SHORT COURSE ON

CROP RESOURCE MANAGEMENT IN HUMID TROPICS

(3.8.1999 TO 12.8.1999)

Dr. G. RAGHAVAN PILLAI

Sponsored by

INDIAN COUNCIL OF AGRICULTURAL RESEARCH, NEW DELHI

Organised by

DEPARTMENT OF AGRONOMY

COLLEGE OF AGRICULTURE, VELLAYANI - 695 522

KERALA AGRICULTURAL UNIVERSITY

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CONTENTS

Role of public funded Agricultural Scientists on Indian agriculture of 21st century

M. R. Sethuraj

India has attained a comfortable position of food security although nearly 30% of its population still live below poverty line. This country has proved certain earlier western predictions of food scarcity during 1980s wrong by ushering in 'green revolution' and our agricultural scientists have played a significant role in this achievement. The major components of 'green revolution'; such as selected high yielding varieties representing a narrow genetic base and high chemical input and irrigation requirements, have however resulted in a situation of long term adverse impact on sustainability of natural resources and on environment. This post-green revolution effects are being increasingly felt by stagnant or even declining trend in yield in these areas. This experience, as well as other environmental considerations and resource limitations discourage extension of green revolution technology to other areas. which represent about 65% of our arable land. In recent years there had been vigorous demand for a paradigm shift towards sustainable crop production systems. The older models of sustainable agriculture which our ancestors have followed are inadequate to increase unit productivity to meet the growing demands. Though much have been said and written about the new alternative technology for sustainable agriculture, the fact remains that appropriate and efficient technology for high levels of productivity under different agro-ecological situations is far from being perfected. Meanwhile, the philosophy of agri-productions has undergone substantial change with the signing of the World Trade Agreement and related norms for intellectual property rights. Monetary and intellectual investments in agriculture have gained momentum with the entry of private multinational companies. There is a fast transition from traditional agriculture to agri-business, and the strategies involved in the process may affect the food and social security of the poorer sections of the society.

In this context, the public funded agricultural scientists have a special role to play. They have to evolve a balancing strategy to adopt sustainable technologies and ensure social and environmental security on the one hand and integrate frontier sciences such as molecular biology, information technology etc. to achieve high productivity to match the emerging agri-business environment. Identification and characterisation of agronomically valuable genes present in our traditional crop societies can contribute substantially in evolution of new location specific high yielding crop varieties which would respond to sustainable systems of agriculture. Our agricultural students should address the problems posed by the terminator gene technology by evolving matching high yielding crop varieties and release them to the public domain.

Biodiversity – An over view

P. Pushpangadan, K. Narayanan Nair and M. Santhosh

Introduction

The rapid depletion of the world's biodiversity is one of the most pressing issues of our time. There is currently enormous concern over the increasing threats to global biodiversity, for it is upon this precious natural heritage depends the very sur-vival of humanity. The emerging realization of the underlying causes and possible ecologic, evolutionary, genetic and economic consequences of the biodepletion crisis was one of the promptine factors which in 1992 led to the eventful Earth Summit at Rio de Janeiro and culminated in 1993 (29 December 1993) in the ratification of a global agreement on biodiversity - *The Convention on Biological Diversity.* The Convention lays an unequivocal emphasis on the need to conserve and utilize sustainably the ecosystems, species and genetic diversity on the Earth for the benefit of the present generation and posterity as well. It also sanctions adequate provisions to ensure the sovereign rights of each country/ state over its biological wealth and to share equitably the benefits arising out of sustainable utilization of its biological and genetic resources.

The intrinsic potentials of biodiversity as a key resource for evolving new kinds of food. medicine. cosmetics and several other value added products of industrial importance have now been increasingly realised, thanks to the recent advance-ments in biotechnology, particularly in the field of genetic engineering. This growing realization of the significance of bioprospecting through biotechnological innovations has prompted many countries, particularly those located in the biodiversity rich areas of the tropics and subtropics, to initiate multidisciplinary scientific researches aimed at long-term protection, maintenance, evaluation, conservation and sustainable utilization of biological diversity.

