 tonnes/ha.

b. Pusa summer prolific round: The fruits are round, 15-18 cm girth and green in colour.

vi. Ridge gourd

a. Haritham: Light green cylindrical fruits with typical ridges and tapering towards the base. Average fruit length is 46.5 cm and weight 650g. Average productivity is 13.24 t/ha. Suitable for summer rice fallows.

vii. Watermelon

a. Sugar baby: Produces medium sized fruits of 4-5 kg, round shape, blackish green skin colour and deep red flesh.

Crop standards

Off types (max. %)		*Objectionable weed plants (max %)*		*Plants affected by designated diseases (max %)*	
FS	CS	FS	CS	FS	CS
0.1	0.2	None	None	0.1	0.2

The agronomic practices and plant protection measures should be adopted as per the recommendations. The pits / channels for sowing are prepared and farm yard manure is applied @ 20-25 t ha^{-1} as basal dose along with 35 kg of nitrogen, 25 kg phosphorus and 25 kg of potash. The remaining quantity of 35 kg nitrogen is applied in several split doses during the growing period. During the initial stages, irrigation is given at 3 - 4 days interval and on alternate days during flowering and fruiting. Bitter gourd, snake gourd and ridge gourd are trailed on pandals and cucumber, oriental pickling melon, ash gourd, pumpkin, watermelon are trailed on the ground. Bottle gourd can be trailed either on the pandal or on the ground. At the time of fertilizer application, weeding and earthing up are done.

Harvesting and seed extraction

The crop should be harvested at optimum stage of fruit maturity since immature and over mature fruits affect the seed quality. It is found that taking one or two vegetable harvests of cucurbits (depending on the total number of fruits) is ideal for economic seed production.

In general, fully ripe fruits are harvested for seed extraction in cucurbits. But in bottle gourd, ridge gourd and sponge gourd, dry fruits are harvested.

Bitter gourd - Taking two vegetable harvests and then leaving the crop for seed production is economical. Ripe fruits of 24 days maturity, when the whole fruit turns to bright orange colour can be harvested. Seeds may be dried in the sun, avoiding peak sunshine hours (12-3pm). Seeds can be stored in 700 gauge polythene bags.

Snake gourd - Fruits can be harvested for seed extraction 36 days after anthesis(in TA19), when yellowing of fruits starts from the stylar end. Big and medium sized fruits (above 85cm length and 2kg weight in Kaumudi) give maximum quality of seeds.

Oriental Pickling Melon - Harvest fully ripe fruits (30 days after anthesis in Mudicode) with deep orange colour when the vines wither. Select big and medium sized fruits (> 1.25kg in Mudicode) for quality seeds. Machine extraction (with out fermentation of pulp) and drying under shade for one day and then in sun, avoiding peak hours (12-3 pm.) gives good quality seeds. Extraction using alkali (1% NaOH) is not at all effective in producing quality seed.

Ash gourd - Ash gourd fruits of 70 days after anthesis are suitable for seed extraction. At this stage, the vines wither, and the thick ashy coating on the fruits dries into white powder, which can be removed on rubbing. Fruits of medium and large fruits (>5kg in KAU Local) give bolder, quality seeds. It is advisable to give a post harvest storage of fruits for 3 months to get higher germination. Manual extraction using 2% HCl for 30 minutes followed by drying under shade gives good quality seeds. Pre storage treatment of seeds with captan @ 2.5g/kg and storing in sealed polythene bags of 700 gauge thickness is the best for seed storage.

Water melon - Fruits can be harvested(42 days after flowering) when the colour changes to light yellow and the skin becomes waxy. The under surface of fruits touching the ground becomes yellow in some varieties and emits a particular dump sound on tapping. Manual extraction using 1% HCl and drying in shade for one day and then in sun, avoiding peak hours gives best quality seeds in water melon(Sugar Baby). Oven drying and sun drying cannot be recommended for water melon.

Pumpkin - Fruits can be harvested when the fruit colour changes from green to light yellowish orange or straw colour . The rind of fruit gets thickened at this stage.

In bottle gourd, sponge gourd and ridge gourd dry fruits are harvested 65 days after flowering. The seeds are extracted by breaking the fruits and dried for 1-2 hours in the sun before storage. The fruits also can be stored as such till next sowing.

The days to flowering, seed maturity, seed yield and seed recovery of the cucurbitaceous vegetables are given below.

Crop	*Days to seed maturity*	*Seed yield (kg/ha.)*	*Seed recovery (%)*
Cucumber	70	-	-
Oriental pickling melon	70	110	0.71
Pumpkin	90	300	1.25
Bitter gourd	65	250	3.0
Snake gourd	65	250	3.2
Bottle gourd	75	-	-
Ridge gourd	75	-	-
Sponge gourd	75	-	-
Water melon	80	200	0.42
Ash gourd	90	300	0.4 to 0.6

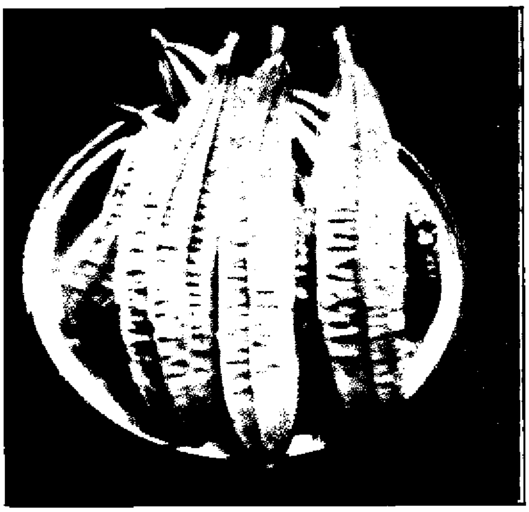
The seed produced should confirm to the specific seed standards. The seed standards are 99% purity, 60% germination and 7% moisture content for both foundation and certified seed. The genetic purity is tested by grow out test. The seeds produced are grown in the field and compared with the standard characters of the variety.

The seeds are dried in the sun avoiding peak sunshine hours to attain safe storage. Dry seeds should be stored in containers and placed in a cool room with provision for dehumidification and with protection against rats.

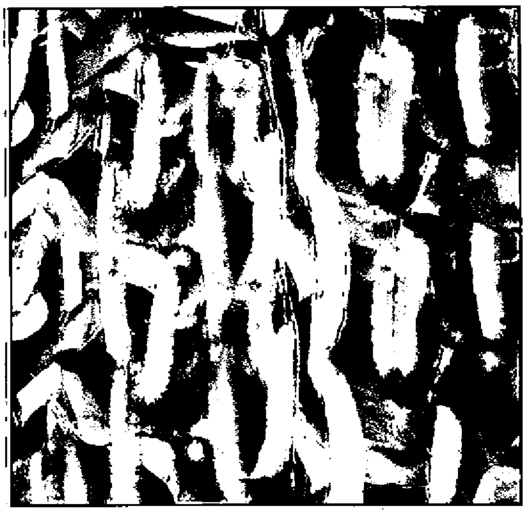
Knowledge on varietal characters is essential to maintain seed purity

Chilli – Anugraha

Chilli – Ujwala



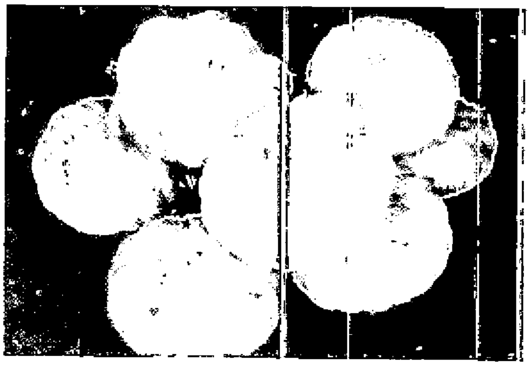
Ridge gourd – Deepthi



Winged bean – Revathy

Bhindi – Aruna

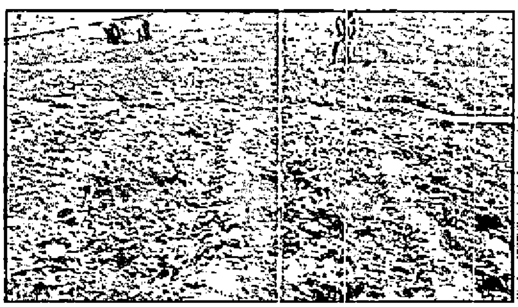
Cowpea – Vyjayanthi

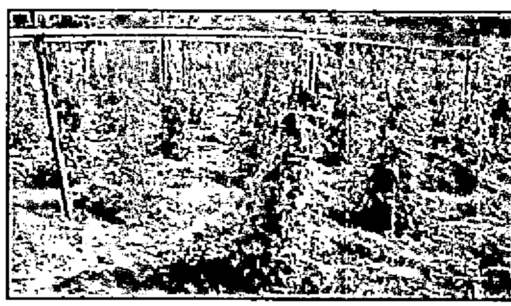


Pumpkin – Ambili

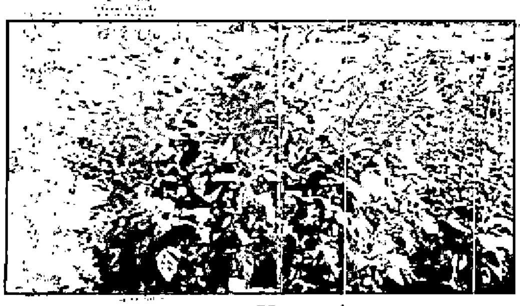
Snake gourd – Kaumudi

The only F_1 hybrid from KAU – Neelima





Seed production field



Harvesting at correct maturity ensures quality seeds

SEED PRODUCTION IN LEGUMINOUS VEGETABLES

Krishnakumary, K

High quality seed is a pre-requisite for achieving higher productivity in any crop. Production of high quality seed is the major objective of any seed production programme. Seed production for unit area is the final outcome of the interaction of genotypes, environment and agronomic techniques.

Cowpea, Dolichos bean, Winged bean, Sword bean, Jack bean are the common legumes grown all over Kerala. Among these, cowpea is grown in intensive as well as extensive scale in different parts of the state.

Seed production in cowpea

The cowpea (*Vigna unguiculata* (L) Walp.) morphotypes grown in the state mainly belong to three groups viz.

1) Grain type (*V.unguiculata* sub.sp. *catjang*).

2) Vegetable type (*V. unguiculata* var.*sesquipedalis*).

3) Dual purpose type (*V. unguiculata* sub.sp.*cylindrica*)

The efficient management practices for higher seed production in vegetable cowpea are described below:

Land requirement

Site selected should be open, receiving good sunlight. Select a field where the same crop was not grown in the previous season unless the crop was of the same variety and was certified. Cowpea can be cultivated in a loamy, well drained soil rich in organic matter.

Season

When the crop is grown for seed production purpose, there should not be rain at the time of maturity of pod. Hence September – October and January – February are the ideal months for sowing seeds.

Crop and variety:

Based on the growth habit there are 3 types of vegetable cowpea. 1) Bush type 2) Semi trailing type 3) Trailing type. Varieties released from KAU and their characters are given in Table.

Table. KAU varieties of vegetable cowpea and their characters.

Name of the variety	*Characters*
Malika	Trailing growth habit with purple flowers and long light green pods. Seed brown coloured with a white speck, purple flowers. Average productivity is 9.8 t/ha.
Sarika	Trailing variety producing long white pods with purple tip, black seeds and the average productivity is 10.6 t/ha.
KMV-1	Trailing growth habit, long light green pods with brown tip,seed colour is reddish brown. Average productivity is 13.5 t/ha.
Vyjayanthi	Trailing variety with long wine red coloured pods and brown seed. Average productivity is 12.6 t/ha.
Lola	Trailing growth habit, long light green pods with purple tip, black seeds. Average productivity is 20 t/ha.
Kanakamony	Semi trailing growth habit, having dark green and medium long pods. Seeds reddish brown. Average productivity is 7 t/ha.
Bhagyalekshmi	Bushy growth habit with early flowering, light green medium sized pods,white flowers and mottled seeds.Average productivity is 6.5 t/ha.
Kairali	Semi trailing growth habit, pink coloured medium long pods, reddish brown seeds, Resistant to mosaic disease. Average productivity is 7.1 t/ha.
Varun	Semi trailing cowpea, light purple pods, seed colour is brown. Average productivity is 8.4 t/ha.
Anaswara	Semi trailing variety with light green pods. Average yield is 12.5 t/ha.

Seed and Sowing

Seed rate and spacing of different types of vegetable cowpea are given below

Type	*Seed rate/ha.*	*Spacing*
Bush type	20 kg.	25 x 15 cm.
Trailing type	4 kg	2 x 2 m.
Semi trailing type	12 kg	30-45 x 15 cm.

Plough the land thoroughly, make channels of 30 cm breadth and seeds of bush type are dibbled at the recommended spacing with two seeds per hole. Trailing varieties can be sown in pits (@ 3 seeds/pit) at 2x2m spacing for trailing on pandal or in channels at 1.5 m x 45 cm spacing for trailing on trellies. Before sowing, seeds should be inoculated with rhizobium.

Isolation distance

Proper isolation distance should be maintained between varieties and related species. Since legumes are self pollinated it requires less isolation distance to maintain the purity. For foundation seed production the distance is 50 m and for certified seed production, the recommended distance is 25m.

Manures and fertilizers

The recommendation is FYM–20 t/ha., Lime–250 kg/ha and N:P:K@20:30:10 kg/ha. Lime should be applied at the time of first ploughing. Half the quantity of nitrogen, whole of phosphorus and potassium may be applied at the time of final ploughing. The remaining nitrogen may be applied 15-20 days after sowing. Excess nitrogen and irrigation leads to delayed flowering. In trailing type of cowpea, split application of fertilizers at 15 days interval was found good for getting more yield. Besides, application of fresh cowdung slurry in the pit and spraying supernatent solution of cowdung was found to increase yield in trailing cowpea.

After cultivation

Hoeing at the time of application of fertilizer will give adequate aeration to the soil and help the root system to spread easily. For trailing types, provide trellies or pandals. Irrigation is required in summer season. Irrigation at the flowering stage induces better flowering and pod set.

Hormone application

NAA (15 ppm) spraying at 15 and 30 days after sowing was found to increase yield in cowpea. Hormone should be sprayed in the morning hours.

Roguing

Roguing should be practiced before flowering, during flowering and at the time of maturation of pod, based on leaf shape, flower colour, pod and seed characters. All the plants infected by diseases like anthracnose, mosaic etc., should be removed from the seed production plot. No objectionable weeds are permitted in the seed production plot. The specific requirement of field standards and seed standards for certification are given below:

Field standards		
Item	*Foundation seed*	*Certified seed*
Off types (%)	0.1	0.2
Plants affected by designated diseases (%)	0.1	0.2
Seed standards		
Pure seed (minimum %)	98	98
Inert matter (Maximum %)	2	2
Other crop seeds (Maximum %)	None	0.05
Total weed seeds (Maximum %)	None	0.1
Germination (%)	75	75

Harvesting and seed extraction

The pods may be harvested when they are dried, but, before seeds are shattered. These pods are further dried in sun before seed extraction. Threshing is done by beating with stick. Seeds should be cleaned and dried under shade to a moisture content of 8-9%.

Good drying and pre-storage seed treatment with carbaryl 10% D(10g/kg seed) or lindane 5% D (20 g/kg seed) and thiram or captan @ 2.5 g/kg seed is essential to protect the seed from storage pests and diseases. *Callosobruchus* is the important pest creating problem in storage. To prevent its infestation, control measures should be taken from the field itself, in the standing crop, by spraying a pesticide at the time of pod maturation. Smearing the seed with coconut oil, neem oil or gingelly oil (1%) was found to prevent the attack of *Bruchus*.

The expected seed yield from 1 hectare is given below.

1) Bush type : 1000 kg.
2) Semi-trailing type (Kanakamony) : 1500 – 1800 kg.
3) Trailing type : 500 – 600 kg.

MINOR LEGUMES

The details regarding the cultural practices, field and seed standards of minor legumes are given below.

Dolichos bean (Lablab purpureus) (Dolichos lablab)	*Winged bean (Psophocarpus tetragonolobus)*	*Sword bean (Canavalia gladiata)*	*Jack bean (Canavalia ensiformis)*
1	2	3	4
1. Land requirement: In the selected field, the same crop should not be grown in the previous season unless the crop was of the same variety and was certified. The field should have a light and well drained soil	Same as in dolichos bean	Same as in dolichos bean	Same as in dolichos bean
2. Isolation distance Foundation seed - 50m Certified seed- 25 m	Same as in dolichos bean	Same as in dolichos bean	Same as in dolichos bean
3. Time of sowing July- August	August- September	August- September	August- September
4. Growth characters and varieties Bush varieties- Arka jay and Arka vijay, Pole type-Pusa early prolific	Pole type-Revathy	Trailing growth habit No named varieties	Bushy growth habit No named varieties
5. Seed rate Pole type: 15-20 kg/ha	15-20 kg/ha	-	-

1			2		3	4
6. Spacing Pole types are sown in pits at a spacing of 1.25 x 0.75m. Bush varieties are sown in ridges and furrows at a spacing of 60 x 15 cm			125 x 50cm		4 x 3m	60 x 60 cm
7. Manures and fertilizers FYM- 20 t/ha, $N:P_2O_5:K_2O$ - 50:100:50 kg/ha			Same as in dolichos bean		FYM- 5 t/ha	FYM- 5 t/ha
8. Intercultural operations Irrigation should be done if there is no rain for a prolonged period. Keep the field free of weeds. In pole types, plants are trailed over pandals, trellis or stakes			Same as in dolichos bean		Same as in dolichos bean	Same as in dolichos bean
9. Roguing Roguing should be done at 3 stages, at pre flowering, flowering and maturity stage based on vegetative floral and fruit characters. Plants affected by bacterial blight and anthracnose should be removed			Same as in dolichos bean		Same as in dolichos bean	Same as in dolichos bean
10. Harvesting and seed extraction Ripe pods are plucked. Dry the pods in sun for a few days. Threshing is done by beating with a stick. Seeds should be cleaned and dried to a moisture content of 9% before storage			Pods should be harvested when they turn brown. Threshing is done by beating with a stick. Seeds should be cleaned and dried to 9% moisture level.		Pods should be harvested when they dry.Separate the seed by beating with a stick. Clean the seeds, dry to 9% moisture level	Same as sword bean
11. Seed yield 300-600 kg/ha			1500 kg/ha		-	-
Field standards						
Off types	0.1	0.2	0.1	0.2		
Plants affected by designated diseases	0.1	0.2	0.1	0.2		
Seed standards			FS	CS		
Pure seed (min %)	98	98	98	98		
Inert matter (Max %)	2	2	2	2		
Other crop Seeds (Max%)	0	0.1	0	0.2		
Total weed Seeds (Max%)	0	0.1	0	0		
Germination %	75	75	70	70		
Moisture (Max %)	9	9	9	9		

SEED PRODUCTION IN BHINDI

Suresh Babu, K V

Land requirement

Select a field where the same crop was not grown in the previous season unless the crop was of the 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 conforming to the varietal purity requirements for certification and from wild *Abelmoschus* species, at least by four hundred meters for foundation seed and two hundred meters for certified seed.

Time of sowing	:	Aug- Sept / Feb-March
Seed rate	:	7kg/ha
Spacing	:	60 cm x 45 cm

Manures and fertilizers

Apply farm yard manure or compost as basal dose @ 12 tonnes/ha. The NPK recommendation is @ 50, 8 and 25kg/ha . At the time of sowing, apply Ammonium Sulphate 125 kg/ha, Super phosphate 50 kg/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 period, irrigate the crop at 5-6 days interval.

Interculture

Conduct regular weeding. Give two earthing up after 15 and 45 days of sowing.

Roguing

Yellow vein mosaic has not been found to be seed borne, but affected plants must be removed. Such plants should be uprooted and destroyed soon after they are noticed. This should be done up to three fruit stage. Further roguing for off types and wild *Abelmoschus* species should be done before flowering. This should be done during flowering stage also.

The characters of varieties released from Kerala Agricultural University is shown below.

Name of variety	*Characters*
Kiran (AE 1)	Open pollinated high yielding variety (11.21 t/ha) Attractive, long, light green fruits Average fruit weight : 27 g, Average fruit length : 25 cm
Salkeerthi (AE 202)	High yield (16.2 t/ha), Attractive, long, light green fruits Average fruit weight : 28 g, Average fruit length : 27 cm
Aruna (AE 198)	High yield (15.8 t/ha), Attractive, long, red fruits Average fruit weight : 27 g, Average fruit length : 27 cm
Susthira (AE 286-1)	Mosaic (YVM) resistant variety, High yield (18 t/ha) Attractive long green fruits, Average fruit weight : 24.5 g Average fruit length : 22 cm, Perennial type; Responds to pruning

Harvesting and seed extraction

Dried pods are harvested leaving the pods at the top of the plant. To avoid 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%. Packing of okra seed in 700 gauge polythene cover increases the storage life up to 7 months. Highest quality of seeds can be obtained when fruits were initially dried using mechanical drier (35°C) for 6 hours followed by drying of seeds under shade for one day and thereafter under direct sunlight avoiding peak hours till the seeds attained 8% moisture level.

Seed yield: 1200 kg/ha

Seed standards

	F.S	C.S
Pure seed (minimum)	9	99
Inert matter (maximum)	1	1
Other crop seeds (maximum)	None	0.05
Total weed seed (maximum)	None	None
Objectionable weed seed (maximum)	None	None
Germination	65	65
Moisture(maximum) (ordinary container)	10	10
(Vapour proof container)	8	8

Specific requirement for certification

	F.S	C.S
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%	0.10%

SEED PRODUCTION IN AMARANTH

Krishnakumary, K

Among the leafy vegetables, Amaranth (*Amaranthus* spp) has attained commercial importance in Kerala. It is considered to be the cheapest leafy vegetable in the market and is a valuable source of nutrients especially vitamins and minerals.

In any crop, seed is the basic critical input playing a crucial role in enhancing productivity. Seed production is influenced by agronomic practices as well as genotype and environment. Basic knowledge on the specific requirement of the crop, specific characters of the variety, pests and diseases and their control measures are essential before taking up the seed production programme. The management strategies for realizing maximum seed yield of good quality for amaranth are described below.