Tropical Biodiversity - The Current Scenario

It is well known that the greatest biological diversity is in the tropical regions of the world, with large concentrations in tropical rain forests - the most complex and diverse biome on the Earth. Even though tropical rain forests occupy only 7% of the Earth's land area, they contain more than half of the estimated 5 million species of plants, animals and microorganisms in the world. For example. about two - thirds of the estimated 2,50.000 species of higher plants in the world occur in the tropical forests of America, Africa and Madagascar, and tropical Asia including New Guinea and tropical Australia. Similar estimates of species richness as in the case of insects, birds and mammals also exemplify the high assemblages of species diversity in the tropical forests. This is further augmented by the fact that it is in the tropical region (and subtropical) where the world's twelve megadiversity countries and as many as megagene centres are located (Zeven & de Wet, 1982; Mc Neely *et al.* 1990). Given with high species richness and diversity, the tropical forests represent nature's treasure trove of myriad potential resources of great economic and industrial value such as basic food supplies, fuels, fodder, fibres, drugs, essential oils, edible oils, gums and resins, dyes. tannins and other raw materials for perfumes, flavours, soaps etc.

Nevertheless, it is these biodiversity rich areas or the trop-ics that are the worst affected of the increasing incidences of biodiversity loss. The number of species that are driven to extinction due to tropical deforestation and other human activities is estimated to be 27.000 per year in the tropici forests alone (Myers, 1993). As pointed out by Michael Soule 1990. noted Conservation Biologist, these facts - the unsuspected vastness of biological diversity and its current vulnerability in the tropics - are the major challenges which the humanity is currently confronted with. What appears to be far more star-tling is the fact that scientists in the world over has just begun to take stock of the existing biological diversity of our planet. and completing the inventory of the worlds biota amidst the escalating crisis of biological extinctions is indeed an uphill task.

The Indian Scene

India is marked by remarkable ecologic. biologic and cul-tural diversity. This has bestowed upon her the unique distinction of being one among the twelve megadiversity countries in the world (Mc Neely *et al* 1990). The country has over 1,26,188 species of fungi. plants, animals and microorganisms already identified and classified (Khoshoo, 1995) Table I.

In India species richness is often accompanied by enormous genetic diversity found within individual species.

Table I. Biological spectrum of India

Taxon	Number of specics	Percentage
Bacteria	850	0.67
Algae	2.500	2.00
Fungi	23.000	18.23
Lichens	1.600	1.30
Brvophyte	2.700	2.14
Pteridophyte	1.022	0.80
Gymnosperms	64	0.05
Angiospcrms	17.000	13.50
Protozoa	2.577	2.04
Mollusca	5.042	4.00
Crusustaceae	2.970	2.35
Insects	50.717	40.00
Other invertebrates includine hemichordata	11.252	9.00
Protochordata	116	0.10
Piscis	2546	2.02
Amphibia	204	0.16
Rcptile	428	0.34
Ayes	1228	l.00
Mammalia	372	0.30
Total	126.188	100.00

Sourct T.N Khoshoo (l 995)

This makes India one of the Vavilovian Centres of diversity and origin of about 167 crop plants and the primary or secondary centre of domestication of a few animals. This rich biodiversity is also matched with equally rich cultural diversity and a unique wealth of indigenous knowledge systems embodying a plethora of useful information on the multifarious uses of biological resources by tribal and traditional communities Anonymous. 1994).