Land requirement

The crop requires an open area for its cultivation. The crop is shade sensitive. Soil should be light, fertile and well drained. The land selected should be such that the same crop was not sown in the previous season unless the crop was of the same variety.

Planting season

Though the crop can be cultivated throughout the year, leaf spot disease is a serious problem especially in rainy season. For seed production purpose, planting time should be adjusted so that seed maturation coincides with dry weather. In Kerala condition, the best time for growing amaranth for seed production purpose is from October to April months.

Genetic purity of a variety is very important and deterioration of varieties may be due to natural crossing, mechanical mixtures, influence of diseases and other minor genetic variations. Maintenance of genetic purity can be achieved by the use of approved seeds, providing isolation distance, inspection of the fields, roguing etc.

Isolation distance

For foundation seed, the isolation distance suggested is 400m and 200m for certified seed. This distance is suggested for other varieties and species of amaranth.

Varieties

Varieties suitable for cultivation in Kerala and their characters are given below

Name of variety	*Characters*
Arun (*Amaranthus tricolor*)	A photo insensitive multicut variety with stem, petiole and leaves maroon red coloured. Average productivity is 20.1tonnes/ha.
Mohini (*Amaranthus tricolor*)	A high yielding multicut green amaranth variety. Stem has a reddish colouration at the base. Average yield is 13 tonnes/ha. and leaf stem ratio is 2:1.
Kannara local (*Amaranthus tricolor*)	A photosensitive multicut variety, flowering in shortday conditions. Dark red in colour. Average productivity is 20 tonnes/ha.
CO-1 (*Amaranthus dubius*)	Plants tall with dark green leaves. Tolerant to pests and diseases. Average yield is 7-8 t/ha.

Seeds and sowing

Though the crop can be grown as direct and transplanted crop, transplanting is preferred for seed production crop. The seed rate is 1.5-2 kg/ha. For transplanting, seeds are sown in nursery beds. Nursery beds of 1m. width, 20-30 cm height and of convenient length are taken and seeds are sown in lines at a distance of 15-20 cm in these beds. Since seeds are very small, they should be mixed well with sand and sown in rows at 1 cm depth. Precaution should be taken against ants carrying away the seeds.

Preparation of land

Prepare the land by ploughing or digging followed by levelling. Shallow trenches of 30-35 cm width are made 30cm apart. Well rotten FYM is mixed with soil in the trenches. Transplant 20-30 days old seedlings in the trenches at a distance of 20 cm.

Manures and fertilizers

Apply 50 tonnes of FYM per hectare as basal dose before planting. After preparing trenches, apply N: P_2O_5 : K_2O @ 50:50:50 kg/ha. Another 50 kg of nitrogen can be applied at 2-3 intervals as top dressing.

After care

Weeding and irrigation (once in 2-3 days) are the other intercultural operations to be carried out.

Roguing

The off types should be removed as and when noticed. Roguing should be done at the nursery stage, vegetative phase and at the time of flowering. Specific requirements of crop standards and seed standards for certification are given below.

Crop standards

Item	*Foundation seed*	*Certified seed*
Off types	0.1%	0.2%
Objectionable weed plants	0.1%	0.1%

Seed standards

Item	*Foundation seed*	*Certified seed*
Pure seed (minimum %)	95	95
Inert matter (maximum %)	5	5
Other crop seed (maximum %)	0.1	0.5
Total weed seeds (maximum %)	0.1	0.2
Germination (%)	70	70
Moisture (%)	8	8

Harvesting and seed extraction

It is economical to take one vegetable harvest at 30 days after planting and then leaving the crop for seed production. Seeds attain maturity when the glumes turn brown in colour and seeds to black. At that time, crop is harvested along with the stem. These are then dried for a few days. Seeds are collected by beating with sticks. Seeds are then cleaned and dried till a moisture level of 8% is reached. Slow drying at low temperature is advisable than quick drying at high temperature. Exposing the seeds to open sunlight during peak hours of sunshine (12 noon to 3 pm) should be avoided. Store the seeds in 700 gauge polythene bags or tight containers in sealed condition. The expected seed yield from one hectare area is 500 kg.

INTEGRATED NUTRIENT MANAGEMENT FOR VEGETABLE SEED PRODUCTION

Meera V Menon, Potty, N N and Sindhu, P V

Seeds are the materials ensuring the continuation of generations. Genetically, they are potentiated for maximum productivity. Unlike field crops like cereals, vegetable seeds are not materials for consumption. Their consumption is only incidental. It is either the leaf or the mesocarp of the fruit, which is generally consumed in vegetables. The mesocarp, or the fleshy part of the fruit, is the intermediate stage between vegetative growth and seed development. Though the fruit is biologically meant for nourishment, protection as well as dissemination of the seed, in vegetables, the physiological maturity of the fruits and seeds do not coincide. Crop management in vegetables is meant usually for fruit production, and the requirements for seed production may not be the same.

Basic considerations

Management for seed production aims at ensuring maximum vigour of the emerging seedlings. Vegetables are mainly seasonal plants, with a life span of three to four months. They are very fast growing and have to respond positively to heavy doses of manuring. Poor vigour of seedlings will prove to be an obstacle in these respects, and will fail to achieve the desired objective.

Fresh vegetable seeds are rarely used for raising crops. Seeds may require some ageing. Some seeds may have a built in dormancy which may be either structural or chemical or both, and this serves as a period of rest for the embryo. Seedling vigour depends on both the quantity of stored food in the seed as well as its availability. This is indirectly linked to seed weight. There is a mistaken notion that seed weight does not change through management. But there are evidences that in acidic iron and manganese rich tropical soils, management can bring about wide variation in seed weight. Organic nutrition was found to increase the seed percentage in fruits of cucurbitaceous vegetables like pumpkin and ashgourd.

Rapid loss of viability is a sign of improper management. Higher levels of potassium or sodium in the seed may lead to higher retention of moisture, which is conducive to loss of viability. Accumulation of free minerals including nitrogen can lead to a faster loss of viability. The fruit petiole, mesocarp and the seed coat may serve as barriers in the translocation of undesirable forms and levels of elements and compounds to seeds, to some extent. In determinate plants where withering starts with fruit development, the restrictive role of plant organs is more effective. But in vegetables, and particularly their fruits, which are highly succulent, the barrier influence may be less effective. Bridgit (1999) found that the translocation of individual elements in paddy grain may vary up to 15%.

Viability is also affected by management for quality. This is best illustrated in coconut. Viability and vigour of seed nuts with low oil content are incomparably high. Similar is the case with spices and other crops. Thus management for seed production should not lay emphasis on quality.

Resistance to pests and diseases, a prime requirement for seeds, is considered a genetic character. However, Girija *et al.* (1994), working on horse gram, observed that the seed had red, white and black colours, and the black couloured seeds were the most vulnerable and the white, the least, to pest and disease incidence. Higher content of water retaining minerals and poor seed coat development (probably due to unfavourable Ca/K ratio) in black seeds were cited as the probable reasons. Mechanical damage in storage can also lead to loss of viability and vigour and early mortality.

Soil characteristics in relation to seed production

The seed is produced by the plant, and the plant is produced from the seed. The progressive developmental pattern is defined in an automatic switch on – switch off mechanism in the time scale which is embedded in the genetic make up of the seed. This is expressed by the plant as conditioned by the environment, which includes the atmospheric and soil environments. Seeds being bred to suit the weather, wide variations between realized and realizable yields (the gap is often 100% or more) is due to the soil effect.

Apart from anchorage, the soil supplies water and mineral elements to the plant. Deficiencies in the soil are made up through irrigation and supply of manures and fertilizers. As manures and fertilizers are meant for nourishing the plants, they are called nutrients.

Growth, differentiation and yield are apparently part of the developmental process. But each one is the product of multiple physiological processes like energy transfer, synthesis, translocation, et., and each process is accomplished through several stages. The different steps of the process are mediated or facilitated by different nutrient elements. At least 16 elements are considered essential for these. Each element is specific in its involvement. Some of the elements also contributed to structure of the products. Thus the quantity of requirement of each element varies. The elements, which are absorbed as ions, are chemically active and naturally the metabolically available fraction will be influenced by chemical reactivity. Stages of plant growth also demand varying levels of elements.

All the elements required for plant growth are present in the soil, but need not be present in sufficient available quantities or proportions to meet the requirements of crops in their various phases of growth. Nutritional management therefore aims at ensuring their availability from the soil in the correct quantities at the proper time. However, in practice, this may prove cumbersome as we have not reached the level of excellence to exactly work out the soil-plant relationships. Instead, what is being done is the integration of amelioration and addition components so as to minimize the harmful effects of soil element excesses on the one side, and maximize the beneficial effects of nutrition on the other. For this, nutrient source integration is the easiest and commonest method and is the basis of integrated nutrient management.

Integrated nutrient management

The concept of integrated nutrient management arose as a means to multiply the ill effects of fertilizer application left behind in the soil. Fertilizers, inspite of quick and easy supply of available nutrients, produce intense acidity in the rhizosphere which in turn results in release of micronutrients in harmful proportions. It may also erode the buffering capacity of the soil through forced oxidation of organic carbon. This practice, however, cannot be totally dispensed with due to inadequacy of organic resources, prohibitive cost per unit input, slow nutrient release pattern, etc,. This is especially true in vegetables where two to three weeks is a sufficiently long period from fertilization to harvest, and every week can yield two harvests.

Vegetables in general are crops which give maximum yield and profit from unit area in unit time. They are the most intensively cultivated crops. Integration of organic and inorganic nutrient sources has been reported to increase yield and quality of produce in vegetables. Favourable responses have been obtained in brinjal, chilli, tomato, bitter gourd, ash gourd, cucumber, okra, amaranth and pumpkin.

Raising of vegetable crops exclusively for seed production is not common. This is because the physiological maturity for the seed takes a longer time than for the fruit. Hence for seed production, fruits will have to be retained for a longer time on the plant. Extended sink action in the fruits may restrict or reduce the growth and productivity. Hence, usually, during the peak period of growth, selected fruits are retained on the plant for seed production. Thus the farmer harvests both seed and fruits from a crop. A very critical factor in deciding the realized yield is the male : female flower ratio. Not much work has been done on the nutritional role on this ratio, but farmers believe that fertilizer application in small quantities every week can bring about a favourable ratio by increasing the female flower production. Through experience, they apply Factomphos to obtain such results.

When vegetable crops are raised exclusively for seed, the plant and fruit succulence will modify the elemental composition of the seed. Induced moisture stress will naturally not be practiced in such crops. Hence a natural nutrient flow to the seed will be facilitated, almost in the proportion in which nutrients occur in the soil solution. For example, relatively higher potassium content will be registered in the seed in most soils. Similarly, iron and manganese in acidic soils and calcium in alkaline soils will find greater entry into the seed. A relatively high potassium content in the seed would likely invite storage pests, while iron, manganese and calcium would inactive phosphorus when the seed had extruded much of the initial moisture, consequently affecting germination and seedling vigour. This is to be normally expected. Integrated nutrient management, that is, nutrition through the integration of organic and inorganic sources can be a remedy to this. This is not due to the source effect as such, but because organic sources alone are natural suppliers of sulphur. Sufficient sulphur content in the plant sap can check absorption of iron, manganese or even calcium as the pH of the sap is kept low. Prasanna (1998) reported that application of poultry manure maximized the seed yield per plant and germination percentage of seeds in brinjal.

Soil effect

Nutritional management systems are decided upon based on soil characteristics. Acid soils like laterite soils have high iron and manganese contents, and alkaline soils have high calcium and magnesium contents. The farmer may require liming to restrict iron uptake. Uptake of iron declines as growth advances. Moreover iron is immobile in the plant. So the growth of plants may not be affected much by iron in the later stages. However, the case of manganese is different as it is mobile in the plant. This would mean that the undesirable influence of manganese will be a persistent one. Manganese can be effectively checked by sulphur.

Source and component integration

Integration of organic and inorganic nutrient sources shall serve the twin objectives of sufficient and steady nourishment on the one hand and amelioration and improvement of soil health on the other. This effect stems from the mixing of organics which are slow nutrient releasers and inorganics which are fast releasers. In addition, organics contain large quantities of carbon and can compensate both oxidative loss of native carbon and also enrich it. More than 75% of the cation exchange capacity of soil is due to its organic matter status. Thus integration virtually prevents loss of nutrients from the soil and will enable maximum use of nutrients. Also, through its chelating influences, organic matter can regulate the supply of micronutrients and prevent them from reaching hazardous levels in the soil solution.

However, sources integration should not be misunderstood as integrated management. Bridgit (2001, Personal communication) found that when cattle manure was substituted with poultry manure in bitter gourd cultivated in a farmer's field trial, yield almost doubled. The superior of poultry manure could be traced to its high calcium and low iron and manganese contents. Similarly, glyricidia leaves have been identified as a poor organic source for long term use. In the permanent manurial trials in rice at Pattambi, Anilakumar *et al.* found that continued use of glyricidia leaves resulted in lowest productivity (Personal communication). These results have been cited to show that integrated nutrient management has two components, both of which will have to be satisfied to achieve the desired objective. They are the integration of the required elements in the schedule and the identification of suitable resources (both organic and inorganic) for integration.

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WEED CONTROL IN VEGETABLE SEED PRODUCTION

Abraham, C T

In general, vegetable crops are poor competitors to weeds. Vegetables grow very slowly during the early stages and are usually short in stature. On the other hand weeds grow faster and establish well before the crop. Hence usually weeds can smother the vegetable crop, unless due protection is given. The ideal soil conditions, high fertilizer application and frequent irrigation given to the vegetables favour the growth of a number of weeds in the field. They compete with the crop for nutrients, water and space. In addition, they harbour diseases and pests and also create difficulties in harvesting the crop.

Some of the common weeds found in the vegetable fields in Kerala are shown below.

No.	*Botanical name*	*English name*	*Malayalam name*
Grasses			
1.	*Cynodon dactylon*	Bermuda grass	കറുക
2.	*Eleusine indica*	Goose grass	പഞ്ഞപ്പുല്ല്
3.	*Digitaria ciliaris*	Crab grass	ഞണ്ടുകാലൻ പുല്ല്
4.	*Ischaemum indicum*		പടപ്പൻ പുല്ല്
5.	*Dactyloctenium aegyptium*	Crow foot grass	കാക്കക്കാലൻ പുല്ല്
6.	*Echinochloa colona*	Jungle rice	കവട്ട
7.	*Panicum repens*	Torpedo grass	കറുക
Sedges			
1.	*Cyperus rotundus*	Nut grass	മുത്തങ്ങ
2.	*Cyperus iria*	Yellow nut sedge	മഞ്ഞക്കോര
3.	*Fimbristylis miliacea*	Globe finger rush	മങ്ങ്
4.	*Cyperus kyllinga*	White kyllinga	വെള്ള മുത്തങ്ങ
Broad leaf weeds			
1.	*Phyllanthus niruri*	Niruri	കീഴാർനെല്ലി
2.	*Emilia sonchifolia*	Red tassel flower	മുയൽ ചെവിയൻ
3.	*Cleome viscosa*	Wild mustard	കാട്ടുകടുക്
4.	*Cleome monophylla*		കാട്ടുകടുക്
5.	*Trianthema portulacastrum*	Carpet weed	തവിഴാമ
6.	*Physalis minima*	Ground cherry	ഞൊട്ടാഞൊടിയൻ
7.	*Leucas aspera*		തുമ്പ
8.	*Borreria hispida*	Button weed	കൂർക്കപെടൽ
9.	*Mollugo pentaphylla*		പർപ്പടകപുല്ല്
10.	*Ageratum conyzoides*	Goat weed	അപ്പ, വേതപ്പച്ച
11.	*Amaranthus spinosus*	Spiny pig wood	മുള്ളൻ ചീര

Weed management in vegetables

Different methods of weed control are practised for effective management of weeds in vegetables. They can be classified as cultural methods, mechanical methods and chemical methods. It has been found that the early stage of the crop is the most sensitive stage for weed competition. The field has to be kept free of weeds during this period. If the weeds are allowed to compete with the crop at this stage, the damage caused will be irreparable. Even though weeding is done at later stages, the adverse affect of the weed competition in the early stages cannot be compensated. This early stage susceptible to weed competition is known as the *critical period* for weed competition.

I. Cultural methods

1. Proper land preparation -- This will ensure that all the existing weeds and weed seedlings are destroyed. An ideal condition for quick germination and growth of the crop is provided.
2. Select varieties which grow fast and develop a good canopy, so that it can compete with the weeds.
3. Crop rotation – If same crop is grown in the same field season after season, there will be a shift in the weed flora to weeds associated with that crop. It will be difficult to manage these weeds. If crop rotation is followed this problem can be avoided.
4. Application of fertilizers should be done to the base of the crop, rather than giving as broadcast application.
5. Irrigation should be given to the basins of the crop. Drip irrigation will ensure that water applied is available to the crop only.
6. Prevent the weeds from flowering and producing seeds. The field kept clean for a few season can reduce the weed problems in the subsequent crops.
7. Mulching the inter areas with crop wastes, straw etc. can check the weed growth. In vegetables grown at wider spacing, coconut leaves can be used as mulch to prevent weed growth. Mulching with black polythene sheet also has been found to be effective for preventing weed growth and to reduce the water requirement of the crop.
8. Stale seed bed technique – Withhold sowing the crop after land preparation. Destroy the weeds that emerge by tillage or herbicides. Repeat this 2-3 times. The seed bed will be free of weed seeds.

II. Mechanical methods

The commonly practised spade weeding, sickle weeding and hand weeding etc. come under mechanical methods of weed control. Though this is the popular method, it is costly and labour intensive. Moreover, it has to be repeated many times as new flushes of weeds emerge after the weeding operation. This method is not effective against the perennial weeds like *Cyperus rotundus* and *Cynodon dactylon*. These methods are not possible on rainy days.

III. Chemical methods:

This involves the use of herbicides. The herbicides can be classified as pre-emergence and post-emergence herbicides depending on the time of application. Pre-emergence herbicides are applied immediately after sowing or planting of the crop. They are intended to prevent the germination and establishment of weeds. Alachlor, fluchloralin, metolachlor, pendimethalin and oxyfluorfen are the common pre-emergence herbicides used in India.

Post-emergence herbicides are applied on the existing weeds to kill them. In vegetable farming these herbicides are usually applied to control the weeds in the field, before the land preparation. As they are not selective to the vegetables crops, they can only be applied as directed sprays in between the crop rows only. Paraquat and glyphosate are the important herbicides in this group.

Details of important herbicides for vegetables

Herbicides	*Commercial name*	*Manufacturer*	*Usual dose (kg ai/ha)*
Pre-emergence herbicides			
Alachlor	Lasso	Monsanto	1.0-2.0
Metolachlor	Dual	Novartis	1.5-2.0
Pendimethalin	Stomp	Cyanamid India	1.5-2.0
Fluchloralin	Basalin	BASF	0.75-1.5
Oxyfluorfen	Goal	Indofil	0.1-0.2
Post-emergence herbicides			
Paraquat	Gramoxone	Novartis	0.4-0.8
Glyphosate	Round up	Monsanto	0.8-1.2
	Glycel	Excel Industries	0.8-1.2
2, 4-D	Fernoxone	Novartis	1.0-1.5

All the above pre-emergence herbicides have been found to be safe to the common vegetable crops of Kerala like cowpea, bhindi, solanaceous and cucurbitaceous crops. Spray any of these herbicides within three days after sowing/planting the crop. A follow up hand weeding one month later will be required to control the later emerging weeds.

The post-emergence herbicides listed are non-selective in nature. Hence, they can be applied as directed spraying only, taking care not to contact the crop. They are recommended for application on weeds growing in between the crop rows, in crops like cucurbits grown at wider spacing. These herbicides are also useful for controlling the weeds in the field before land preparation.

Precautions while using herbicides

1. Use the herbicide recommended for the crop.
2. Use at the recommended dose and time
3. Ensure uniform coverage on soil/weed.
4. Use the nozzle for herbicide application.
5. Calculate to find out the quantity of spray fluid required to cover the area.
6. Use clean water for spraying.
7. Spray when there is likelyhood for 3-4 hours rain free period after spraying.

Soil solarisation for weed control

This is the practice of covering the soil with transparent polythene during summer months to increase the soil temperature for killing the weed propagules and disease organisms in the soil. The soil is formed into beds of 1-1.5 m width and covered with polythene sheet. Irrigate the bed before covering to facilitate better conductance of heat. The sides of the polythene sheet should be sealed with soil so that there is no free air movement. The temperature in the solarised soil will increase by 10-12°C. In a trial conducted at Vellanikkara, the soil temperature at 6" depth rose upto 46-48°C when the atmospheric temperature was 34°C. It was also noticed that the soil salarised for 45 days had very few weeds in the subsequent season. The seed propagated weeds are better controlled than the vegetatively propagated weeds like *Cynodon dactylon* and *Cyperus rotundus*.

Control of perennial weeds

Perennial weeds like *Cynodon dactylon*, *Panicum repens* and *Cyperus rotundus* are serious problems in many vegetable fields. When most of the annual seed propagated weeds are controlled by ordinary weeding operations like spade weeding, hand weeding etc., these perennial weeds can escape as they can regrow from the underground parts capable of reproduction. The tillage operations usually increase their problems, as the operation will break the underground parts into pieces, each of which is capable of emerging as a new plant. A trial conducted at Vellanikkara has revealed that the herbicide glyphosate sprayed at 1.20 kg ai/ha can kill these weeds. This spraying should be done 45 days before the crop season. A second spot application one month later to the surviving weeds ensures that all the weeds are killed. As the herbicide is a translocated one, the weeds are completely killed, including the underground parts. Land preparation and sowing of the crop can be done 15 days after the second application of the herbicide. No residual toxicity exists to affect the crop.

INTEGRATED PEST MANAGEMENT IN VEGETABLE SEED PRODUCTION

Maicykutty P Mathew

Integrated Pest Management (IPM) is the judicious use of various pest management techniques in a harmonious manner to reduce the pest population below economic threshold level, a level that will not cause economic damage. The methods include cultural and mechanical methods, use of host plant resistance, physical methods like use of various pheromone traps, light traps etc., use of biocides like botanicals and biopesticides and lastly, the use of synthetic chemical pesticides. The knowledge on the biology of the pest, mode of attack, season of occurrence of the pest etc. are very essential to select and execute the various management practices.