Due to increased human activities. India's biodiversity. as in any other part of the tropical region. is in peril. Several of the country s major biomes arc being irrcparably degraded. leading to virtual decimation of several species and depletion of genetic diversity. Over 10% of the vascular tiora of India is facing serious threats of rarity, endangerment and extinction due to various reasons. Nayar & Sastry (1987, 1988. 1990) have catalogued about 600 species of vascular plants in India under various threat categories. More than 150 species of the fauna arc also under serious threats of extinction. These include 81 species of mammals, 47 birds. 15 reptiles. 3 amphibians and several species of buttertlies, moths and beetles. Out of the eighteen global hot spots' of biodiversity which represent high areas of endemism and significant threat of imminent extinctions, two lie in the Indian subcontinent viz, the Western Ghats and the East Himalayas (Myers. 1990). These two areas together contain about 5330 endemic species of higher plants. mammals, reptiles, amphibia and butterflies.

The Western Ghats - A "Global Hot Spot" of Biodiversity

Lying along the west coast of peninsular India (8°20 - 20°40' N & 73°- 77°50' E) in the north-south direction from the mouth of Tapti River in Gujarat to Kanyakumari in Tamil Nadu, the Western Ghats form a continuous relief (except the 30km wide Palakkad gap which separates the Nilgiri Hills from the Anamali Plateau) constituted of a series of hills attaining an average height of 1500m above msl. Anamudi, which towers upto 2694m, is the highest peak in the ghats south of the Himalayas. The geological antiquity of the 1600 km long mountain chain is marked by the occurrence of Pre-Cambrian Archaean crystalline rock types like charnockites . gneisses and schists. The main types of soils found in the ghats are laterites, red and black soils.

The western side of the Western Ghats. which lies on the south-west monsoon path, receives abundant annual rainfall (2000-7000mm) during the months from June to September. and is hence supported by luxuriant vegetation. The eastern side of the ghats is on the leeward side receiving only poor annual rainfall and the vegetation here is dominated by scrubs and dry deciduous forests. The mean annual temperature of the Western Ghats ranges from 20'-24°C.

Vegetation and biogeography

Influenced predominantly by the gradient of rainfall, the Western Ghats are known for their vegetational exuberance and biological diversity. Depending up on the rainfall regime. temperature, altitude and soil types. they feature remarkable diversity in the composition and structural attributes of different forest biomes, the main types of which include tropical evergreen, semi evergreen, moist deciduous and dry deciduous forests, besides montane sholas. savannas. grasslands and lowland scrub jungles. The most outstanding feature of thc vegetation of the Western Ghats is thc development ot tropical rain forests. especially on the windward side of the southern Western Ghats. usually between 500-1500m (Subramanyam & Nayar, 1974).

Characterized by a unique blend of geographic. geologic. edaphic and climatic gradients. the Western Chats represent a distinct biogeographic zone in India and are known for their biotic richness with high incidence of endemism. The geological antiquity. evolutionary history and biogeographic patterns with special emphasis on endemism in the flora and fauna of the Western Chats have been discusscd by seveal earlier au-thors [Blasco, (1970); Krishnan (1974). Mani 1974). Subramanyam & Nayar (1974). Nayar ((977, 1980a. 1980b). Ahmedullah & Navar (1987), Rao (1978). Pascal (1988). Nair & Daniel (1986). Nair (1991)]. Though not exhaustive, all these studies point to the uniqueness of the biodiversity of the Western Ghats. while the present authors attempt here to highlight the scope of preserving the precious biotic wealth of the West-ern Chats for conservation and sustainable utilization.

Phytogeographically. the Western Chats correspond to the erstwhile *'India aquosa'* or *'Malabar'* province of Prain (1903) and Hooker (1907) respectively. The region supports a rich and varied flora, which according to Subramanyam & Nayar (1974), shows characteristic distributional patterns in four such well defined phytogeographic segments as (I) Wesrtern Ghats from the River Tapti to Goa (2) Wesrtern Ghats from the River kalindi to Coorg (3) The Nilgiris and (4) The Anamalai. Cardamom and Palni Hills.