The important vegetable pests occurring in Kerala and their management practices are given below.

BHINDI

(1) **Shoot and fruit borer.** *Earias vittella* (Fb.)
Earias insulana

Dark brown coloured larva of these moths bores into the shoots and fruits of bhindi and feeds on the internal tissues. The attack results in drooping and wilting of shoots and fruits show bore holes on them plugged with excreta. The total life cycle of the pest takes place in 25 days.

Management:

1. Collection and destruction of attacked plant parts and spray 5% neem seed kernal extract (NSKE) or 4% neem leaf decoction (NLD).
2. Severe infestation can be controlled by spraying carbaryl at 0.15% at 15-20 days intervals.

(2) **Leaf hopper** *Amrasca biguttula biguttula* (Ishida)

Leaf hopper cause serious damage to the plant during summer months. The small green coloured nymphs and adults feed on the leaf sap from lower leaf surface and cause hopper burn on the leaves. The edges of leaves turn pale green, then yellow and finally brick red or brown in colour. This symptom is known as hopper burn. This is due to the injection of toxic saliva into the leaf tissue during feeding by the hoppers.

Management:

1. Initial infestation can be checked by the application of 2% neem oil garlic emulsion.

2. Severe infestation can be controlled by application of acephate (acetaf 0.75 g/l), acetamiprid (pride @ 1g/ 10l.) or imidacloprid (confidor @ 2.5 ml/ 10 l of water).

Other insects which cause mild to moderate infestation on bhindi are aphid, *Aphis malvae* (Koch.), leaf roller, *Sylepta derogata* Fb, petiole maggot, *Melanagromyza hibisci* Spencer, green semiloopers *Anomis flava* Fab. and *Xanthodes groellsi* Fsth, leaf beetle *Podagria bowringi* and red spider mite, *Tetranychus urticae* Koch.

Quinalphos at 0.05% controls the leaf roller, green semiloopers and leaf beetles. Aphid can be controlled by dimethoate 0.05% and the red spider mite by splashing water over the plant or by application of Kelthane.

BRINJAL

Shoot and fruit borer *Leucinodes orbonalis* Guen. and leaf hopper, *Amrasca biguttula biguttula* are the major pests of brinjal. In the case of shoot and fruit borer and leaf hopper the symptoms, mode of attack and management are similar to that on bhindi.

Another major pest on brinjal is the leaf beetle or hadda beetle, *Henosepilachna vigintioctopunctata* (Fab.)

The yellow spiny grubs and the tortoise shaped adults scrape the green matter from the leaves and results in drying up of leaves in patches. This type of damages is known skeletonization.

Management

1. Collect and destroy the life stages of the pest and spray NSKE 3 to 5% during initial periods of attack.
2. Severe infestation can be controlled by spraying carbaryl at 0.15% at 15-20 days intervals.

Other pests commonly occur on brinjal are aphid, *A. gossypii* Glover, Lacewing bug, *Urentius hystricellus* (Richt), leaf folder, *Antoba olivacea* Wlk., leaf caterpillar, *Selepa docilis* Butl, ants, *Solenopsis geminata* F. and red spider mite *T. urticae*.

Aphids and lacewing bugs, if occur seriously can be controlled by dimethoate. Caterpillar pests and beetles and grubs can be destroyed by applying NSKE 3-5% or quinalphos or carbaryl. The ants can be managed by keeping ant trap near infested plant or by dusting carbaryl or lindane into the ant nest. Ant trap is prepared by smearing jaggery inside a coconut shell and apply furadan granules over jaggary.

CUCURBITS (Pumpkin, cucumbers and gourds)

Melon fly, hadda beetle, gall fly, fruit borers, leaf miner, snake gourd semilooper etc., are the major pests of cucurbitaceous vegetables.

1. **Melon fly** *Bactrocera cucurbitae* (Coq.)

Serious pest of all cucurbitaceous vegetables. Adult fly inserts eggs into the rind of fruit. The emerging maggots feed on the tissues by remaining inside the fruit resulting in rotting of fruits. In addition to the attack on fruits the maggots are also seen feeding on flowers and inside vines of cucumber and bitter gourd. Infestation on vines results in drying up of the vines.

Management

1. The residues of the previous crop of cucurbits should be collected and burnt before the next crop.
2. Collect and destroy all infested fruits.
3. Place pheromone trap @ 1 number / acre to attract and kill the male flies from flowering onwards.
4. Place banana fruit trap @ 1 no. / cent to trap and kill both males and females.
5. Cover the fruits as far as possible with paper or polythene covers.
6. Bait spraying with malathion or carbaryl 0.2% containing sugar @ 10 gm / litre solution.
7. The adult flies can be controlled by spot spraying of protein hydrolysate and malathion over a large area. Spots are selected 7mts apart on both sides.

2. Hadda beetle / leaf beetle - *Henosepilachna septima*

The nature of damage, symptoms of attack and management etc., are similar to the leaf beetle on brinjal.

3. Leaf hopper *Empoasca (Empoasca) motti* Pruthi

Small green leaf hopper cause hopper burn on the leaves of bitter gourd only. Mode of attack and management of leaf hopper is similar to that on bhindi.

4. Gall fly – *Neolasioptera falcata* (F.)

Light yellow coloured maggots of the gall fly cause elongate galls on the vines of bitter gourd and coccinia. The pest attack results in reduction in growth of the plant.

Management

1. Collect and destroy the galls.
2. Apply NSKE 3% regularly at 15 days intervals.

5. Fruit borers

a. Eudioptis indica (Saund)

b. Helicoverpa armigera Hubner

Eudioptis indica

The adult moth is a delicate moth. Wings are white in colour with dark brown borders. Caterpillar is green in colour with a pair of white lines on the dorsal side. It is a leaf folder of cucurbits. They also bore into the flower buds and fruits of cucumber, pumpkin and bitter gourd.

Management

1. Collection and destruction of the early infested leaves with caterpillars inside give good control of initial infestation.
2. A combination of *Bacillus thuringiensis* formulation Dipel @ 1 ml / litre with acephate 0.05% give good control of the pest.

Helicoverpa armigera

The caterpillars are slight yellowish brown with lines on the body. These are fruit borers of bitter gourd. Usually the larva inserts half of its body into the fruit and feed on the tissues. There is no rotting of fruits as seen in fruit fly attack.

Dipel + acephate controls the pest effectively. Carbaryl can be sprayed in seed production plots.

6. American serpentine leaf miner *Liriomyza trifolii (Dietars)*

This pest was introduced in India during 1991. Severe infestation is seen in pumpkin, ash gourd, cucumber and snake gourd. The maggots feed on the mesophyll tissues after mining the leaf resulting in serpentine mines on the upper leaf surface. Maggots fall to ground and pupates in soil. Adult is a small black fly with yellow scutellum.

Management

1. Collection and destruction of early infested leaves of crop plants. Weeds serving as collateral hosts should be removed.
2. NSKE 3-5% gives good control of the pest.
3. Synthetic insecticides kill the natural enemies of the pest, hence repeated chemical application increases pest attack.

7. Snake gourd semilooper *Anadevidia peponis* (Fb.)

Among cucurbits, this pest attacks only snake gourd and bottle gourd. The green coloured semilooper with black warts on the body is a defoliator of these crops. They are seen on the lower leaf surface. Usually older caterpillars cut the leaf at the base and the leaf is seen partially wilted. Hence it is very easy to locate such infested leaves. The pest pupates pest in a leaf fold on the plant itself.

Management

Collection and destruction of wilted infested leaves with the caterpillars give good control. If severe infestation occurs, a contact insecticide like quinalphos or carbaryl can be used.

AMARANTHUS

The major pests of amaranthus include two species of leaf webbers, namely, *Hymenia recurvalis* (Fab.) and *Psara basalis* F., amaranthus weevil,. *Hypolixus truncatulus* (F.) and panicle borers, *Conogethes punctiferalis* and *Helicoverpa armigera.*

Leaf webbers *Hymenia recurvalis* (Fab.)

The adult is a black moth with wavy white markings on wings. The green coloured caterpillar webs together leaves and feeds from within skeletonising the leaves completely. Several larvae are seen within webbed up leaves. Total life cycle takes about 27 – 28 days.

Leaf webbers *Psara basalis* F.

Adult is a small moth having yellow forewings with faint black dots. Life cycle and damage caused by both species are similar.

Management

(1) Prompt collection and destruction of webbed leaves.

(2) Application of a contact insecticide like quinalphos 0.05% or DDVP 0.05% will control the pest.

Amaranthus weevil *Hypolixus truncatulus*

The cream coloured legless grubs of the weevil attack the plant by boring into branches and stems causing twisting and swelling of branches and stem. The attack results in suppression of shoots and leaf production. Total life cycle from egg to adult takes place in 6 weeks.

Management

1. Destruction of wild amaranthus hosts and affected plants.
2. Hand picking and killing of the adults seen on the plants.

Panicle borer *Conogethes punctiferalis* (Guen.)

Moth is yellow with small black spots all over the wings. The caterpillars feed on the flowers and also bore into the central rachis causing drying of the inflorescence. In seed production plots, this pest can cause serious damage.

Panicle borer *Helicoverpa armigera* (Hiibner)

The caterpillars bore into the panicle of amaranthus, resulting in the drying of panicles.

Management

1. Hand collection and destruction of the larvae seen on the panicles.
2. Application of contact insecticide like carbaryl 0.15% gives good control.

COWPEA

Aphid, *Aphis craccivora* Koch.

Small, soft bodied sucking pest of cowpea which is brown in colour. These occur in groups and suck juice from flower buds, leaves, shoot tip etc., causing curling and crinkling of leaves. General yellowing results due to aphid attack. Fruits get malformed. Aphids transmit cowpea mosaic disease.

Management

1. Lady bird beetles, their grubs and maggots of hover flies are usually seen as predators of cowpea aphid. If predators are seen in large numbers, there is no need for any control.
2. The fungus, *Fusarium pallidoroseum* is very effective against this aphid. Neem oil emulsion or use of synthetic chemicals like malathion 0.05% or dimethoate 0.05% is effective.

Pod borers

(a) *Maruca testulalis* Guem.

(b) *Lampides boeticus* Linn.

These are the most important species of pod borers of cowpea in Kerala. Caterpillars bore into the pods and feed on the seeds inside. Caterpillar of *M. testulalis* is brownish green with black warts and is very active. They also web the flowers and bore into them.

L.boeticus larva is flat and pale green or violet in colour, which bores into the buds or pods and feed on the internal tissues. The caterpillar is usually attended by ants which are attracted to the secretion produced by glands present on the abdomen.

Management:

1. Neem seed kernel extracts 3.5% or neem leaf decoction 4% at regular intervals controls the pest to a great extent.
2. Carbaryl 0.15% can be applied at 15-20 days intervals in seed production plots. Synthetic pyrethroids like cypermethrin, fenvalerate etc., are found to be very effective against pod borers.

DISEASE MANAGEMENT IN VEGETABLE SEED PRODUCTION

Beena, S and Sally K Mathew

Diseases of seeds are the result of an interaction between the susceptible host, the pathogen involved and the environment. The seeds may carry several destructive pathogens usually result in severe infection on crops raised from them. The seedlings raised from the diseased seeds not only suffer from damage, but also produce large amount of inoculam which further helpto spread the disease to vast areas. Seed transmission of pathogen their establishment and development in the host are influenced by environmental conditions. Atmospheric temperature and soil moisture play an important role in seedling infection, subsequent disease establishment and spread.

Many seed borne pathogens are asymptomatic. Any infectious agent which is associated with the seeds having the potential of causing a disease of a seedling or plant pathogens are associated in three different ways with seeds.

1. Infestation (Externally seed borne)
   The pathogen may be present just on the surface of seeds and adheres to its either as sperm or mycelium. This occurs during harvesting or threshing.
2. Infection (Internally seed borne)
   The pathogen lies within the tissues of seeds and emerges as the seedlings come out. Infection of seeds may occur on the crop itself.
3. Concomitant contamination
   Here the seed material is mixed with bits of infected crop tissues or with microscopic parts of the pathogen.

Damage caused by seed borne pathogens

Seed borne pathogens cause significant yield loss, affect seed germination or cause seed abortion and produce symptoms on seeds such as discolouration, rotting, shriveling, reduction in size etc. Seeds serve as most important source for the perpetuation of pathogens and cause biochemical deterioration and change the quality of seed nutrients. Some pathogens and saprophytes produce toxins in seeds.

Seed borne pathogens

Pathogens associated with seeds are fungi, bacteria and viruses. Fungi form the major group of pathogens and can be seed borne or transmitted through seeds. Fungi that attack seeds are classified into field or storage fungi on the basis of their ecological requirement. Field fungi invade seeds either during development or after maturity, but before harvest. Generally damage caused by field fungi occurs in the field with little or no damage during storage. Storage fungi generally deteriorate seeds after harvest, when relative humidity and temperature are high. Normally they do not cause diseases in the field, it affects the seed germination and causes discolouration and shrinkage of seeds. Main storage fungi are species of *Aspergillus* and *Penicillium.*

Seeds serve as an important means for the survival of plant pathogenic bacteria and also for the development of epiphytotics and bacterial diseases. They are associated with seed coat or other tissues of the seeds. Most of the seed transmitted plant viruses are found in embryo of seeds. Successful seed transmission of viruses occurs when the host is infected systemically prior to flowering and when the virus is able to invade either pollen or the ovule. None of the plant diseases caused by phytoplasmas and PLO are known to be seed transmitted.

Important seed borne pathogens associated with vegetable seeds and diseases caused by them

Fungi constitute the major seed borne pathogen associated with vegetable seeds. Field infection by these fungi cause leaf spot, anthracnose, die back, blights, damping off, wilt and fruit infection. Bacteria and viruses are also responsible for seed borne diseases in vegetable, causing bacterial leaf spots, and mosaic respectively.

Table. Major seed borne diseases caused by various pathogens.

Crop	*Diseases*	*Causal organism*
Chilli	Seedling blight Damping off Dieback and fruit rot Leaf blight and fruit rot Bacterial leaf spot	*Rhizoctonia* spp., *Fusarium* spp. *Pythium* spp., *Phytophthora* spp. *Colletotrichum capsici* *Alternaria* spp. *Xanthomonas vesicatoria*
Tomato	Damping off Seedling blight Early blight Fruit rot Mosaic Bacterial leaf spot	*Phythium* spp., *Phytophthora* spp. *Rhizoctonia* spp., *Alternaria* spp. *Alternaria solani* *Phytopthora* spp. Tobacco mosaic virus *Xanthomonas vesicatoria*
Brinjal	Damping off Leaf spot and fruit rot Fruit rot and leaf blight	*Pythium spp., Phytophthora* spp. *Alternaria tenuis, A. melongena, A. solani* *Phomopsis vexans*
Cowpea	Dry root rot Anthracnose Seedling blight Mosaic Bacterial blight	*Macrophomina phaseolina* *Colletotrichum lindemuthianum.* *Ascochyta* sp. Cowpea mosaic virus *Xanthomonas axonopodus* pv *vignicola*
Beans	Anthracnose Bacterial blight Mosaic	*Colletotrichum lindemuthianum* *Xanthomonas axonopodis* pv. *phaseoli* Bean common mosaic virus
Cucurbits	Anthracnose Seedling blight Fusarium wilt Angular leaf spot Bacterial leaf spot Mosaic	*Colletotrichum. lagenarium* *Rhizoctonia solani* *Fusarium oxysporum* *Pseudomonas salvastoni* pv.*phaseolicola* *Xanthomonas cucurbitae* Cucumber mosaic virus Cucumber green mottle mosaic virus

Disease management

Control of seed borne pathogens and diseases can be attained through integrated disease management. This include

1. Crop management

Proper crop management can help in the production of relatively pathogen free seeds. For that, use high quality seeds, adopt correct seedling rate, adjust the planting time and apply balanced fertilizers.

2. Planting method

Keep the correct spacing while planting seedlings and adopt proper water management.

3. Crop rotation to reduce soil inoculum.
4. Keep isolation distance between seed production and commercial plots.
5. Roguing out of infested plants from the field.
6. Insect control
7. Weed control
8. Harvesting in time
9. Seed certification
10. Foliar spraying with fungicides to control diseases in the field
11. Seed treatment

Seed treatment include physical/ mechanical, chemical and biological method to eliminate externally or internally seed or soil borne micro organism. This will help in the emergence of healthy seedlings and subsequently healthy plants. Seeds may be treated to promote good seedling establishment, to minimize yield loss or to maintain and improve quality and to avoid further spread of pathogen. The physical methods include visual observation of seeds and remove infected seeds before sowing. Another method is hot water treatment, but this may sometimes reduces the germinability of seeds, Biological method means the use of antagonistic organisms against the pathogen and are applied on the seed as dry or wet seed treatment. Commonly used biocontrol agents are *Trichoderma* spp. *Chaetomium globosum*, *Bacillus subtilis, Pseudomonas fluorescens* etc. For the seed treatment, fungal antagonists @ 4-5 g/kg seed and the bacterial antagonists @ 10g/seed is recommended.

Application of chemicals/ fungicides to seed is the cheapest and most effective means for controlling most of the seed borne diseases. Commonly used chemicals for fungal pathogens are thiride, captan, captafol, carbendazim, benomyl, metalaxyl (Aproon) 2g/ kg seed. Streptomycin sulphate and streptocycline @ 100 ppm for 30 minitues dip are recommended against bacterial pathogens. Trisodium phosphate @ 5g/litre for 20 minutes is recommended for the management of seed borne virus diseases.

HARVESTING AND PROCESSING OF VEGETABLE SEEDS

Mini, C

Harvesting, extraction, drying, storage and packing form the major operations in the post harvest handling of seed production. These operations marketedly influence the seed yield and quality, especially its viability.

I. HARVESTING

Proper harvesting for high yields of better quality seed aims at determining the ideal time and stage of harvesting.

Stage of harvest has a direct bearing on seed quality. In general, the later the crop is harvested, the greater will be the seed yield. In several vegetables, the earlier ripened seed may be lost before the bulk of the crop is ready to harvest. Delayed harvesting in such cases may cause heavy crop losses. The optimum time of harvest for a given seed crop is the point beyond which losses will be greater than the potential seed yield which requires further ripening. Hot dry weather conditions greatly accelerate the rate of natural seed drying on the plant.

Vegetable seed crops are divided into three broad groups, such as dry fleshy fruits and wet fleshy fruits depending on the state of seed at harvest time.

The harvesting of seed or fruits containing the seed may be carried out manually or mechanically, depending upon the scale of production, cost and availability of labour and availability of suitable harvesting machines.

Shattering is the opening of seed heads in the field before the seed crop is harvested. Shattering may lead to heavy crop losses in some instances. The seed crop must, therefore, be secured before a significant amount of seed is lost either by shattering, lodging or loss by birds.

Prolonged prevalence of low humidities and a dry weather increase the incidence of shattering. The crop plants which show tendency to drop their seeds by shattering should, therefore, be harvested and handled at times of comparatively high relative humidity. Crops prone to shattering should preferably be handled early in the day or after rain. Similarly, the greenhouse crops may be harvested after irrigation.

Sprays of plastic solutions or polyvinyl acetates have been recommended to prevent the seed loss by shattering. The economics of application as well as their effects on seed yield and quality need to be investigated.

Lodging of a seed crop before harvesting may be caused by wind, higher levels of applied nitrogen during early plant growth, heavy rain and stray animals. The lodged crops are difficult to harvest and deterioration in seed quality may be encountered when seeds are harvested during wet seasons.

Many of the small vegetable seeds are prone to loss by birds before harvest. Human labour may be employed to scare the birds if labour is cheap and easily available. A wide range of appliances, such as rattles, gongs, clapping, scarecrows and aerial balloons are used to protect the crop from birds. Small experimental plots of vulnerable seed crops can be covered by fine mesh nylon nets supported on a frame- work of posts and wires.

Number of days to seed maturity for different tropical vegetables is shown below

No.	*Crop / varieties*	*Number of days to maturity (seed - to- seed)*
1	Amaranth	90-150
2	Ash gourd	90
3	Bitter gourd	65
4	Brinjal	77
5	Bottle gourd	75
6	Chilli	65-77
7	Bush cowpea	65
8	Pole cowpea	70
9	Cucumber	70
10	Jack bean	95
11	Okra	80
12	Pumpkin	90
13	Snake gourd	65
14	Sword bean	98
15	Tomato	75
16	Watermelon	80

In a commercial seed production programme we have to assess the proper seed maturity based on certain visual indices. Many workers have reported fruit maturity standards for seed production of many vegetables, which have been mentioned in concerned chapters.

II. SEED EXTRACTION

Threshing

Threshing involves beating or rubbing the plant material to detach the seed from its pod or fruit. Seed has to be extracted from dry seed heads (eg onion, lettuce, brassicas), dried fruits (chilli, pepper and gourds) or from fleshy fruits like tomato, cucumbers and melons in which the seeds are wet at the time of extraction.

In traditional method, threshing is carried out by beating or rolling the seed containing material to separate it from other plant debris or straw. Hand threshing is simplest and can be a cheaper method if sufficient labour is available. Seeds may be hand- rubbed (legumes), beaten against a solid wall (lettuce) or on the ground with stick (dried fruits).

Various types of threshing machines with adjustable cylinder speeds are available for extraction of vegetable seeds. Every care must be taken to avoid damage to the seed during mechanical threshing. Dry seeds are generally more brittle and more prone to damage during threshing operations.

Wet seed extraction

Wet seed extraction is followed in certain vegetable crops which bear ripe seeds in fleshy fruits, e.g. tomato and cucumbers. Such seeds have a gelatinous layer around them. The seeds along with this gelatinous material and the pulp are squeezed or scooped out from the cut fruit into containers. The fruit skin and other cell debris are discarded. The pulp containing the seed is allowed to ferment for 1 to 5 days depending up on the stage of fruit ripeness and fermenting temperature. Completion of the fermentation process leading to break down of gelatinous coating can be determined by daily inspections. The mixture must be stirred daily to allow uniform fermentation and avoid seed discoloration. After the completion of the fermentation process, the seed is washed repeatedly. The light seed and other debris floating on the surface should be discarded, and the remaining quality seed is finally collected.

Dilute inorganic acids such as hydrochloric acid may also be used to separate gelatinous material from the seed. The mixture of pulp and acid is stirred for about 30 minutes and seed is washed out as described above. Seeds of some fleshy fruits like melons, sweet peppers etc which are also extracted wet, do not require fermentation. They are simply macerated and rubbed in water.

All wet extraction processes should be completed as quickly as possible in order to reduce the possible deterioration by microorganisms. All utensils, sieves and other apparatus used for seed extraction processes should be cleaned thoroughly between each seed batch to avoid admixture of seed lots and to maintain high seed purity. Legislation in most countries does not allow such impurities beyond a certain level.

III. SEED DRYING

Seed moisture is probably the most important factor influencing the longevity and germination capacity of the seed. Seeds contain natural moisture, which at harvesting time is often higher than the optimum required for the maximum potential life and best germination. Seed drying involves removal of excess moisture to acceptable level for packaging and storage.

Seed ripening is usually associated with significant loss of moisture in favour of food reserves. The moisture content of most seeds at harvest may be less than about 50%. After the seed is detached from the mother plant, its moisture content is a function of relative humidity and it is at equillibrium with that of the surrounding air. Seeds of fleshy fruits such as tomato, cucumber and melons, have a much higher moisture content at harvest, and may absorb more water during their wet extraction process. On the contrary, seeds formed in fruits which become desiccated during the ripening process are relatively dry at the time of harvest, eg. Amaranth.

Advantages of drying

1. Makes, threshing easier.
2. Helps in easy removal of impurities from the mixture.
3. Increases the longevity of the stored seed.
4. Increases the viability of the seed due to reduced respiration, prevents seed from heating up during storage, especially in tightly packed seed lots.
5. Slows down the activity of storage moulds.

However, an excessive drying of large seeded legumes may cause cracking of hypocotyls, seed coats or whole seeds. Under humid tropical conditions, the freshly harvested vegetable may have a moisture content ranging from 18 to 35%, which must be reduced to a 'safe level'. The safe moisture level for open storage of starchy seeds is 12%, oily seeds is 9%, and for seeds to be stored under seal is 6 to 8%.

Influence of temperature on seed drying

Depending upon the climate and the method of harvesting, seeds may or may not be dry enough for storage after the threshing process. Artificial drying can depress seed germinability, giving rise to abnormal seedlings, affecting the permeability of the seed coat, destroying enzymes or causing the outer layers of seed coat to become hard so that when seed imbibes water and swells, the testa cracks and separates from the cotyledons. The seedlings emerging from such seeds show reduced vigour and poor field establishment.

The temperature and duration of seed drying play an important role in the retention of seed viability. Temperature up to 45°C are generally safe but higher temperatures may be injurious. The time or duration of seed drying will depend upon the initial seed moisture, the final moisture content required, rates of seed drying and forced air flow, air temperature and relative humidity of the atmosphere. The final moisture content for the safe or satisfactory seed storage will depend on the crop species as well as on the method of storage employed.

After drying, the seed must be cooled by forced ventilation before it is stored. Based on drying rate, seeds are divided into quick driers (eg. Cucurbits), Medium driers (eg. Tomato) and slow driers (eg. Peas and beans).

The basis for calculating drying rate is that 0.3 per cent of seed moisture is removed per hour at an air flow rate of 4 cu m per minute per cu m of seed held at 43.5°C.

Methods of drying

Natural drying

The seed is dried under the sun, spreading it in a thin layer on a suitable surface such as mats or concrete floors. This method utilize solar and wind energy to dry smaller quantities of seed most effectively. Natural sun drying is generally employed in the areas with prolonged arid conditions with brighter sunlight.

However, sun drying is time consuming and direct exposure to sunlight may affect germination capacity, particularly when the seeds containing high moisture are exposed prolonged solar radiation with high temperatures and ultra violet radiation.

Artificial drying

Artificial drying using heated air is required to be followed in the temperate and humid tropical regions where natural drying cannot be adopted with efficiency. Artificial drying are divided into continuous and batch drying systems.

The rate or drying must be appropriate to retain the seed viability. Too rapid or too slow rate can damage the seed either by withdrawing water too quickly or through accelerated deterioration caused by delayed drying.

Different processing equipments used in vegetable seed production are furnished in Table 1.

Table 1. Vegetable seed processing equipments

No.	*Name of equipment*	*Use*
1	Axial flow vegetable seed extracting machine	For extraction of watermelon, cucumber, ash gourd, brinjal, tomato and chillies
2	Seed driers	For drying seeds
3	Screens Air separators (winnower) Air screens	To separate undesirable materials from desirable seeds
4	Seed separators Magnetic separators Spiral separators Gravity separator Electronic colour separator	For cleaning seeds and upgrading the quality of cleaned seeds
5	Roll Mill	To separate smooth seeds from those having rough seed coats or irregular shape
6.	Picker belts	To remove off coloured, mis-shapen and broken seeds from seed lots
7.	Slurry seed treater	For treating the materials in slurry form.
8.	Automatic seed packing machine	For packing and sealing seed packets automatically
9.	Polisher	To improve lustre of seeds

IV. SEED CLEANING AND GRADING

Seeds are to be cleaned by winnowing and graded to free them of undesirable contaminants, like chaff, straw, soil, stones etc.

V. SEED BLENDING

Seed blending is for improving quality of marginal seed lots by mixing them with seeds having exceptionally high quality. The exact quantity of high quality seeds required for blending can be calculated by establishing a simple balance equation based on the principle of conservation of mass.

SCIENTIFIC SEED STORAGE

Mini, C

The purpose of seed storage is to maintain the seed in good physical and physiological condition from the time they are harvested until they are planted.

The seeds are considered to be in storage from the moment they reach physiological maturity until they germinate, or until they are considered worthless. The entire storage period can be conveniently divided into following stages:

1. Storage on plants (physiological maturity until harvest)
2. From harvest, until processed and stored in a warehouse
3. In storages (warehouses)
4. In transit (rail wagons, trucks, carts, railway sheds, etc.)
5. In retail stores
6. On the user's farm

The seed quality can be considerably affected at any of the stages mentioned above, unless sound principles involved in seed storage are practiced and the seeds properly handled.

Type of seed and storage requirement

The type of storage needed can be related to the time of storage expected and can be classified into four.

1. Commercial seed

The largest storage need of about 75- 80% is for the storage of seed from harvesting until planting time. The storage period ranges from a few days to eight or nine months. Usually gunny bags are used for storage. In this type of storage, sum of relative humidity (per cent) and temperature is above 80.

2. Carry over seed

About 20-25% of the stored seeds may have to be carried over through one growing season to second planting time. The storage period is usually between 1 to 1½ years. Use of storage bags, sealing the floor against moisture penetration, storage of seeds in steel bins with tight fitting lid or moisture proof bags etc. are needed. Sum of RH (%) and temperature (°C) of storage conditions should be around 70.

3. *Foundation, stock and enforcement seed samples*

Enforcement of seed sample must be kept for a year or more with germination per cent as same when the sample was drawn. These specifications calls for a much better seed storage facilitates than are needed for commercial or carry over seeds. Dehumidifiers, refrigerator and desiccants like silica gel, activated aluminium or lithium chloride can be used for the storage of foundation seeds. For long term storage of 3-5 years, the sum of relative humidity (%) and temperature (°C) of storage atmosphere should be around 30-45.

4. *Germplasm seeds*

Seeds are to be kept for very long period. Storage temperature should be the lowest economically possible and seed moisture equilibrium with 20-25% RH. Storage building should have rooms maintained at 5°C–10°C and 30% RH. Cryopreservation of seeds are done at –196°C using liquid nitrogen in different containers like plastic cryovials, foil laminated envelopes and sealable metal cans.

Factors affecting longevity of seeds in storage

At physiological maturity, seeds generally have maximum germination and vigour if conditions during growth of plants are optimum. However, seeds lose viability during storage. It is decided by a number of factors.

1. Genetic effect/ type of seed/ natural longevity
2. Harvest effects and initial seed quality
3. Moisture content of the seed
4. Moisture content of the storage atmosphere (relative humidity)
5. Temperature of storage atmosphere
6. Insect and diseases
7. Oxygen pressure in storage
8. Seed packing and packaging materials

1. Genetic effects/ type of seed/natural longevity

The longevity of seed primarily depends on its inherent keeping quality which varies with species. Tropical species generally live for shorter period. Onion and brinjal have short life span where as *Cucumis sativus, Cucumis melo, Cucurbita* sp. have long life span.

Based on the relative storability index, when stored under ambient conditions after 3-5 years, vegetables are classified into three categories.

Category	*Characters*	*Vegetables*
I	Include plants in which 50 percent or more of seeds can be expected to germinate after 1-2 years of storage under favourable ambient conditions.	Cowpea, beans, pepper, onion.
II	Include plants in which 50 percent or more of seeds can be expected to germinate after 3-5 years of storage under favourable ambient conditions.	Pumpkin, watermelon, muskmelon, cucumber, okra.
III	Include plants in which 50 percent or more of seeds can be expected to germinate after 5 years of storage under favourable ambient conditions.	Tomato

In addition to species variability, there is significant differences in storage potential between cultivars of the same species.

Differences in longevity have been observed (Table 1) in different muskmelon cultivars having genetic variability for yield attributes. Seeds were packed in paper bags and stored under ambient conditions (16- 35^{0}C, RH 25-90% for 5 years).

Table 1. Seed viability in different cultivars of muskmelon

Cultivars	*Germination %*	
	Initial	*After 5 years of storage*
Hara Madhu	100	90
Durgapura Madhu	96	83
Punjab Sunheri	91	68
Main stream	95	60
Gulf stream	85	57
Bokor	99	55
Arka Jeet	80	38
UFG-510	97	19
Koy Bush	99	2

Varietal differences are also reported in crops like cucumber, peas, watermelon, brinjal etc.

2. Harvest effects and initial seed quality

A major factor that affects seed quality and its subsequent performance is the seed maturity at harvest. Seeds attain maximum quality at their physiological maturity. At this stage seed moisture content will be relatively low and the embryo will be in the fully developed condition. Harvesting a crop at correct stage eliminate the field damage to the seed by way of exposure to the inclement (wet) weather conditions as well as to the field pests and pathogens. Seeds harvested before and after physiological maturity had poor storage life.

Mechanical damages to seeds during harvesting, processing or drying can reduce the potential storage life. Damaged seeds lose vigour than undamaged ones and are more vulnerable to storage pests and pathogens. Large seeded legumes are the most susceptible species to mechanical damage. Excessive moisture in the seed, especially if seed is immature, cause damage during processing. Over drying will produce brittle seed predisposed to breaking. Even the method of drying is found to affect the storability. It is seen that shade dried seed in brinjal is found to have better storage potential when compared to sun dried seeds.

3. Moisture content of seeds

Under humid tropical conditions, freshly harvested seeds will have moisture content ranging from 18- 35%, which has to be reduced to safer levels for storage. A one percent reduction in seed moisture doubles the life of the seed, if moisture content is in the range of 5 to 14%. Safe moisture level for open storage of starchy seed is 12%, for oily seed is 9% and for vegetable seeds under seal 4-8%. Under high moisture content, heating due to microorganisms will occur if oxygen is present, resulting in rapid death of seeds. If seed moisture is above 10-13 percent, sprouting, heating and fungal invasion can occur thus destroying the seed viability quickly.

4. Moisture content of the storage atmosphere

Seeds are hydroscopic and the moisture content of a seed normally comes to equilibrium with the ambient relative humidity. Seeds that are hard coated (eg. Legumes) are exceptions. Each kind of seed will attain a characteristic moisture content at a given RH and at a particular temperature which is called equilibrium moisture content (Table 2).

Table 2. Equilibrium moisture content of vegetable seeds at different RH at 25°C.

Seeds	Relative humidities (%)				
	15	30	45	60	75
	Moisture content on percent weight basis				
Okra	7.5	8.0	9.5	11.0	13.0
Tomato	6.0	7.0	8.0	9.0	11.0
Chilli	6.0	7.0	8.0	9.0	11.0
Watermelon	6.0	7.0	8.0	9.0	10.5
Cucumber	6.0	7.0	7.5	8.0	9.5
French bean	5.0	6.5	8.5	11.0	14.0

Table shows that as the RH of the storage atmosphere increases, seeds absorb moisture and increases its moisture content, indicating the importance of RH of storage atmosphere in deciding the seed moisture.

Control of seed moisture can be achieved by using several methods listed below.

1. Ventilation
2. Moisture-proofing
3. Dehumidification
4. Sealed containers
5. Desiccants

Ventilation is an effective technique for reducing the temperature of storage and of the seeds in it. It could also help in further drying of seeds. However, under any circumstances, the ventilation alone will not be adequate to improve the storage.

Moisture-proofing is useful to moisture-proof a storage which is relatively less expensive than insulating a store. The three most common moisture-proofing materials are polyethylene, asphalt and aluminium foil. To be effective, polyethylene should be 10 mm thick, asphalt should be 3 mm thick and aluminium foil should be bonded by moisture-resistant plastic to some surface (such as paper) that will keep the foil from cracking. Whichever material is selected, the entire storage structure must be made moisture-proof. The doors, should be moisture-proofed and gasketed like cold storage doors. There should be moisture-proof coverings over ventilation openings when they are not in use. A storage that is moisture-proofed will allow essentially no moisture leakage from outside.

In constructing a seed storage, moisture-proofing and insulation are done together.

Dehumidification

If the relative humidity within the room averages above 60 per cent, special dehumidification becomes necessary. There are two major types of dehumidification.

(a) Refrigeration type

(b) Chemical or adsorption type

Refrigeration type

The refrigeration type dehumidifier operates by draining warm moist air over a metal coil, through which a refrigerant such as freon is circulated. A part of the atmospheric moisture condenses on this cooling coil and is collected in a pan, or is drained off. The cooled air coming from over the coil, which now has a low temperature and a high relative humidity, is re-heated by the condenser coil of the refrigeration system. This raises the temperature and lowers the relative humidity.

Adsorption type.

The adsorption type dehumidifier operates by draining moist air over a solid drying agent (desiccant), which has the ability to extract and retain moisture on its surface by a phenomenon known as adsorption. The air is filtered and dried to a very low dew point in the process, and the desiccant is periodically regenerated by means of heated outside air which vapourizes the moisture and dispels it to the outside of the conditioned space.

Desiccant dehumidifiers provide maximum efficiency at low temperature and are able to maintain constant relative humidities even below ten per cent.

Sealed containers

Storage of well dried seed, in sealed containers is one of the most effective methods of controlling seed moisture. If seeds are first dried to a safe moisture levels and then stored in sealed moisture vapour proof containers, the low moisture content of the seed will be maintained even under storage conditions of high relative humidity also.

Use of desiccants

Since moisture-proof containers are difficult to open and reseal, they are not very useful for small samples that must be readily accessible. Such samples could be stored in metal boxes with gasketed snap-on lids or with a desiccant (e.g., silica gel) enclosed with the seed samples. Silica gel is available with all or some of the granules treated with cobalt chloride. The usual cobalt chloride treated silica gel turns from blue to pink at about 45 per cent relative humidity. The silica gel (1 kg per 10kg seeds and packets) is dried and enclosed with the seeds in metal box. When the granules turn pink the silica gel is removed, reactivated by drying in an oven at 175°C, cooled in a sealed container and returned to the metal box. The seeds are thus kept below equilibrium with 45 per cent relative humidity, a moisture content desirable for several years of storage in a temperature range of 20 to 25°C. The only care required is periodic inspections to make certain that the indicator silica gel remains blue.

5. Temperature of storage atmosphere

Temperature is an important factor, which affects the seed viability in storage. Higher the temperature more rapid is the seed deterioration at a given moisture level. Harrington's thumb rule relating to storage temperature suggests that for every 5^{0}C decrease in storage temperature, life of the seed, kept between 0^0 and 50^{0}C, doubles.

In practice it is the combined effect of temperature and relative humidity, which affects the longevity in storage. Germinability of seed is significantly affected by storage conditions. Germinability is high (97%) in seeds stored in cold storage and it is maximum (100%) in subzero temperature (-18^{0}C and RH 40%).

Temperature control may be achieved by one of the following ways:

1. Ventilation 2. Insulation 3. Refrigeration

These methods are not mutually exclusive, and are normally used to supplement each other.

Ventilation

Ventilation could be used to reduce seed temperature and seed moisture content, if used judiciously. In addition, it also helps prevent hot spots from developing, the formation of convection air currents and maintenance of uniform seed moisture content and temperature.

Time of ventilation. Whenever the outside temperature and relative humidity are low enough to benefit the seeds, either by reducing seed temperature or seed moisture content, the ventilating fans (exhaust fans) can be turned on.

Determine the temperature and relative humidity of air inside and outside the storage. The temperature is measured with thermometers and the relative humidity with a psychrometer. After determining these values it could readily be determined from Table 3 when it is safe to ventilate a storage room in order to cool it without increasing seed moisture.

Table 3. Method to calculate the time of ventilation of the seed storage (Harrington and Douglas, 1970)

Storage Condition		*Outside temperature in °F*										
		95°	90°	85°	80°	75°	70°	65°	60°	55°	50°	45°
Temp, (°F)	*RH. (%)*	*Ventilate at these temperatures when the relative humidity % is less than the figure given*										
100	90	100	100	100	100	100	100	100	100	100	100	
	80	93	100	100	100	100	100	100	100	100	100	100
	70	81	95	100	100	100	100	100	100	100	100	100
	60	69	80	94	100	100	100	100	100	100	100	100
	50	58	67	79	92	100	100	100	100	100	100	100
	40	47	55	63	75	89	100	100	100	100	100	100
90	90	–	90	100	100	100	100	100	100	100	100	100
	80	–	80	94	100	100	100	100	100	100	100	100
	70	–	70	82	96	100	100	100	100	100	100	100
	60	–	60	70	83	98	100	100	100	100	100	100
	50	–	50	58	69	81	95	100	100	100	100	100
	40	–	40	47	54	65	77	90	100	100	100	100
80	90	–	–	–	90	100	100	100	100	100	100	100
	80	–	–	–	80	94	100	100	100	100	100	100
	70	–	–	–	70	82	98	100	100	100	100	100
	60	–	–	–	60	70	83	100	100	100	100	100
	50	–	–	–	50	59	70	82	99	100	100	100
70	90	–	–	–	–	–	90	100	100	100	100	100
	80	–	–	–	–	–	80	96	100	100	100	100
	70	–	–	–	–	–	70	82	99	100	100	100
	60	–	–	–	–	–	60	72	85	100	100	100
	50	–	–	–	–	–	50	59	70	83	100	100

Insulation

Insulation of seed storage is done to reduce the flow of heat from the warmer exterior, through the walls, roof, and floor of the storage, to the cooler air and seeds in storage. Heat flow depends upon:

1. Temperature difference between the two places in the material- Heat flow is twice as fast with a 20° temperature difference as with a 10° difference.
2. Distance the heat must flow- Heat flows twice as fast through one inch of insulation as through two inches of the same material.

Based on the thermal conductivity value, air, mineral wool, glass wool, cork board, form polystyrene, fibre board and saw dust are considered as good insulators. But no material is considered as a perfect insulator.

Refrigeration

The basic objective of refrigeration is to keep the storage temperatures below the usual ambient temperatures. An alternative to refrigeration is storing the seeds dry, either by using dehumidification or by drying and storing in sealed containers. Refrigeration often becomes necessary for carry-over seeds, special kind of seeds, foundation seed and nucleus seed/ breeder seed.

Refrigeration alone is not considered sufficient for storage of seeds. Refrigeration storages must be used in combination with dehumidification, or with sealing the dried seeds to moisture-proof containers before they are placed in refrigerated storage.

One consideration frequently overlooked in seed storage is the climate of the place where the seed storage is located. There are large variations from one area to another when the mean temperature and relative humidity data for different months are combined. It is important to recognize these differences in planning the seed storage needs in different areas.

6. Insect and diseases

Insect pests often cause substantial loss to the stored vegetable seeds. Moisture content of seed and ambient temperature are two vital factors influencing insect infestation in storage. Most of the vegetable seeds can be made free from insects by keeping them at low moisture content below 8%.

Compared to insects, seed borne pathogens cause more significant yield losses. They cause symptoms on the seed such as discolouration and shrivelling, results in biochemical deterioration, changes quality of seed nutrients and some pathogens also produce toxins. So application of chemical is the safest, cheapest and most effective method in controlling seed borne diseases. The details of management of stored pests and seed borne diseases are dealt in separate chapters.

7. Oxygen pressure in storage

Researches on the role of gaseous environment on seed viability indicates that increase in pressure of oxygen tend to decrease the period of viability.

A study conducted to know the effect of partial vacuum on viability of bell pepper seeds, showed that the viability of the vacuum packed bell pepper seeds stored in paper foil polyethylene bag under ambient conditions (16-35°C and 25-90% RH) was more compared to control.

In sealed containers oxygen concentration in the atmosphere decreases and the carbon dioxide concentration increases with time, whereas in open storage, composition of atmosphere remains constant. It is not feasible to continually adjust the composition of the atmosphere in sealed containers

8. Seed packing and packaging materials

The seed package, in reality, is a small storage container. The kind of container needed is affected by several factors including

- The quantity of seed desired in each package
- The protection desired
- The cost of package
- The value of seeds
- The storage conditions into which the container is to be placed
- The facilities for drying the seeds
- Period of storage and its environment

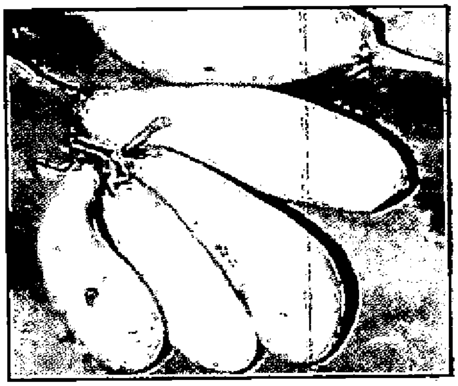
Packaging of seed result in exclusion of moisture, insects and micro organisms by creating a barrier to these factors. The materials used for seed packing and the existing storage conditions exert a great influence on various seed quality parameters.

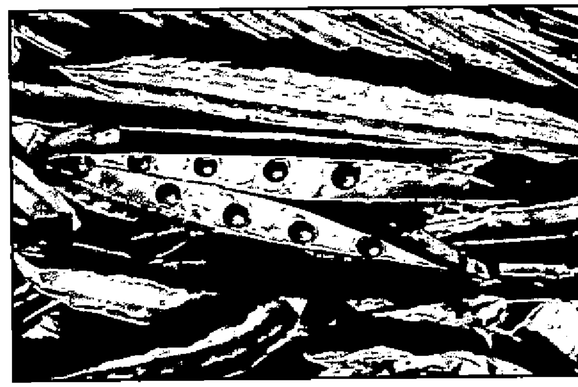
Packing materials can be classified into three types.

1. Moisture vapour permeable containers eg. jute bag, cloth bag, paper bag.
2. Moisture vapour resistant containers eg. jute bag laminated with 200-300 guage polythene film.
3. Moisture vapour proof containers eg. sealed tin or aluminium cans, polythene bags of 700 guage or more, aluminium foil pouches, glass mason jars with gasketed lids etc.

For storing vegetables, moisture proof containers are found to be best. Seeds are dried to safe moisture level, slightly lower than that is needed for normal open storage and are sealed in moisture vapour proof containers. As a result of packaging each lot will be in its own environment. They can be stored under ambient temperature and relative humidity for one or two years with no deleterious effect on germination. Polyethylene bags have been regarded as the most attractive because of their relatively low cost compared to other kinds of sealed containers. Rigid plastic containers and sealed tins offer some possibility for hybrid seed, if the quantity needed is not great. The metal box has the additional advantage of rodent and insect-proof as well as moisture-proof. The boxes, which are not very expensive, can be easily stacked on shelves in a small area. Generally seeds remain viable for 36 months in impermeable containers where as the viability will be only for 12 months in the case of permeable containers such as butter paper and kraft paper.

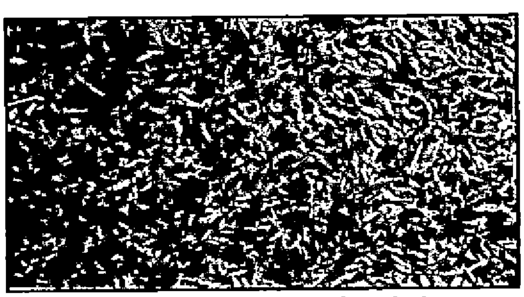
Harvesting fruits at correct maturity



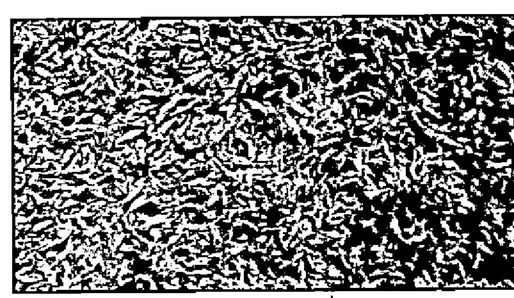


Seed extraction

Proper drying to reduce seed moisture



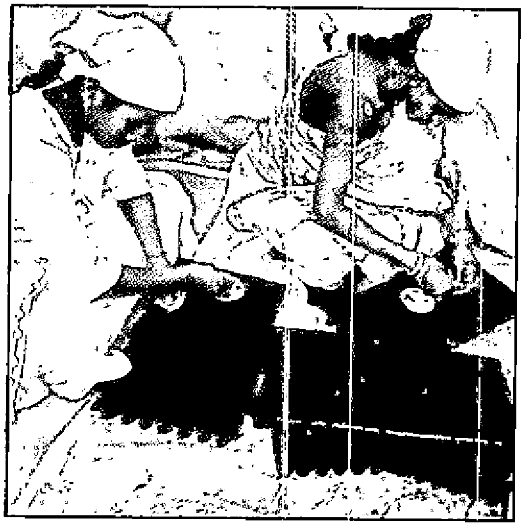
Harvested chilli fruits before drying



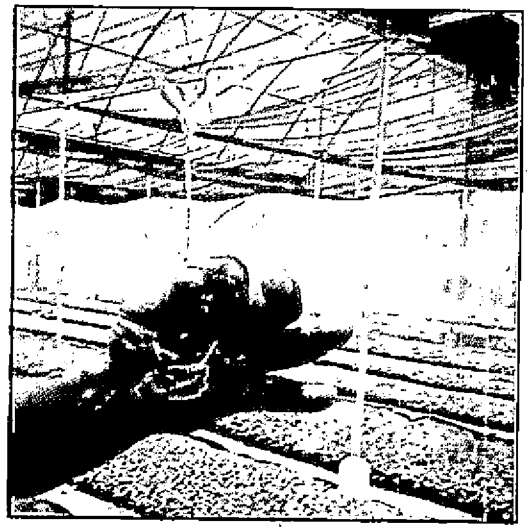
Harvested chilli fruits after drying

Winnowing to clean seeds

Vegetable seedling production



Filling portrays

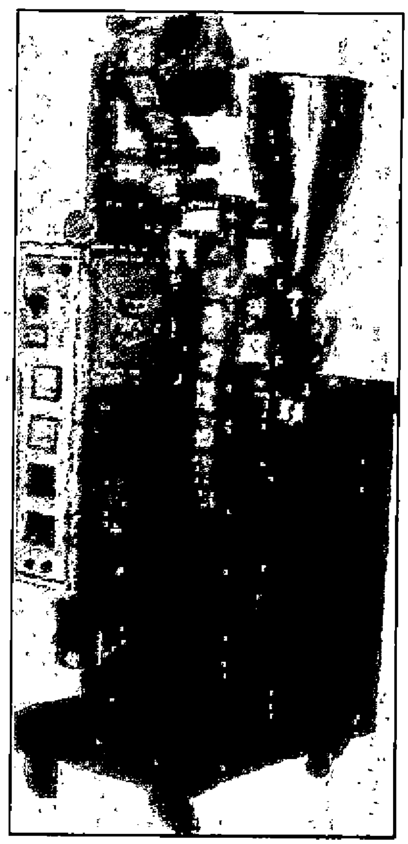


A healthy seedling

Seed processing equipments

Seed extractor

Seed drier



Automatic seed packing machine

FLORAL BIOLOGY AND POLLINATION OF TROPICAL VEGETABLES

Mareen Abraham

The floral biology includes the morphology and anthesis of flowers and it is studied with regard to its flowering duration, panicle emergence, sequence of blooming in a panicle, daily blooming, opening and closing of individual spikelets, anther dehiscence, stigma receptivity and viability of the pollen. So in hybrid seed production, floral biology is important to study the mode of pollination of a particular crop so that hybridization can be made line effective.

The floral biology and pollination of important tropical vegetables are detailed below.

AMARANTHUS

Flowers are small, monoecious produced in the axillary clusters or dense terminal thyrsoid panicles. The base units of influence are small dichacial cymes usually called glomerules, each consisting of an initial staminate flower and an indefinite number of pistillate flowers.

The glomerules are crowded in a leafless axil to form complex inflorescence technically thyrses, which are generally called spikes. Flowers are small, regular, tri/pentamerous, bracteate, perianth parts 2-5, imbricate, stamens 2-5, free, anthers 2 celled, dorsifixed. Ovary superior with one campylotropous ovule, stigmas 2-4 and pubescent, Fruit is a one seeded utricle. Seeds are black, brown or white smooth and compressed.

Leafy amaranthus species takes about 80-130 days for flowering. Monoecious species of amaranthus are chiefly self pollinated. The flowers are protogynous with stigma in pistillate flowers becoming receptive several days before opening of staminate flowers. Arrangements and sequence of anthesis favour a combination of self and cross pollination viz. the maturation takes place from bottom to top. The single staminate flower in each cyme may not be able to pollinate its adjacent surrounding female flowers. But the male flowers of cymes situated above in the inflorescence will be supplying pollen grains to the female flowers below their level. The flower is anemophilous leading to self fertilization. In grain amaranthus species since the inflorescences are coloured, they are occasionally visited by bees and thus cross pollination is encouraged. The dehiscence of anthers and release of pollen grains are maximum between 11 am and 1 pm on sunny days. Fruit is dry, membranous indehiscent, opening circularly or tearing irregularly at the end containing one vertically compressed seed.

ASH GOURD

Flowers are unisexual, solitary, axillary and light yellow to white in colour. Plants are monoecious. Calyx has 5 sepals, gamosepalous forming the calyx tube, calyx lobes alternating with corolla tube. Corolla has 5 petals, gamosepalous, pale yellow to white in colour. Stamens are 3, free, sometimes attached with the calyx tube. Ovary is inferior, tri carpellary with parietal placentas.

The anthesis is from 6.00 am to 7.00 am. The anther dehiscence is seen 3 hours before anthesis (3.00am to 4.00 pm). The pollen is fertile from 7.00 am to 4.00 pm on the day of anthesis. The stigma becomes receptive 12 hours before anthesis and continues to be receptive till 36 hours after anthesis.

BHINDI

Flowers are bisexual, solitary, axillary with about 2 cm long pedicel, epicalyx 8 to 10, narrow hairy bracteoles which fall before the fruit reaches maturity. Calyx has 5 hairy sepals gamosepalous and form a protective covering for bud. Calyx split longitudinally as flower opens and falls with corolla after anthesis (caducus calyx). Corolla contains 5 petals, yellow with crimson spot on claw, 5-7cm long, obovate, connate at the base and adnate to staminal tube. Androecium has numerous stamens, filaments united to form a staminal column (monadelphous staminal tube). Staminal column fused to the base of petals, anthers reniform in shape. Ovary is superior, pentacarpellary syncarpus, ovules in axile placentation. Stigma 5, deep red and capitate. Fruit is a loculicidal capsule, light green or sometimes red in colour, pyramidal, oblong, beaked, longitudinally furrowed, 10-30 cm long, dehiscing longitudinally and loculicidally along their middle of each locule when ripe. Seeds are green to dark brown, round and numerous.

A flower bud appears in the axil of each leaf above 6^{th} to 8^{th} leaf depending upon the cultivar. At this time the crown of the stem bears 3-4 under developed flowers. But later on, during the profuse flowering period of the plant, there may be as many as ten under developed flowers on a single crown.

As the stem elongates, the lowermost flower buds open into flowers. There may be a period of 2,3 or more days between the time of development of each flower, but never does more than one flower appear on a single stem. A flower bud takes about 22-26 days from initiation to full bloom. Time of anthesis varies with cultivar, temperature and humidity. Flower opens between 8 to 10 am. Anther dehiscence is transverse and occurs 15-20 minutes after flower opening. Dehiscence is completed in 5-10 minutes.

Pollen fertility is maximum in the period between an hour before and an hour after opening of the flowers. After pollination, pollen takes 2-6 hours for fertilization. Flowers remain open for a short time and they wither late in the afternoon. Stigma is receptive at opening of the flower. Hence pollination at bud stage is not successful. Experimentally it has been found that there is no significant difference in fruit set under open- pollinated, self pollinated by bagging alone and self-pollinated by hand pollination of bagged flowers, indicating that it is potentially a self-pollinated crop. Though essentially self pollinated, because of its showy corolla, the possibility of cross pollination by insects cannot be ruled out. Consequently, cross-pollination to the extent of 4.0 to 19% with the maximum of 42.2% has been reported. Hence it can be classified as often cross- pollinated. The extend of cross-pollination in a particular place will depend upon the cultivar, competitive flora, insect population, season etc.

Studies on the influence of ovule position on pollen tune entry and seed set revealed that ovule positions 7-14 received the maximum number of pollen tubes. i.e. about 90%. The pollen can remain viable in storage at 50% relative humidity for 55 days.

BITTER GOURD

Plants are monoecious, flowers are unisexual, large, showy, and yellow in colour. *M. dioica* is dioecious. Calyx contains 5 sepals and gamosepalous calyx lobes are alternating with corolla lobe. Corolla is 5 lobed, bright yellow in colour. Staminate flowers are produced mostly in long pedicels and borne singly. Ovary is inferior, 3 to 5 carpels usually three, style short and thick.

Flowers start opening at 5 a.m. They completely open between 9.30 am- 10.30a.m and wither away at 7.00p.m. The petals open and close one by one in a definite sequence. Anthers dehise about two hours before blooming. i.e. between 7 to 8 a.m. Though the pollen fertility starts from 5.00 am and lasts till 12.30 p.m., it is maximum at the time of anther dehiscence. Similarly though the stigma becomes receptive one day before anthesis and continues to be till one day after anthesis, it is maximum at the time of dehiscence of anthers.

BRINJAL

Hermaphrodite flowers are large and showy, produced in lateral raceme. Calyx has 5 gamosepalous sepals, light green in colour and persistent. Corolla contains 5, purple or white petals, gamopetalous and rotate. Androecium has 6 stamens, filaments are attached to the throat of the corolla. In gynoecium, capitate stigma is found either above or on the same level or below the stamens. Ovary is bicapillary. Fruit is pendant and fleshy berry, borne singly or in clusters. Colour of the fruits varies from purple, blackish purple, white green and striped depending upon the cultivars. After full ripening, the fruits become yellow in colour. Fruit shape varies from round to oval or oblong or pear shaped or extra long oval. Seeds are discoid and are borne on the fleshy placenta and the placenta with the seeds completely fills the locular cavity.

Four types of flowers have been identified depending on the length of styles (hetrostyly) namely:

1. Long styled with big size ovary
2. Medium styled with medium size ovary
3. Pseudo- short styled with rudimentary ovary and
4. True short styled with very rudimentary ovary.

Long and medium styled flowers produce fruits, whereas pseudo- short and true short styled flowers do not set any fruit. However, chances of cross pollination is more in long styled flowers. In long styled flowers, the fruit setting ranges from 70 to 80 per cent while short styled flowers do not set fruit.

It has been observed that at a temperature of 20 to 22°C and 50-55% relative humidity, pollen viability is retained for 8-10 days. Repeated pollination with pollen from different plants increases both fruit and seed set.

Flowering commences 70-75 days after transplanting. Full bloom is observed 80 days after planting. The whole period of effective flowering lasts for 75 days.

Anthesis starts at 5.35 am and continues upto 7.35 am with peak at 6.05 am. Atmospheric temperature and relative humidity does not have any marked effect on anthesis.

The dehiscence of anthers begins 30 minutes after anthesis. It commences at 6.00 am and continues upto 8.00 am with the maximum at 6.35 am. Anther dehiscence usually starts 15-20 minutes after the flower bud had opened.

The stigma is receptive from 2 days before anthesis and upto 8 days. The maximum receptivity is on the day of anthesis, and remains effective upto 4 days after anthesis. The pollen grains remain viable from the day of anthesis up to 10 days at an average atmospheric temperature of 24.6°C and relative humidity of 82%.

All cultivars bear flowers in cluster or in solitary. The flowers in cluster are either short styled and medium or all medium styled. However the fruiting habit in a cultivar is not directly related to the occurrence of different flower types in clusters.

BOTTLE GOURD

Bottle gourd is monoecious. Flowers are solitary and appear on leaf axils, white in colour. Sepals are 5, united at the base of form a tube, and the calyx lobes are alternating with corolla tubes. Petals are five in number and united. Stamens are three, attached to the calyx tube. Ovary is inferior, tri carpellary with parietal placentation.

It is a cross-pollinated crop. The time of anthesis is between 5.00p.m and 8.00 pm. The anther dehiscence is seen a few hours prior to anthesis viz. around 1.00p.m to 2.30 pm. The pollens remain fertile from the time of anther dehiscence till the next day morning. The stigma becomes receptive 36 hours before anthesis and continues to be receptive till 60 hours after anthesis.

CHILLI

Flowering starts 1-2 months depending on weather conditions and species. Flowers are usually borne singly or in clusters and are terminal, but due to the branching they appear to be axillary, pedicels upto 1.5cm long. Flowers are hermaphrodite usually white in colour. In *Capsicum frutescence*, corolla is greenish white and in *C. baccatum* corolla is with yellow throat. Calyx is companulate, shortly dentate 10 ribbed, about 2mm long enlarging and enclosing base of fruits. Corolla is rotate, campanulate, deeply 5- partite, 8-15 mm in diameter. Androecium has white or greenish stamens, 5-6 inserted near base of corolla, anthers bluish, dehiscing longitudinally. Occasionally anthers are yellow in colour. In Gynoecium, ovary two celled, superior, style simple, white or purple, stigma capitate. Fruit is indehiscent, many seeded berry, pendulous or erect, borne singly at nodes, variable in size, shape, colour and degree of pungency, linear, conical or globose 1-13 cm long, unripe fruit green yellow, brown, cream or purplish. Seeds 3-5 mm long, pale yellow.

Both self and cross pollination occur in chilli. The extend of cross pollination is 7-36% by bees, ants and thrips. Pollination is also by gravitational force. Cross pollination is mainly due to heterostyly and protogyny. Flowers open by 4 am. and continues up to 1 pm. with a peak at 6-8 am. Anthers normally dehisce between 8 am and 11 am. Pollens are fertile on the day of anthesis. Stigma becomes receptive 1/2 to 51/2 hours before opening of flower depending on weather. Flowers remain open for 2-3 days. The percentage of fruit set is 5-35%. Production of seed is favoured by large quantity of pollen grains for pollination.

COWPEA

The anthesis time for cowpea is between 7 to 9 am. The flowers open late in the morning, the dehiscence of the anthers is much earlier.

Inflorescence is axillary with few flowers crowded near tip in alternate pairs on thickened nodes, usually 2-4 flowered, peduncles stout, grooved, often exceeding length of leaf, 2.5- 15 cm long, with cushion like nectary between each pair of flowers, pedicels very short, calyx companulate with long or short triangular teeth, of which the upper 2 are usually connate and longer than the rest, corolla dirty white, sordidly yellow or violet, much exerted, standard 2-3 cm in diameter, keel truncate, stamens diadelphous, anthers uniform, ovary sessile, many- ovuled, style bent, bearded on inner curve immediately below oblique stigma. Pods variable, linear, semiterete, 8-100 x 0.8 – 1cm, 8-20 seeded. Seeds very variable in size, shape and colour.

CUCUMBER

Flowers are axilliary, solitary and monoecious. They are yellow to deep yellow in colour. Staminate flowers are numerous than the pistillate flower. The cultivated forms of cucumber are mostly monoecious while gynoecious stocks have been developed for producing F_1 hybrids. Calyx is gamosephalous, tubular and hairy. Calyx lobes are superior while calyx tube is adnate to the ovary. Corolla is companulate, yellow and five lobed. Stamens are three and yellow in colour. Anthers syngenecious and adhering to the corolla tube. Ovary is inferior, tri carpellary with three parietal placentas.

Flower opening is seen between 5.30 am and 7.00 am while the dehiscence of anthers takes place from 4.30 am to 5.00 am. The pollen are found to be fertile from the time of anther dehiscence upto 2.00 p.m. The stigma becomes receptive 12 hours before flower opening and receptivity continuous upto 6-7 hours after flower opening.

DOLICHOS BEAN

Calyx is companulate with 5 sepals, gamosepalous with imbricate aestivation. Corolla has 5 petals, polypetalous with descendingly imbricate aestivation. Stamens 10, diadelphous

(9+1), filaments alternately short and long, anthers dithecous, intorse and reniform. Ovary sessile, superior, monocarpellary, unilocular with few ovules on marginal placentation. Style terminal, hairy beneath the stigma. Stigma truncate and flattened.

MUSKMELON

Flowers are solitary, axillary, attractive, unisexual and showy, yellow in colour. Most of the cultivated forms are andromonoecious. Calyx is gamosepalous forming a tube, its lobes alternating with corolla lobes. Corolla is companulate, showy and 5 lobed. Stamens are three with the filaments forming a column. In Gynoecium, ovary is superior, thick carpelled, style is short and thick.

Anthesis takes place between 5.30 am to 6.30 am. The dehiscence of anthers takes place just before anthesis ie. 5.00 am to 6.00am. The pollen fertility lasts from 5.00 am to 2.00 pm, and fertility becomes lower as the day advances towards evening. The stigmas are highly receptive two hours before anthesis and the receptivity continues up to 2-3 hours after anthesis.

POINTED GOURD

Flowers are unisexual, plants dioecious in nature. In *Trichosanthes dioica* pollination has been established as a sure means for successful fruit setting and hence the necessity of including male plants also in cultivation is emphasized. Cross pollination is effected by both diurnal and nocturnal insects.

PUMPKIN

Flowers are unisexual, deep yellow in colour, epigynous, solitary in leaf axils. Calyx contains 5 sepals, lobed ..nd adnate to the ovary, the calyx lobes are superior. Corolla is with 5 petals, fused, companulate and deep yellow in colour. Stamens are five in number and syngenecious . Ovary is inferior, tri- carpellary, with parietal placentation. The number of staminate flowers produced always exceeds that of the pistillate ones.

Pollination is effected by insects, mainly bees and they are naturally cross pollinated. Hand pollination assists fruit setting,

RIDGE GOURD

Based on flowering habit, plants are of 4 types, *viz.* monoecious, andromonoecious, hermaphrodite and gynoecious. The flowers are solitary pale yellow to yellow in colour. Staminate flowers are borne in racemes. Sometimes both staminate and pistillate flowers are borne on the same node. Calyx is 5 lobed, united at the base. Corolla has 5 petals, companulate and bright yellow in colour. Stamens are three, attached to the calyx tube, anthers free. Ovary is inferior, tri- carpellary with parietal placentation.

Anthesis starts in the evening by 5.00 p.m. and continues upto 8.00p.m. The anther dehiscence is seen immediately after anthesis. Pollens are fertile from the time of dehiscence till 2 to 3 days in winter and 1 to 5 days in rainy season. The stigma is found to be receptive even 6 hours before anthesis and continues to be receptive till 84 hours after anthesis.

SNAKE GOURD

Flowers are unisexual, white in colour, solitary and axillary. Plants are monoecious. Sepals are five in number, calyx form a tube. Petals are five in number and free. Stamens are three attached to the calyx tube, filaments are five. Ovary is inferior, tri carpellary with parietal placentation.

Flowers are borne in the upper portion of the plant. Five distinct stages in the development of floral buds prior to opening were noted and it was observed that opening of flowers from the time of its appearance in the leaf axil as a bud, required 8-12 days in case of pistillate and 13-16 days for staminate ones.

It was found that the flowers open at night (after 6.00 pm upto 9.00 pm). Temperature particularly the minimum temperature influenced greatly the time of opening of flowers. The dehiscence of anthesis takes place shortly before anthesis. The pollen grains of *Trichosanthes* remained viable from 10 hours before dehiscence and upto 49 hours after dehiscence. Pollen grains germinate after 30 minutes of their deposition on the receptive stigma and after one hour in 5% sugar solution.

The stigma remains receptive from 7 hours before opening till 51 hours after opening in *T. anguina* and *T. dioica*. Fertilization is effected in about 6 to 12 hours after pollination and the colour of the ovary and its size are the chief indication of fruit formation, which is accomplished after 2 days of pollination.

TOMATO

Flowers are yellow in colour, borne in clusters, extra axillary in position, the flower cluster appears like racemose cyme with dichotomous branching. Flower pedicel is highly pubescent, very thin and green in colour. The flower cluster is called a "truss". Calyx is grey in colour with 5-7 sepals, alternate with petals, persistent having valvate aestivation. Corolla has 5-7 petals, bright yellow in colour, alternate to sepals with valvate aestivation. Androecium contains 5 greenish yellow stamens, free at the base and united at the top. Gynoecium is multi coloured, syncarpous with numerous ovules in each locule. Style is pale green and present within the anthredial cone. Fruit is a berry, borne singly or in clusters. Fruit at mature stage is deep red and immature fruit is green in colour. It is borne with persistent calyx. Seeds are numerous in each fruit. Fruits are spherical, oval or oblong in shape. The fruit colour is due to the presence of pigments like lycopene and carotene. Seeds are numerous, round in shape, yellowish in colour, with adherence of mucilaginous substance.

Anthesis starts at 6.30 am, and continues upto 11.00 am. Anther dehiscence is longitudinal. It occurs 1-2 days after opening of corolla. The stamen shed its pollen when the style grows up through anther tube, thus self pollination occurs. When the stigma protrudes above the anther tube, chances of cross pollination through bees increases. The optimum temperature for pollination is around 21°C.

Cross pollination also occurs to an extent of 14-30%. The bottom most flower is the oldest and will open first. Generally the flower cluster will produce 1-2 fruits/cluster.

WATER MELON

Flowers are unisexual, light yellow in colour. Plants are monoecious. Calyx is cup shaped bearing tiny teeth. Corolla is showy, yellow in colour, petals 5 in number and united. Stamens three, syngenecious, attached to the calyx tube. Ovary is inferior, fruit has a thick hard rind and seeds many.

The whole period of bud developmental stage of the male flower is completed in 12-16 days and in 11-13 days by female flower. The rate of increase in size is more rapid in earlier stages. i.e. upto 8-12 days, thereafter it decreases and during the post developmental period remains more or less constant.

The anthesis starts at 6.00 am continues upto 7.30 am with peak between 6.30 - 7.00 am. The dehiscence of anthers starts 1 ¼ hours before anthesis *viz.*, 4.45 am and continues upto 6.30 am. The peak period varies from 5.15 am to 5.45 am. The stigma becomes receptive 2 hours before anthesis and continues upto 3 hours after anthesis. It takes 30 to 40 days to full maturity and ripening of fruits from the date of pollination.

HYBRID SEED PRODUCTION IN TROPICAL VEGETABLES

Nirmaladevi, S and Sadhankumar, P G

In the recent past, a lot of interest has been generated in the exploitation of heterosis in vegetable crops in our country. The first report about the possible potential of hybrids in brinjal came from Japan in 1924-25. Since then, a large number of hybrids have been evolved all over the developed countries, possessing not only high yield potential but many other economic traits. In the advanced countries like Japan, United States of America, Europe and Scandinavian countries more than 90% of the vegetable varieties grown commercially are F_1 hybrids. Therefore, the prospects of hybrid varieties have to be visualized not only in terms of high yield contributed by size and weight of fruits, but in the total acceptability of the final product.

In India, prospects of increasing vegetable production by increasing land under vegetable cultivation is limited. In this context, hybrid vegetable technology is one of the better opinions. The first F_1 hybrid in India was produced in bottle gourd (Pusa Meghdoot) in 1971 at IARI regional station, Katrain. Immediately after two years, F_1 hybrids of summer squash (Pusa Alankar) and cucumber (Pusa Samyog) were also developed. Private sector undertakings are also actively associated with development of hybrids. Growing F_1 hybrids became popular with the introduction of new seed policy declared in 1988. The import of seeds was liberalized under Open General License with the objective of providing the farmers the best planting material.

In our country, the credit for generating interest in hybrid varieties, in fact goes to private seed industry which could offer hybrids possessing high yield potential, uniformity and resistance/tolerance to biotic and abiotic stresses. In the present context of development, F_1 hybrids offer good opportunities for maximising the productivity of good quality vegetables. The exploitation of hybrid varieties can only be successful if adequate quantity of hybrid seed can be produced at reasonably low cost, as there is great competition among the seed companies to produce best hybrid to compete the world market.

Manifestation of heterosis for commercial exploitation could be for any of the following attributes: -

High yield

Early maturity

Uniform maturity and size

Plant vigour

Different growing conditions (open or protective culture)

Better quality

Better keeping quality

Efficient in nutrient uptake

Wider adaptability

Suitable for machine harvest

Multiple disease and pest resistance

Tolerance to abiotic stress

Steps in hybrid seed production

a. Inbreeding and production of inbred lines
b. Testing of combining ability
c. Improvement of inbred lines/ varieties
d. Hybridisation and production of hybrid seed

A good knowledge on the growth habit, floral biology, fruit and seed development and maturity are essential.

Basic requirements

1. Availability of a proven heterotic hybrid combinations which could distinctly and profitably surpass the yield level of the commercial variety being in cultivation.
2. Availability of an easy, economic and effective means of eliminating or rendering functionless of the male part of the bisexual seed parent mechanically, genetically or even biochemically.
3. Availability of a strong fertility restoration system (in case of the use of cytoplasmically governed male sterility system) or availability of tightly linked marker gene system in the case of genetically governed male sterility, full and the detectable expression of self incompatibility.
4. Absence of modifier genes or gene systems in case of, the use of self incompatibility for hybrid seed production.
5. Complete synchronization of flowering in both seed and the pollen parents.
6. Free, unrestricted and natural transfer of pollen to seed parent.
7. Good seed setting on the seed parent.
8. A skilled organised effort for large scale seed production, certification, processing and well knitted distribution channels of hybrid seeds.

Methods of economical production of hybrid seed

a. Use of male sterile lines- genic MS, gene- cytoplasmic MS(male sterility can be induced by application of various chemicals also).

b. Use of self incompatibility

c. Use of gynomonoecious and gynoecious lines

d. Use of growth regulators

Three main mechanisms utilizing natural pollination have facilitated the procedure of crossing. These include the sex expression (dioecism and monoecism), self incompatibility and sterility both genetical male sterility as in tomato, brinjal, capsicum, onion, pumpkin, squash etc. and triploidy in seedless watermelon. In self fertile species possessing hermaphrodite flowers, emasculation is usually done either by hand or genetically with the help of male sterility genes.

F_1 hybrid seed production in tropical vegetables

BRINJAL

The commercial method followed in brinjal is emasculation and pollination. Raise the female and male parents in 10:1 ratio. Male parents should be raised 15-20 days ahead of female parent. In the female parent, select well developed plumpy long styled flower buds which are going to open on the next day morning. Emasculate these flower buds between 3 pm and 5 pm using a needle. Cover the emasculated flowers with butter paper cover.

Similarly, on the previous day evening cover the flowers of the male parent from which pollen is going to be collected on the next day morning. Next day morning by 6 am, collect flower buds from male parent before opening and separate the anthers and put it in a petridish covered by glass. Keep the petri dish against sunlight to facilitate the dehiscence of anthers and release of pollen grains.

Remove the butter paper cover of the emasculated flower and dust the pollen over the stigmatic surface using a small brush. Rebag the flowers and label them, since the stigma is receptive for four days, remove the bags only after 8-10 days where the fertilized ovary becomes prominent. After fruit maturity, extract the F_1 seeds.

CHILLI

1. Emasculation and hand pollination

As in brinjal ratio of female to male is maintained at 5:1 ratio.

2. Using genic male sterility

Genic male sterility is maintained in chilli under heterozygous condition by back crossing with recessive parent every year.

ms ms x Ms ms

↓

ms ms ms ms
(male sterile)

For commercial seed production, heterozygous seed stock is sown which segregates into 50% heterozygous male fertile and 50% heterozygous male sterile.

	Ms ms	
	↓	
Ms ms		ms ms (male sterile)

The former is removed from the population before flowering whereas the latter is kept as female parent for hybrid seed production in the seed production plot where male parent is also there. In this, there is problem of identification of male sterile plants before flowering. This is done based on morphological characters.

CUCURBITS

Hand emasculation and pollination is the most common method of hybrid seed production in cucurbits. In bitter gourd, bottle gourd, cucumber, pumpkin, ash gourd, snake gourd and ridge gourd, emasculation refer to removal of male flower buds in the female parent before anthesis. The female flowers are pollinated with the pollen of the male parent during the receptivity period of stigma preferably between 6 am and 9 am. To avoid any chance of cross pollination the female flowers are covered with butter paper cover on the previous day of flower opening and also after hand pollination. The private companies have trained personnel for production of F_1 hybrid seeds and they produce it efficiently and economically.

The genic male sterility system is used for production of F_1 hybrids in muskmelon. The steps involved in utilizing male sterility is given below. The farmers are trained to utilize male sterility for F_1 hybrid seed production in Punjab.

Male sterile maintainer field

ms ms	x	Ms Ms
	↓	
	↓	
Ms ms	x	ms ms
	↓	
	↓	
50% Ms ms		50% ms ms

Hybrid seed production

ms ms (Parent 1)	x	Parent 2
(o o o o)	↓	(* * * *)
(o o o o)	↓	(* * * *)

Hybrid seed

*oooo*oooo*
*oooo*oooo*
*oooo*oooo*
*oooo*oooo*

Ms Ms & Ms ms : Male fertile

ms ms : Male sterile

Gynoecious sex expression has been used to develop cucumber hybrids. The gynoecy is linked with parthenocarpy. Hybrids developed by utilizing gynoecious lines are having parthenocarpic genes and do not require pollination for fruitset. The gynoecious lines are maintained by spraying silver nitrate 50-100 ppm or silver thiosulphate 25-50 ppm at 2-3 true leaf stage. A number of male flowers will be produced and can be used for maintaining these lines.

A large number of F_1 hybrids have been produced in cucurbits. The F_1 hybrids recommended at national level and those developed by public and private sector are given in Tables 1 & 2 respectively.

Table 1. F_1 hybrids recommended under national level

Sl.No.	*Crop*	*F_1 hybrids*	*Source*
1	Bitter gourd	RHRBGH-1 Pusa Hybrid-2 NBGH-167	MPKV, Rahuri, IARI, New Delhi Nirmal seeds
2	Bottle gourd	Pusa Meghdoot, Pusa Manjari PBOG-1, PBOG-2 NDBH-4	IARI, New Delhi GBPUAT, Pant nagar NDUAT, Faizabad
3	Cucumber	Pusa Sanyog PCUCH-1 Hybrid No.1	IARI, New Delhi GBPUAT, Pant nagar Century Seeds
4	Muskmelon	Punjab Hybrid MHY-5	PAU, Ludhiana ARS, Durgapura, Jaipur
5	Watermelon	Arka Jyothi MHW-6	IIHR, Bangalore Mahyco

Apart from these, there are a number of F_1 hybrids of private seed companies that are popular among farmers.

Table 2. Popular F_1 hybrids of public / private sector

Sl.No.	Crop	Name of hybrid
1	Bitter gourd	Reshma, Shreya, INDAM-49, BSS 405
2	Bottle gourd	Sujata, Shambhu, Swathi, Soumya, Vikrant, Divya, NBBH-48
3	Cucumber	Ragini, Shivneri 125, NCH-38, Hybrid No. 2
4	Ridge gourd	RHRG-2 x 5, Bio Kaveri, NRGH-2, Mahima, Arati.
5	Watermelon	NDWMH-15, NDWMH-14, Apoorva, Black Magic, Super Dragon

OKRA

Heterosis has been successfully exploited in okra for production of F_1 hybrids. Apart from various economic traits, resistance to the most serious yellow vein mosaic virus is also considered in developing hybrids.

Generally hand emasculation and pollination is being done to produce hybrid seeds in okra. Emasculation of flowers on the female parent is done before anthesis. The emasculated flowers are covered with butter paper bags. Pollination is done the next day morning and again covered with the bag.

Induction of male sterility using chemicals and irradiation has indicated the possibility of using it in hybrid seed production.

The F_1 hybrids DVR-1, DVR-2 and DVR-3 developed at IIVR,Varanasi have been recommended for cultivation in different parts of the country. Several F_1 hybrids developed by public institution are being evaluated at National level (Table 3).

Table 3. F_1 hybrids under evaluation

Sl.No.	Name of hybrid	Source
1	JNDOH-2	GAU, Anand
2	JNDOH-1	
3	RHROH-1	MPKV, Rahuri
4	RHROH-4	
5	HYOH-1	ANGRAU, Hyderabad
6	HYOH-2	
7	HBH-142	CCSHAU, Hissar
8	HBH-114	

The F_1 hybrids Vijay, Varsha, Panchali, AROH-221, SOH-77, Karishma, Mahabeej, Anokhi, evergreen, Biokeerti, NOH-24 etc. developed by private seed companies are also popular among farmers. Two F_1 hybrid combinations, AE-238 x AE-190 and AE-265 x AE-190 are identified by Kerala Agricultural University.

TOMATO

The increased interest towards hybrid breeding is due to the possibility of combining a complex of valuable attributes in a genotype like high fertility, earliness, uniformity of plants and fruits, complex resistance to diseases, adaptability to different environmental conditions, increased shelf life etc.

The commercial method followed in tomato is emasculation and hand pollination. As tomato is self pollinated, the parental lines are maintained by continuous selfing. The male parental lines are to be raised at least 15 days in advance of raising the female. This will help in ensuring sufficient pollen availability for hybridizing the first formed flowers in the female parent. A female: male parental ratio of 5:1 is recommended in tomato. Flower buds of female parent should be emasculated 12-18 hours before opening. Emasculation should be done in the evening hours. After emasculation, the female flower buds should be bagged. Hand pollination is done next day morning using pollen from the male parent. For this, the flowers of male parent are bagged in the bud stage and picked up in the early morning. The pollen is collected in dry petridishes as stamens are hygroscopic in nature. Pollination is done in the morning hours between 7 am and 10 am. Dust the pollen on the receptive stigma of the emasculated flower using a small brush. After hand pollination, cover the pollinated flower with butter paper and label them. Removing all the other flower buds leaving one or two crossed flowers in a truss will ensure good fruit set. Allow the flowers with cover for seven days to ensure fruit set and afterwards remove the covers. Harvest the fruits at red ripe stage and extract F_1 seeds.

Commercial Hybrid Seed Production: Problems and Remedies

Cheap availability of hybrid seed is key and crucial and perhaps the most important factor in the usage of the hybrid seed by the farmer. Hand emasculation + hand pollination of individual flowers is the most expensive method and may be economically worthwhile only in certain vegetables such as tomato, brinjal, cucumber, squash and pumpkins where each fruit give a reasonable quantity of seed and limited quantities of seed required for planting. But such a procedure is out of question in other vegetables, where each fruit resulting from a single pollination provides a very limited number of seeds and in crops where flower parts are so arranged that manipulation of flowers for emasculation is difficult.

The hybrid seed could be produced at cheap rates only if the crop species have certain built in morphological or physiological mechanisms suitable for the control of parentage for successful hybrid seed production and its floral morphology is amenable to it. It is comparatively easier to produce the seeds of F_1 hybrids in dioecious crops, monoecious vegetables and self-incompatible crops than in the self fertile species having hermaphrodite flowers such as tomato, brinjal and capsicum.

The success of hybrid technology depends on production techniques of crops raised from hybrid seeds. Full potential of hybrids can be harvested only by adopting improved production technology that starts from raising the seedlings under controlled condition, use of heavy dose of fertilizers, mulching, crop shading using nylon nets and proper pruning and training.

The parental lines of F_1 hybrids developed by public sector are easily accessible. Any private company or other organization can purchase seeds of parental material for production of F_1 hybrid seeds with people's participation.

VEGETABLE SEEDLING PRODUCTION

Indira, P

A progressive vegetable producer says :" A good seedling is 50% of the production", based on the relevance of proverb " as you sow, so your reap". This is in accordance with the trend of new agricultural policy which concentrates on clean food product with high quality for local as well as export markets.

Vegetable transplant production has become a commercial venture all over the world but it is still in infancy in our country. Recently hybrid vegetable seedling production has become a reality in states like Karnataka, Maharashtra and Uttar Pradesh. Since the hybrid seeds are expensive, this method helps to reduce the cost by minimizing the seed waste.

Many young entrepreneurs and progressive farmers are coming forward to take up quality seedling production and supply to the vegetable farmers based on their orders. This method provides healthy and uniform growth of the seedlings.

Commercial production of vegetable seedlings is not yet popular in Kerala. Most of the vegetable farmers are using their own seedlings. Seeds are procured from public organizations/ private nurseries. Some of the private nurseries are producing the seedlings of a few vegetables and they are sold at a higher price.

There are many reasons for limited production of vegetable seedlings in Kerala.

1. Most of the summer vegetables grown in rice fallows are direct sown
2. Hybrid vegetables are not very popular except in certain tracts
3. Lack of awareness about scientific transplant production.

Plug or container seedling production has become very popular in Karnataka. Seedlings of tomato, capsicum, cauliflower, cabbage, chillies and brinjal are produced under cover on a large scale. The selection of root medium is an important factor. An organic material used in making substrate are not uniform and not available everywhere. Use of commercially sterile potting mixture will decrease the incidence of seedling disease problems.

The intensive cultivation of hybrid vegetables was commercialized the container seedling production in Karnataka. In the commercial nursery 98 celled portrays are used and the most common growing media used is sterilized cocopeat which helps to prevent nursery diseases.

Cocopeat is a byproduct of coir industry, which after digestion has high water holding capacity and good texture. Since it is low in mineral nutrients, the media need to be supplemented with the nutrient solution. Use of micro irrigation and fertigation helps in maintaining uniformity in growth of seedlings by maintaining good soil moisture and nutrient regimes without crushing of soil surface.

Use of protected structure for quality seedling production is a recent practice especially in the tropics. The structure may be green house, plastic/net house and tunnels. Growing plants under a cover protects the crop from damaging rains and winds, scorching radiations and temperature and dangerous pest and diseases. Hi-tech structures with computerized climate control systems are utilized in developed countries. But in developing countries plastic/net houses are good enough to raise vegetable seedlings under partial controlled environmental conditions. The most commonly used method to reduce radiation and temperature is by shade net covering and with fogging or misting facilities. This is ideal for vegetable seedling production as it is economical and feasible. Use of low cost structure involving wooden poles, shade net and 40 mesh nylon net to prevent some vectors which transmit viral diseases are in practice in and around Bangalore.

Hardening of vegetable seedlings before transplanting is essential for reducing transplant shock and also to have better crop stand. It is done by slowing down their rate of growth to prepare them to withstand conditions like chilling, water shortage, drying winds, shortage of water or high temperature. Withholding water or minimal water supply are the best ways to harden a plant.

Steps involved in raising portray or flat tray seedlings

1. Use 98 celled portrays for raising seedlings of capsicum, tomato, chilli, cabbage, cauliflower and brinjal.
2. Plastic portrays are disinfested by dipping in thiram or copper fungicide solution prepared by mixing 3 g. chemical per litre of water.
3. Fill the seedling tray with sowing medium such as cocopeat or potting mixture or vermiculite.
4. Sow one seed per cell and cover 1 cm deep.
5. Keep about 10-15 trays one over the other, cover with a plastic sheet and leave as such until germination. Later keep them singly over plastic mulched beds prepared under protected net cover and shade net.
6. Water the tray thoroughly every day or as needed using a fine sprinkler. Leaves should not be too wet.
7. Apply 0.3% (3g./l) macro and micronutrients twice at 10 and 20 days after germination for producing healthy seedlings.
8. Follow plant protection schedules depending up on crop and infestation.

Advantages of Pro-Trays

1. The farmer can save a lot on expensive seeds.
2. Helps in proper germination.
3. Reduce seedling mortality rates.
4. Uniform and healthy growth of all seedlings.

5. Easy in handling and economy in transportation.
6. Root development is minimum.
7. Ensure better transplant establishment

Raised nursery bed method

This is the conventional practice of vegetable seedling production in Kerala. Raised beds of 15-20 cm height, 1 m width and convenient length are prepared and the rooting medium is potting mixture made up of sand, soil and powdered farm yard manure (1:1:1). These nursery beds are sterilized by burning 3-4 cm thick layer of rice straw or other organic matter on the bed. Soil solarisation during summer months is also practiced. Well prepared nursery beds are to be watered thoroughly. Then cover the moist beds with transparent polyethylene sheet of 200 guage for 30 to 40 days.

Sow the seeds in lines in the prepared beds. Irrigate with a rosecan daily. The bed should not be too moist as it will enhance damping off disease. Before transplanting the seedlings, they are hardened by restricting irrigation or exposing them to direct sunlight. The seedlings are ready for transplanting within 30 days (tomato, cauliflower, cabbage) or 40-45 days (chilli, brinjal and capsicum).

Healthier the seedlings better will be the performance. Growing vegetable seedlings in plastic trays under cover using insect proof nylon mesh is a good practice that can be adapted by all vegetable growers.

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INTEGRATED PEST MANAGEMENT IN STORED VEGETABLE SEEDS

Mani Chellappan

Considerable post-harvest losses occur during storage of vegetable seeds. Many factors such as seed moisture, relative humidity, temperature and infestation by stored grain pests influence the viability of seed during storage and reduce the quality of seed. The seeds damaged by insects do not germinate well resulting in poor plant stand and consequently yield, and economic loss. This condition forces farmer to sell seed immediately after harvest even though the market price may not be remunerative at that time.

Storage losses to seeds vary. It depends on the crop, variety, season in which the seed is produced, insect pest complex, length of the storage, methods of handling of seeds, transportation, distribution and the rate of utilisation. In general, 10-20 per cent loss in storage is recognised. The losses occur because of the biotic and abiotic factors. The physical conditions *viz.*, temperature, relative humidity and moisture content in the seeds are the important abiotic factors. The biological factors for storage loss of seed include insects, mites, rodents, birds, fungi and bacteria.

Types of losses and damage to seeds due to insects

The types of losses are of different kinds. They are,

a. quantitative or physical loss in weight
b. qualitative loss leading to bad appearance, rotting, etc.
c. germination or viability or vigour loss which leads to yield loss in subsequent crop
d. stimulating seed germination at 15 per cent moisture level
e. devaluation of market value of stored seeds, and
f. economic loss

Factors favouring insect multiplication and damage

The major factors which favour insect multiplication and damage are,

a. increased production and unsound storage condition
b. varieties without resistance to storage insect attack
c. introduction of pest due to rapid transport facilities
d. destruction of natural enemies of pests
e. unchecked carry over from field to store house
f. uncontrolled infestation on threshing yard

g. use of infested storage facilities
h. moisture content in the seed
i. longer storage period
j. storing seeds along with already infested materials, and
k. accumulation of spilled seed materials and wastes

The stored seeds provide abundance of all essential requirements except water for insects. Though a small number of insect species attack the stored seed material, frequently their population increases rapidly. The biotic potential of the species adopted to storage condition is enormous.

The behaviour and habits of storage insects are very closely related to the moisture and temperature of their food media. A moisture content of about 12.5% favours feeding and reproduction of most major pests of storage and the temperature between 21-42 °C accelerates the breeding of insects. The optimum moisture content for safe storage of seeds varies with the kind of seeds. At less than 8% moisture most of the seeds will be resistant to insect invasion and feeding.

Insect infestation coupled with microbial infection often cause substantial storage losses to seeds. Such losses are quite high in large seeds like cow pea, beans, peas, etc. In small seeds, storage losses due to insect damage are relatively of lesser importance.

MAJOR INSECT PESTS OF STORED VEGETABLE SEEDS

Insect and fungal damages often cause substantial storage losses to vegetable seeds. Such losses are quite high in leguminous seeds. Hence, an effective protection of vegetable seeds from insect pests and microbial spoilage is indispensable for maintaining their viability and vitality.

a. Pulse beetle – *Callosobruchus* sp. (Bruchidae: Coleoptera)

These insects are the most serious problem on variety of leguminous seeds *viz.*, cow pea, beans, green peas, etc. The grubs eat the seed kernel and make a cavity. The larvae attack pulses in the field also. Even though several larvae enter the grain, usually only one completes the life cycle in a single grain. Adults are short lived and do not feed on storage material at all. The adult female lays 80-100 eggs singly, glued to the surface of pods in field or seeds in storage.

b. Cocoa moth – *Ephestia elutella* Hubn. (Phycitidae: Lepidoptera)

Bhindi seeds are subjected to damage by this insect pest. The larvae feed mainly on endosperm and partially on the germ. The host range of this insect varies wide, groundnut, maize, sorghum, etc. The larvae are pale reddish-brown and feed inside tubular galleries made up of powdery matter and particles of endosperm, all webbed together in a compact mass.

The larvae feed mainly on germ portion leaving the rest of the kernel undamaged. The damage is limited to peripheral top layers only. Web formation covers the bag, floor space and other things.

The size of the moth is about 13mm. The wings are dirty white to greyish with indistinct black bands. It rests with slopped wings over the body almost like a slanting roof of warehouse. The moth mostly rests in dark corners during day time and become active at dusk and dawn.

The female moth lays about 200-250 eggs on seeds exposed at the sampling spots in jute bags. The caterpillar is an active and voracious feeder of embryo of rice. One larva feeds approximately on 64 germs in its lifetime. Before pupation large number of wandering larvae leave behind silken threads. Such fine threads form the carpets of white sheen over the bags.

c. Rice moth – *Corcyra cephalonica* Staint (Galleriidae: Lepidoptera)

Bhindi seeds are also found to be damaged by the rice moth larvae. The larvae aggravate the damage by weaving silken galleries incorporating feed and frass particle into them. Ultimately, the infested seeds become a powdery mass on account of webbings made.

The other insects causing damage to vegetable seed in Kerala include the lesser grain borer, red flour beetle and psocid lice, *Liposcellis divanatroius.*

d. Red flour beetle – *Tribolium castaneum* Herbst. (Tenebrioniidae: Coleoptera)

The adults and larvae are basically secondary pests of seeds, feeding on embryo or germ portion. The adult beetle is brown or reddish brown, flat and measuring about 3mm in length. The female lays about 400-500 eggs on sacks, in cracks or on grains. Life cycle is completed in about 45-56 days. The damage is more during rainy season. Adult can live up to 2 years.

e. Saw toothed grain beetle – *Oryzaephilus surinamensis* Linn. (Sylvanidae: Coleoptera)

The insect has flattened shape which enable this species work into packages of seeds that are highly sealed. Basically, it is a secondary feeder.

f. Flat grain beetle – *Cryptolestes ferrugenus* (Stevens) (Cucujidae: Coleoptera)

The larvae feed on germ portion and the adults are only scavengers. The adult is the smallest among the storage insect pests (1.5 – 2.0 mm) with long antennae. If infested seeds are sampled out, the flat grain beetles are the first to move out. Adults live for 6-12 months.

g. Ware house moth or Fig or Almond moth – *Ephestia cautella* Walker (Phycitidae: Lepidoptera)

The larvae feed mainly on germ portion leaving the rest of the kernel undamaged. The damage is limited to peripheral top layers only. Web formation covers the bag, floor space and other things.

h. Indian meal moth or Mealworm moth – *Plodia interpunctella* Hubner (Phycitidae: Lepidoptera)

It is a primary pest and causes serious damage to seeds. It prefers to feed the germ portion. The adult moth has basal half of forewing with silvery white or grey. Outer 2/3 is reddish/ copper brown with irregular band. The females lay the eggs indiscriminately. Larvae feed superficially and construct silken tunnels.

NON INSECT PEST

MITES

a. Grain mite – *Acarus siro* Linn. (Acaridae: Acarina)

The mites eat the germ portion of seeds. It also imparts a bad smell to the grain called 'mintiness'. When handled the infested material imparts itching sensation called 'grocers itch'.

b. Bulb mite – *Rhizoglyphus* sp. (Acaridae: Acarina)

It is a very important pest of sweet potato tubers, onion and garlic seed material in the storage. The mite occurs both in field and in storage, resulting in tuber rot and onion rot. This mite causes pithy formation of garlic and onion.

Rodents – House Rat, House Mouse, Lesser Bandicoot And Indian Mole Rat

Birds – Blue rock pigeon, house crow, house sparrow, etc.

INTEGRATED MANAGEMENT OF STORAGE PESTS

Among the present methods of insect control, the following are the important methods that can help in safe storage of seeds particularly in small holdings.

Preventive: Prevention is better than cure. Hence the following preventive measures are recommended.

Hygiene or sanitation

Walls and floors – Thorough cleaning is done using vacuum cleaner to clean up plant parts, spilled grains, direct and physical impurities harbouring insect. Clean up spray 10-15 days before storage of fresh stocks using DDVP or cythion @ 0.1 %.

Disinfestations of stores/receptacles

Seeds can be stored in moisture cum vapour proof containers or polythene bag – 700 gauge thickness or multiwall kraft paper bags/ laminated cotton fabric bag. The seed packets can be kept on wooden racks in AC. The seeds can also be stored in small metallic bins.

Non-chemical methods are

1. Ecological management methods
   - - Temperature control - Sun dry the seed thoroughly before storage as the seed containing moisture > 10% will attract storage pests and is likely to be damaged soon. The seed can also be solarized for couple of days before storing them in shade. High temperatures (~65°C) in polythene bags due to sunrays will kill any living insect pest. Such bags can be stored for longer period without any chemical treatment and thus seed would remain safe for both sowing as well as consumption.
   - Moisture content of the seed
   - Availability of oxygen regulation

2. Mechanical Methods

- Traps and entoleter
- Probe trap
- Pulse beetle trap
- Pitfall traps
- Light traps
- Sticky traps
- Bait traps
- Pheromone trap
- Automatic removal

3. Physical Control Measures

- Controlled atmosphere
- Use of activated clay
- Coating of seeds with oils coconut/ ground nut/ palm oil @ 1ml /100g seeds
- Mixing of inert dust viz., silica gel/ powdered rock phosphate/ Aluminium oxide/ rice husk @ 1:100 on a w/w basis

4. Use of plant products (3% on w/w) like,

- Neem seed kernel
- Leaves of 'notchi' (*Vitex negundo*)
- Fruit ring powder of soap nut (*Sapindus laurifolius*)
- Leaf powder of tobacco
- Dry rhizome bits of sweet flag (*Acorus calamus*)

Chemical methods

a. Prophylactic treatment

a. Mixing with seeds with malathion 5% D 1 kg/100 kg seed in polythene lined bag or

b. Surface treatment of seed containers with either of the following

- Malathion 50 EC 10ml/l – 3 lit. spray sol. / 100 m^2
- DDVP 76 SC 7ml/l – 3 lit. spray sol. / 100 m^2

c. Gang way treatment

- Malathion 50 EC 10ml/l - 1 lit. spray sol. / 270 m^3 or 10000 Cu ft
- DDVP 76 SC 7ml/l - 1 lit. spray sol. / 270 m^3 or 10000 Cu ft

d. Gunny bag impregnation

- Malathion 50 EC - 0.1 % for 10 minutes

b. Curative methods

This method is to salvage severely damaged seeds and a drastic method – to be restored to as the last resort. To begin with

- Draw seed samples at fortnightly interval
- Fumigate if > 2 insects/ sample
- Seed moisture should not be > 12%
- Fumigation should be in a fairly air tight condition
- Effect of fumigation depends upon dosage-exposure, time-temperature and grain moisture

Fumigants

- Aluminium phosphide @ 3 tab/ ton of seed (cover fumigation)
- Aluminium phosphide @ 21 tab/ 28 m^3 (shed fumigation)
  (Period of fumigation 5 days)
- Ethylene di bromide @ 22g/ m^3 (shed fumigation)
- Ethylene di bromide @ 3ml/ 100 kg seeds (small fumigation)
  (Period of fumigation 7 days; not for oil seeds & moist grains)
- Methyl bromide @10g/ m^3(shed fumigation)
  - Deadly poisonous in the gaseous stage; lead to germination loss of seeds
- CO_2 fumigation
  - Advantageous for long term storage @ > 35% as dry ice blocks or pellets for 15 days
- Clean the seed store and remove old seed. Do not store new seed with old seed.
- Disinfect the floors and walls of stores well in advance by spraying with 1% malathion (50 EC).

- Plug all the cracks in floor or walls of store to prevent entry of vermin. Fumigate the store by Aluminum phosphide (celphos). While fumigating, care should be taken that the storeroom must be air tight as these chemicals are poisonous.
- Use new gunny bags lined with polythene to store seed in them. In case of old bags, disinfect them with 0.1% malathion 50 EC or with fenvelrate 20 EC. Dip the old gunny bags in this solution for 10-15 minutes and dry properly in shade before storing seed.
- Seed bags should be stored away from walls and they must not touch the floor. Seed bags should be placed on a thick layer of fine sand or cowdung ash as the layer acts as a repellent for insect pests.
- Grain earmarked for sowing should be mixed with 5% malathion dust at 250 g 100-kg^{-1} seed. Inspect the seed in store at regular intervals.
- For storage in seed bins (metal containers), disinfect the containers and place seed in them after proper drying. Spread 2-3 inches thick layer of dry coarse sand on the top of the seed and close the lid of the bin properly.

SEED PRETREATMENT AND INVIGORATION

Sudhakara, K and Mini, C

Seed is a living mature plant. The seeds are harvested at physiological maturity when the seeds will have reduced moisture and maximum quality attributes. After harvest, wherever the seeds are stored, the deterioration process commences, the rate of seed deterioration is however influenced by many intrinsic and extrinsic factors. Deterioration of seeds stored under ambient condition especially under hostile environment, will be very steep. Our seed producers and farmers are facing this grave and recurring problem with loss of viability and vigour even within a crop season. This chapter deals with different types of seed problems and possible control measures.

Seed Dormancy is a condition in which viable seeds fail to germinate when provided with conditions normally favourable to germinate. Several types of dormancy exist, and sometimes more than one type of dormancy occurs in the same seed. Two types of dormancy are normally observed in vegetable seeds. Pre-sowing dormancy, which is associated with seeds before sowing, in just after harvest or even during storage and Post-sowing dormancy which associates with seeds after sowing where the differential days for germination is a typical way of manifestation.

Causes of dormancy

1. Physical factors – Seed coat structure like porosity, thickness
2. Physiological factors – Inhibitor content, auxin fractions
3. Biochemical factors – Enzyme content and proportions
4. Nutritional factors – Deficiencies of micronutrients, improper ratio of nutrient fractions.
5. Other factors – Partially or poorly filled endosperm, spoilt endosperm, inactive or dead embryo.

Advantages of dormancy

Dormancy prevents seeds from germinating during storage and handling procedures, and induction of dormancy by drying and dark storage, generally promotes storability.

Disadvantage of dormancy

When dormancy is complex and seeds need a very specific pretreatment, failure to overcome these problems may result in very poor germination. Low germination rate of seeds, which are found to be sound and viable (through cutting test or tetrazolium test) should be due to dormancy. Seeds may fail to germinate altogether, germination may be slow or germination of individual seeds in a seed lot may take place over a lengthy period. This is partly because of lack of knowledge of their seed physiology and partly because of variation in dormancy rate.

Knowledge on the biology and physiology of various types of dormancy and the occurrence in relation to regeneration biology are essential to study the nature of particular seed problems and possible pretreatment methods.

Seed Pretreatments are value addition treatments or conditions applied during post harvested period, shortly before sowing, to break dormancy and to improve germination and seedling vigour. High value seeds are increasingly exposed to varying pretreatments to improve their performance further.

In some cases dormancy is overcome by providing appropriate germination conditions, rather than a special pretreatment. eg. light and fluctuating temperature conditions required to break physiological dormancy in some seeds.

In nature, dormancy is broken gradually or by a particular environmental event. Type of the event depends on the dormancy type. Hard seed-coat dormancy may be overcome by gradual or instant abrasion, and darkness induced dormancy by exposure to light. In seed handling, the natural dormancy-breaking mechanism is applied or simulated during the process of pretreatment.

Some pretreatment procedures are not directly related to seed dormancy, but are carried out in order to speed up the germination process or promote seedling establishment. Various hormones and nitrogenous compounds may help in breaking dormancy under certain conditions, and may simultaneously have a direct impact in germination.

Different pre-treatments used in vegetables for improved seed quality are shown in Table 1.

Table 1. Different pretreatments used in vegetables for improved seed quality

Crop/variety	*Pre treatment*	*Effect*
Bitter gourd	Scarification with sulphuric acid, nitric acid or hydrochloric acid for 30-60 minutes.	Breakdown of dormancy in fresh seeds
Watermelon	Seed treatment with NAA (25-100 ppm), GA_3 (25 ppm) for 24 hours	Enhanced germination
Snake gourd Chillies and tomato	GA_3 (500 ppm) for 24 hours KNO_3	Improved germination Improved germination
Chillies Ash gourd	NAA at 30 and 50 ppm 1. Storing seeds till 4 months 2. Dil. H_2SO_4 (5N) for 10 minutes or GA_3 (50 ppm) for 24 hours	Larger sized seeds 1. Natural breaking of dormancy 2. Improvement of germination in fresh seeds
Bitter gourd var. Kalyanpur Baramasi	GA_3 150 ppm and hot water 40°C for 2 minutes	Improved germination during spring/summer season even in inherently dormant seeds.

Crop/variety	Pre treatment	Effect
Cucumber cv. Barod	Puncturing, removal or cutting the inner integument	Breaking dormancy
Cucumber cv. Large yellow 58	Cutting the seeds and then soaking in 0.34 M NaCl for 16 hrs	Overcoming dormancy in freshly harvested seeds
Cucumber cv. Himangi	Oven drying at 45°C for 72 h or soaking in 1000 ppm GA_3 for 24 hr	Increased germination in freshly harvested seeds
Cucumber	Acetone (10°C for 15 minute and 12 h)	Breaking dormancy
Cucumber cv. Poinsette	Ethanol application	Breaking dormancy
Water melon and cucumber	Fermentation (3 days at 25°C in the dark)	Accelerating germination of seeds from unripe fruit
Bitter gourd	Soaking in 1% KNO_3 for 12 hrs	Enhanced germination and vigour

Influence of after ripening

Fruit of cucumber cv. Green long when harvested at 40 days after anthesis (DAA) and post harvest ripened for 15 days gave highest seed quality in terms of germination, field emergence and vigour. However, seeds harvested beyond 40 DAA did not benefit from post harvest ripening.

Physiological dormancy in *Cucumis sativus* var. *hardwickii* required 100 days after-ripening under ambient temperature (25°C and humidity approx. 60 %) for 50 % germination (T_{50}). Increasing the RH above 60 % in the atmosphere surrounding seeds stored at 25°C decreased the after ripening time for T_{50} to between 42 and 56 days. After ripening at 37 or 47°C reduced the T_{50} to 75 days in comparison to T_{50} of more than 100 days for temperature below 37°C. After ripening increases the growth potential of the embryo by allowing radicle penetration of the seed coat which present a significant physical barrier in dormant seeds. After ripening treatments during dry storage may overcome primary seed dormancy in muskmelon (*Cucumis melo* L.) seeds.

Influence of pre-germinated seeds

Pre-germinated seeds of ash gourd cv. CO-1 gave early field emergence and flowering than plants raised by sowing dry seeds directly into soil irrespective of soil moisture content. Under low soil moisture content (30-40% field capacity), dry ash gourd seeds did not emerge even after 12 day from sowing.

Seed deterioration

Although ageing of seeds cannot be stopped once for all, it can however, be controlled to an appreciable extent by adopting suitable methods of storage and technologies. Controlled storage of seeds is one of the modern approaches to minimise the loss in seed quality. But such facilities are not always available for bulk quantity of crop seeds at all places. Moreover it is very expensive.

Loss of membrane function and free radical production are considered as the main reasons for seed deterioration.

Priming

Priming is a treatment in which seeds are hydrated sufficiently to allow the preparative events for germination to take place but insufficiently hydrated to allow the radicles to emerge, making seedling emergence more predictable, advanced and more synchronized giving earlier growth. Scavenging free radicals by hydration – dehydration (H-DH) treatment was proved beneficial for controlling seed deterioration.

Mid storage hydration can be accomplished in various ways

1. Soaking the stored seed for 2-3 hours in water.
2. Dipping the seeds in water for 2-5 minutes and then keeping the wet seeds covered for 2-3 hours
3. Raising the seed moisture very slowly by keeping them in water saturated(100% RH) for 24-28 hours

In all these cases, after hydration, seeds are again dried back to their original weight. Hydration–dehydration treatment is done under ambient conditions. The treatment is not effective in harvest-fresh seeds. It is not a dormancy breaking treatment. The possible dormancy must be broken by an appropriate pretreatment prior to priming. Water alone is sufficient, and has the major action in this treatment. But use of certain chemicals in the water showed further advantage on subsequent field performance and productivity. Potassium nitrate, potassium phosphate, sodium chloride, calcium chloride, boric acid, sodium phosphate(dibasic), kinetins, gibberellins, NAA, IAA etc. are used for this purpose.

Advantages of priming

- Enhancement of cellular repair system during storage.
- Reduction in the rate of lipid peroxidation resulting in more rapid and uniform seedling emergence.
- Partial reversal of negative effects of ageing.
- At the biochemical level, osmopriming increases the amount of RNA, DNA and protein synthesis which allow the seeds to advance pre-germination processes and repair.
- During priming the variation in initial imbibition rate is overcome. All seeds tend to reach a stage where they are ready to germinate once they are provided with optimum germination conditions.
- Primed seeds can be stored and handled at least for some time without damage to the seeds.
- Fast germination and thus having a competitive advantage under field conditions.

Disadvantages

However, primed seeds may have a shorter storage life that reduces seed viability and germination speed, which is attributed to seed membrane damage incurred during dry back.

Factors influencing the seed performance during priming:

1. Osmoticum used during priming

In tomato, inorganic salts were more deleterious to seeds through membrane damage and enzymatic changes than PEG.

2. The amount of oxygen supplied to the seed during priming

Low (<21%) oxygen levels resulted in better muskmelon seed performance than seeds primed in pure oxygen.

3. Initial seed moisture content.

The use of acetone can be toxic to pea seeds depending on their initial seed moisture content.

Matriconditioning and drum priming are other approaches to improve seed performance by direct application of water to seeds followed by drying.

In **osmopriming,** seeds are soaked in a priming fluid with high osmotic pressure. PEG is commonly used. Conditions and duration of priming vary with species. A common priming condition is 15°C for 5 to 15 days. Stirring or bubbling is essential during priming of large quantities in containers to assure uniform treatment and proper aeration. Once priming is completed, the seed lot is washed, dried superficially and coated with a film, eg. sodium alginate. The priming fluid may be reused. Drying rate and coating depend mainly on time of priming in relation to sowing date. Seeds to be sown immediately are only slightly dried, seeds to be sown later may need slightly more drying, e.g, by warm air, and protection against fungi. Fertilizer, pesticide or inoculant may be added as an integral part of the coating process. Fungicides are also occasionally added to the priming fluid.

The beneficial effects of priming in different vegetable seeds are furnished in Table 2.

Crop	*Treatment details*	*Effect*
Okra	Soaking seeds in distilled water for 12 hours and in 400 ppm GA, 200ppm IAA or 100 ppm NAA for 12 hrs.	Enhanced germination, plant height and dry matter content
Tomato, cluster bean	Water soaking	Enhanced germination and vigour
Chillies	Soaking in water or 1% KNO_3 + 1% KH_2PO_4 for 72 or 96 hours	Uniform germination
Brinjal	Soaking in water for 24-72 hous	Reduced loss of vigour and viability under ageing

Crop	Treatment details	Effect
Chilli and tomato	Priming in -1.1, -1.3 and -1.5 MPa PEG for 14 days	Early germination
Chilli	Osmopriming with sodium chloride	Increased and early germination, production of normal seedlings
Phaseolus vulgaris 1. cv. Arka Komal 2. cv. Selection-9	Osmopriming using PEG 8000 at water potentials of -1.25 MPa,	1. Increased germination. 2. Reduction in leakage of electrolyte and improved seed vigour
Musk melon (cv. Pb. Hybrid, Pb. Sunehri)	Osmoconditioning with PEG-6000 (-8 bars) and KNO_3 (0.35M) containing 0.2% thiram at 15°C for 3, 5 and 7 days	Increased germination, speed of germination and vigour

The effects of priming has been very useful in several crops. But the adoption of this technology by the farmers is very less due to non-feasibility of this treatment.

Other constraints are

- The process require enormous physical facilities both for soaking and drying
- The treatment is to be given the mid way of storage which is not practical.
- Often the weather conditions would not permit effective sun drying of soaked seeds.
- Lack of mechanised system to carry pout the treatments easily.

Fluid drilling

In fluid drilling, the germination process is allowed to proceed until radicle emergence. Germination takes place in aerated water, and once the radicle has emerged, the seed is mixed with a viscous gel to protect the radicle from mechanical injuries and desiccation.

Presowing seed treatment in which a solid matrix is used instead of an osmotic solution to enhance germination is called 'solid matrix priming'.

Halogenation

Halogenation is a prestorage treatment, where the halogens that readily pass into vapour phase at room temperature are taken up by unsaturated fatty acid components causing stability and render extension of longevity. Further, the halogen possess antimicrobial and insecticidal properties offering protection against storage pathogens and pests.

Dharmalingham (1982) standradised a new dry dressing halogenation process which is applicable to fresh and old seeds. The halogens used include chlorine, bromine and iodine in vapour form. The molecular reaction involve with dry dressing halogen treatment would be same as that of vapour form resulting in stabilization of unsaturated fatty acid components of lipo-protein membranes and rendering them less susceptible to peroxidase changes. It has been suggested that it might react with C=C double bonds of poly-unsaturated-fatty acids making them less susceptible to further oxidation.

Halogenation treatment has been standardised for tropical vegetables like tomato, bhindi, brinjal, chilli and gourds. The herbal, iodine based halogen formulation (HITRON) @ 3g kg^{-1} can be used for improving storage under ambient condition and enhancing the crop yield by 7 to 15 % in various crops.

Methods to determine the successful application of biologicals and their efficacy are still to be developed in the seed-testing laboratory.

Seed enhancements by pelleting and coating

Seed companies have developed physical seed enhancements, including seed pellets and coatings.

Seed pellets totally obscure the shape of the seed, thereby making small and light seeds larger and heavier and irregularly shaped seeds uniformly round. Both procedures facilitate accurate planting by mechanical seeders. The functional substrate is mixed with an adhesive before application. Pelleted seeds achieve in that way a larger, heavier and more uniform size, which facilitates some types of handling, e.g. machine sowing. Major components of pelleting material are a filler, kaolin clay, vermiculite, gypsum, peat etc.

In coating, seeds are covered with the substance with or without an adhesive applied to the seed coat. The method does not significantly increase seed size or weight. Seed coatings improve seed performance but do not obscure seed shape. Traditionally, they have been applied in slurry but a current trend is toward the use of film coatings where additives are dissolved in a dyed solution of a sticky polymer. This allows minimal application of the growth promoting chemical, thereby addressing environmental concerns while simultaneously reducing dust-off problems associated with unwanted removal of the chemical and unnecessary human exposure during handling. Coating material gives some protection to the seed. Special coating material may add some particular protection, e.g. alginate as an anti-desiccant and lime at low pH.

The process of applying the seed pellet/coating also influence seed quality, For instance, pelleting and coating materials are 'wet' during application and may inadvertently initiate the process of germination that leads to increased respiration and reduced seed quality. Pelleting materials that are too hard after drying may also restrict radicle emergence. In other cases, pellets form around multiple seeds that compromise precision planting and further challenge the seed analyst conducting a purity evaluation.

Various substances which promote germination and early seedling development may be added to the coating or pelleting material. E.g. fertilizers, PGRs, fungicides or insecticides, rodent and bird repellent, microsymbionts (mycorrhiza, rhizobia, frankiae). These substances can rarely be applied all to the same seeds at the same time. Fertilizer and fungicides are for instance normally antagonistic to microsymbionts. Coating and pelleting are not economical if seed drills are used.

Seed pelleting with micronutrient ($MnSO_4$ and $ZnSO_4$), fungicide, thiram (2g/kg), either individually or in combination can improve the seed yield (5-10%) and seedling vigour (18-21%). Arappu powder (*Albizia amara*) @ 500 g/kg can be used for pelletting tropical vegetable seeds. Pelleting with *Trichoderma* has been reported to improve germination by controlling disease organisms.

ECONOMICS OF VEGETABLE SEED PRODUCTION

Jesy Thomas, K and Sreeja, K G

Introduction

It is widely accepted now that agriculture must diversify production and achieve sustainable higher output and at the same time safeguard the environment and conserve natural resources and adapt to climate changes and teeming population. In order to release the pressure on cereals as well as to improve upon the human nutrition through consumption of the other nutritious crops, diversification in cropping pattern provides better option. The increased production and consumption of horticultural crops including vegetables with its wide adoption and provider of important nutrients offer promise for the future. Vegetables are rich source of nutrients (especially vitamins and minerals), besides its medicinal values.

In order to tap the potential for raising vegetables in the state of Kerala by taking advantage of the diverse climate and other favourable features, massive vegetable development programmes have been implemented in the state such as the Kerala Horticulture Development Programme (presently VFPCK) and Intensive Vegetable Development Programme (IVDP). As a result there is increased demand for quality seeds in the vegetable production sector. Traditional cultivation of vegetables in the state had been greatly handicapped by the non-availability of quality planting material (Thomas and Thomas, 2005). Therefore the vegetable development programmes in the state have been promoting cultivation of vegetables for seed production in order to meet the growing demand for vegetable seed material. Vegetable seed trade has also become highly competitive with the increasing global dimension acquired by the markets as well as through the entry of multinational hybrid seed companies into the seed production scenario. The value of vegetable seed export from India had been increasing over the years.

Several studies in the past in the state throw light on the economic aspects of vegetable cultivation for seed purpose. Though Rajendran and Habeeburrahman (1994) had reported that seed production was less profitable than production for fresh vegetable purpose, several other workers like Narayanankutty *et al.* (1998) and Rajan and Sukumar (1998) have reported that vegetable cultivation for seed production is indeed a viable option. The percentage increase in income from the seed crops of okra, cowpea and chilli per hectare as against the corresponding commercial crops were 518.18, 346.15 and 516 respectively (Satyanarayanan and Raza, 1999)

Economics of production

The economics of production involves the calculation of the cost of cultivation as well as the assessment of financial performance to judge whether the venture is financially viable.

Cost of cultivation

The cultivation costs of vegetables for seed production would include the added costs of seed extraction and processing compared to vegetable cultivation for fresh vegetable purpose. Manuring, *Panthalling*, harvesting and seed processing expenditures are found to occupy the paramount position in almost all vegetable crops grown for seed purpose. (Das, 2000; Narayanankutty et al., 1998; Preeti, 1997). A postgraduate study undertaken at the Department of Agrl. Economics, College of Horticulture, KAU revealed that in cucumber, chilli, bittergourd, okra, cowpea, snakegourd and brinjal human labour was the single largest item of expenditure. Manures can form a major item of expenditure especially in crops like amaranthus and certain cucurbitaceous crops like ashgourd and pumpkin. Fertilizers account for close to seven percent of the total cost of cultivation. As crops like brinjal are of longer duration, the fertilizer requirement may be higher. In the seed production of cucurbits, plant growth regulator is another input component. When it comes to vegetable production for seeds the use of plant protection chemicals is greater compared to cultivation for vegetable production. The cost of staking materials has gone up in the recent times due to paucity of bamboo poles.

Cost of production

The cost of production per kilogram is expressed as the ratio of cost of cultivation per hectare to the yield on the farm. This can be obtained by dividing the total costs by the output. Though cost of cultivation is low in crops like brinjal, pumpkin and ash gourd, the cost of production is high due to lower seed recovery in these crops. On the contrary, in crops like cowpea, chilli and okra the cost of production is low compared to a high cost of cultivation because of higher seed yield. Thus, cost of production of pumpkin seeds was 2.69 and that of ash gourd seeds was 2.87 times that of okra seeds (Das, 2000). As seen from Table, the cost of production was highest for brinjal (Rs. 220.04/kg) followed by bitter gourd (Rs.211.24/kg) whereas it was lowest for okra at Rs. 61.17 per kilogram.

Returns

The income from seeds, vegetables and by-products like dehydrated bitter gourd, chilli powder etc. determine the gross returns received by the seed growers. In amaranthus, income from seeds contributed 96.72 percent of the gross returns whereas in chilli sale of seeds gave an income of 73.72 percent of the gross income.

Benefit Cost Ratio

BCR indicates the value of output per rupee of input cost. According to a study conducted at the Dept. of Agrl. Economics, KAU, amaranthus, cucumber and chilli were found to have higher BCR whereas okra and cowpea have lower BCR despite lower costs of production. From Table it can be seen that BC Ratio was highest for amaranthus at 3.56 whereas it was only 1.45 for cowpea.

Through an analysis of various studies such as Satyanarayanan and Raza (1999), Narayanankutty *et al.* (1998) and Das (2000) it was found that amaranthus and cucumber are preferred crops in vegetable seed production due to the low risk, low care and attention and low labour required by these crops. Income and Benefit Cost Ratio were also high for both the crops.

Constraints and strategies in vegetable seed production

With the entry of private players in the seed market, vegetable seed production has become highly competitive. Private traders and seed companies are found to enjoy a better market share in the seed market. Quality seed production is a highly specialized activity. Hence inadequacy of training and infrastructural facilities available to the farmers is a glaring constraint leading to huge losses. There are major problems in the distribution side also due to disparity in production resulting from high uncertainty of demand. Often prices received are not proportionate to the cost of production. High incidence of pests and diseases which force the farmers to dispose off the vegetables in the fresh form itself rather than keep it for seed purpose is another major constraint.

Certain strategic interventions such as assessment of seed demand of each crop and corresponding varietal preferences in each area, formulation of separate Package of Practices recommendations for vegetables cultivated for seed purpose, provision of infrastructural facilities for storage and quality control and skill impartment in scientific agri-business management can help make vegetable seed production more economically attractive to the farmers.

Table. Cost of Production, Returns and Benefit Cost Ratio of vegetable seed production

Sl. No.	*Name of crop*	*Returns (Rs./ ha)*	*Cost of production (Rs/kg)*	*Benefit-Cost Ratio*
1	Amaranthus	101752.50	70.34	3.56
2	Cucumber	71025.00	114.44	2.63
3	Chilli	103572.00	174.64	2.01
4	Bitter gourd	99216.25	211.24	2.01
5	Okra	37920.60	61.17	1.47
6	Cowpea	70974.80	89.78	1.45
7	Pumpkin	47740.00	162.99	1.53
8	Snake gourd	108353.75	231.68	1.84
9	Ash gourd	47160.00	166.29	1.51
10	Brinjal	67817.75	220.04	1.47

Source: Unpublished M. Sc. (Ag.) thesis of Das, Sandhya M., 2000.

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INDIGENOUS KNOWLEDGE ON VEGETABLE SEED PROCESSING

Jayasree Krishnankutty

Cultivation of vegetables held a prime position in traditional Kerala Agriculture. The predominant system of cultivation was and continuous to be the homestead cultivation. Each homestead was designed as a self sustainable unit, producing mostly all feed items for the farm family, with the least possible usage of external inputs. Vegetables were cultivated either on relatively large scale in rice fallows or on a consumption basis in the homestead backyard. But in either case, there was a regular pattern for everything right from selection of crops to harvesting, storing and seed preservation for the next season. This pattern formed the rhythm of traditional agriculture, based on knowledge, time tested and handed over from generation to generation. This traditional system may not always have been aimed at increasing production year after year, but it assured healthy, succulent, tasty and storable produce.

As new widely agreed upon, scientific agriculture has robbed away some of these superior qualities of the traditional crop. It is time we integrated our rich traditional knowledge into modern agriculture, so that we can have the best of both worlds.

Following is a collection of indigenous knowledge on the seed production aspects of vegetables. These practices have been evolved by generations of trials and modifications by farmers. All of them must have a scientific rationale hidden beneath, which are mostly beyond the practical knowledge of the farming community. There is an urgent need to standardize, field verify and bring out the scientific rationale of each of these practices before they are lost forever from the farming front.

Crop	*Selection of plants/fruit*	*Collection of seeds*	*Storage of seeds*
1	2	3	4
Cowpea	-	Keeping ripe pods in the sun for one or two days and exposing to smoke.	Sun dried cowpea seeds are stored after smearing them with coconut oil/ gingelly oil/ castor oil. Seeds are mixed with river sand, pepper or ash and stored in earthen pots
Tomato	Fruits formed at the initial stages of bearing will be better.	Keeping the selected and squeezed fruits for fermentation overnight.	Drying seeds in shade for 4-5 days

1	2	3	4
Snake gourd	Fruits from the main vine are kept aside for seed extraction. It is retained in the plant till the colour changes. To prevent the fruit from falling down when ripe, it is usually kept on top of the pandal. The harvested fruit is kept for 2 days and only then seeds are extracted.	-	The extracted seeds are cleaned and kept in the open for one day and one night. Then they are exposed to smoke for another day. Such seeds, when stored in air tight containers will remain viable for a long time.
Ash gourd		After extraction seeds are mixed with either charred rice bran or coirpith and rubbed well with hands. Another method to separate the seeds is to place the entire slushy seed portion in a closed jar. Shake it vigorously and keep still for 2-3 hours. The seeds will collect together at the bottom.	Seeds are rubbed with ash, dried in the sun and stored. Storing the seeds inside cowdung balls will increase yield.
Brinjal	Fruits from the first six harvests are used for seed collection.	The ripe fruits after harvest are kept in sealed plastic covers. This will make them hot. They are washed and seeds taken out.	
Pumpkin	Fruits with good colour and shiny surface are chosen for seed extraction.		Cleaned and dried seeds are stored inside cowdung balls
Bhindi	When well ripened fruits start to crack they are harvested for seeds. Fruits formed during the initial stages of bearing are better for seed extraction	Fruits are dried in the sun for 2-3 days.	The dried seeds are mixed with dry red chilli skin, kept in earthen pots and stored air tight.
Bitter gourd			Washed and dried seeds are smeared with ash and stored. Seeds are covered with a paste of cowdung and then affixed on the wall of the kitchen or oven hearth.

1	2	3	4
Amaranth	When the stem starts to turn brown, the plant is cut. Seeds will be jet black at this time		Seeds are stored in earthen pots smeared with cow's urine
Chilli	Fruits for seed collection are selected from the first six harvests.	Fruits for seed extraction are dried in the sun for 3-4 days.	The dried seeds are smeared with ash and stored. The dried red fruits or the seeds kept in cloth pouches are hung over smoke until taken for sowing
Cucumber	The first borne fruits themselves are kept aside for seed extraction. Fruits are harvested when the vines start to dry up	Cut both ends of the harvested fruit. Split it open, take the seed portion out and separate the seeds.	The seeds are coated with soil, dried and stored
Dolichos bean	Large,worm free beans are kept aside for seed extraction. They are allowed to remain in the plant and dry up.	The beans are dried in the sun and seeds are separated manually.	Dried seeds are mixed with river sand and stored in earthen pots. Beans are dried as such, kept in cloth pouches and hung over smoke
Bottle gourd	Larger fruits of the plant are earmarked for seed extraction.	When the vines start to dry up fruits are harvested.	The harvested fruits are hung as such in a hot, dry place.

Crop	*Pest and disease control in storage*	*Germination, sprouting*
1	2	3
Cowpea	Mixing the seeds with cashew nut rinds, will repel pests. The outer skins of pods after extraction of seeds are charred. This ash is mixed with seeds during storage to prevent pests. Put hair around the seed sacks to ward off rats	Soak the seeds in a day old rice water for a few hours and then sow them
Tomato	Dry pieces of 'Vayambu' (*Acorus calamus*) and tubers of 'Kacholam' (*Kampferia galanga*) are mixed with seeds to ward off pests	The stored seeds are wet, tied in cloth pouches and kept over night before sowing

1	2	3
Snake gourd	Seeds are mixed with garlic petals	One day before sowing the seeds are taken out, sprinkled with water and immersed in cow dung slurry. Then they are sown the next day. Breaking away the tip of the seed before sowing enhances germination
Brinjal	Leaves of 'Karunochi' (*Vitex negundo*) are dried, powdered and sprinkled inside the sacks in which seeds are stored	Seeds are tied in a cloth pouch and immersed in cow dung solution for around one hour. Then they are taken out and kept with occasional wetting. The next day the seeds are sown.
Amaranth	Seeds are stored by mixing them with ash or neem cake powder to ward off pests	The seeds are sprinkled with water and kept tied in a wet sack overnight. The next day they are sown. When the seeds are sown, sprinkle rice grains along with. This will prevent ants from eating the seeds
Chilli	The leaves of 'Panal' (*Glycosmis* sp) are crushed, juice extracted and diluted. Seeds are soaked in this solution for one hour before sowing. This will prevent ants	The seeds are dipped in cowdung solution and then kept tied in cloth pouches. 12 hours before sowing seeds are soaked in water. This will enhance sprouting.
Bitter gourd	Seeds are smeared with ash and stored to keep away storage pests. Mix leaves of bandi (Marigold) plant with stored seeds.	Seeds are covered in fresh cow dung and stuck on the walls. When they are about to be sown the flakes of cow dung are removed. This will reduce the germination time from 10 days to 6 days.
Dolichos bean	Mix the seeds with powdered castor seeds against storage pests	Seeds are soaked in water for one hour and then kept tied in cloth pouches overnight. Seeds are sown the next day.
Pumpkin	To prevent pest attack and moisture contamination to the stored seeds in earthen pots sprinkle powdered hay along with the seeds.	
Bhindi	To ward off storage pests, powdered leaves of 'Adakkamaniyan'are tied in cloth pouches and kept along with the stored seeds	Seeds are soaked in one day old rice water overnight and then sown
Cucumber Ash gourd Bottle gourd	Neem or Tulsi leaves are mixed with seeds. Seeds are smeared with ash or covered in soil. Mango leaves are mixed with seeds.	Seeds are immersed in cowdung slurry overnight and sown the next day. Add a handful of common salt in the water used for soaking the seeds. This will remove the fungal coating of the seeds and improve their vigour Cucumbers when tied with rope and hung high, can be stored without losing the germination power for about an year.

General

- Mixing stored vegetable seeds with leaves of "Erukku" or wood pieces of "Venga" will help prevent storage pests.
- Smoking neem leaf powder in seed storage will repel storage pests.
- Dried wild basil leaf powder kept in cloth pouches will act as pest repellant in seed storage.
- Two days before sowing wet hay tied into small bundles are placed on top of seeds. This will accelerate germination.
- Keep red chillies along with vegetable seeds to ward off storage pests.

LIST OF CONTRIBUTORS

Dr. Abraham, C.T
Associate Professor & Head
Department of Agronomy
College of Horticulture, Vellanikkara

Dr. Beena, S
Assistant Professor (S.S)
Department of Plant Pathology
College of Horticulture, Vellanikkara

Dr. Gopalakrishnan, T.R
Associate Professor & Head
Department of Olericulture
College of Horticulture, Vellanikkara

Dr. Indira, P
Associate Professor
Department of Olericulture
College of Horticulture, Vellanikkara

Dr.Jayasree Krishnankutty
Assistant Professor
Department of Agrl. Extension
College of Horticulture, Vellanikkara

Dr. Jesy Thomas ,K
Assistant Professor
Department of Agrl. Economics
College of Horticulture, Vellanikkara

Dr. Krishnakumary, K
Assistant Professor
Department of Olericulture
College of Horticulture, Vellanikkara

Dr. Maicykutty. P.Mathew
Associate Professor
Department of Agrl.Entomology
College of Horticulture, Vellanikkara

Dr. Mani Chellappan
Assistant Professor
Department of Agrl.Entomology
College of Horticulture, Vellanikkara

Dr. Mareen Abraham
Assistant Professor (Pl. breeding)
Cashew Research Station, Madakkathara

Dr. Meera V.Menon
Assistant Professor
Department of Agronomy
College of Horticulture, Vellanikkara

Dr. Mini. C
Assistant Professor (Hort.)
Cashew Research Station, Madakkathara

Dr. Nirmaladevi, S
Assistant Professor, AICVIP
College of Horticulture, Vellanikkara

Dr. Potty, N.N
Professor & Head (Retd)
Department of Agronomy
College of Horticulture, Vellanikkara

Dr. Rajan, S
Officer on Special duty
Directorate of Research
Kerala Agricultural University, Vellanikkara

Dr. Sadhankumar, P.G
Associate Professor
AICVIP, College of Horticulture,
Vellanikkara

Dr. Sally K.Mathew
Associate Professor
Department of Plant Pathology
College of Horticulture, Vellanikkara

Ms. Sindhu, P.V., Ph. D student
Department of Agronomy
College of Horticulture, Vellanikkara

Ms. Sreeja, K.G
Research Associate
Department of Agrl. Economics
College of Horticulture, Vellanikkara

Dr. Sudhakara, K,
Associate Professor
College of Forestry, Vellanikkara

Dr. Sureshbabu, K.V
Associate Professor
Department of Olericulture
College of Horticulture, Vellanikkara