Biotic wealth

It is estimated that the flora of the Western Ghats contains about 4000 species of flowering plants, of which 51 genera and 1600 species are endemic to the region. It is interesting to note that out of the 51 endemic genera of flowering plants in the W. Ghats, 43 are monotypic. The occurrence of a large number of paleoendemics and the remarkable affinities of the extinct and extant flora to that of the Indo-Malaysian and Afro-tropical realms suggest the early history and evolution of the Western Ghats flora as originated from the ancient Gondwanaland.

The faunistic pattern and its endemicity also reflect the biogeographical significance of the Western Ghats (Mani, 1974). The ghat region is notable for several genera and spe-cies of amphibia, reptiles,birds and mammals that are unique to the area. Eighteen species of frogs are endemic to the Western Ghats; so also the mammalian species like the lion tailed macaque. Nilgiri langur and the Nilgiri tahr.

The Western Chats represent a primary or secondary cen-tre of origin and diversification of wild progenitors and wild relatives of several cultivated plants and domesticated ani-mals. As regards plant genetic diversity, the Western Ghats are rich in supporting about 145 wild relatives of crop plants be-longing to 66 genera (Arora & Navar, 1984). The important plant genetic resources of the region include among others rice, pepper, cardamom, ginger. turmeric, cinnamon.jack fruit. mango and pigeon *pea*. Blessed with diverse agroclimauic zones embracing varying altitudinal, latitudinal and edaphic gradi-ents, the Western Chats of peninsular India are unique in harbounng remarkable genetic polymorphisms. especially in terms of chemical polymorphisms as found in medicinal and aromatic plants. The unparalleled genetic wealth of the Western Chats constitutes a potential resource base for sustainable agriculture and genetic upgradation of important crop plants.

Despite such high richness and diversity, no exhaustive study on the complete spectrum of biota and their biogeographic pattern in the Western Chats has ever been attempted. The extent of biological diversity in the lower group of plants and animals, especially the microflora and microfauna of the Western Chats is not fully known. Therefore, the productive potentials of such invaluable but imperfectly known biota remain either unexploited or underexploited. The rain forests of the Western Ghats are expected to be rich in microbial wealth which might prove excellent biological /genetic materials for chemical, indusnial, pharmaceutical and gene pros-pecting.

Kerala's Biodiversity - Current Status and Tasks Ahead

In many respects, Kerala represents an epitome of the Western Ghats. Located in the west coast of peninsular India between latitudes 8°18' & 12°48' north and longitudes 74°4' & 77°50' e ast, Kerala is remarkably well known for her luxuriant vegetation and rich biological diversity. Perhaps no other state in India with similar geographic and physiographic conditions has been so blessed with an immensely rich natural resource base as in Kerala. The geographical isolation of this state - bordered in the west by the Arabian Sea and in the east by the Western Ghats, and its peculiar, physiographic, edaphic and climatic gradients have contributed significantly to the development of diverse types of ecosystems, each supporting unique assemblages of biological communities with an impres-sive array of species and genetic diversity.

An undulating narrow strip of land with varying altitude ranging from below mean sea level (msl) to 2694m above msl, Kerala is sprawled over an area of 38,863 sq.km. Based on the topography, altitude and. soil types, the state is divisible into three natural zones- lowland, midland and highland. The low-land region is demarcated by its 580km long sea coast and beautiful backwater systems (lakes, rivers, lagoons, canals etc.) extending to an area of about 500 sq.km. The occurrence of wetland, estuarian and mangrove ecosystems in the ecotone areas is a characteristic feature of the lowland region. The high-land represents the mountainous or rocky terrain in the Western Ghats, exceeding altitude of 900m. The windward or rainfed part of the Western Ghats in Kerala is endowed with lush green vegetation comprising different types of pristine or climax forests like the tropical rain forests. The midland zone constitutes the low or medium hills and hillocks in the Western Ghats. This area also supports extensive forest tract. but is also known for the cash crops iikc cardamom, rubber ctc.

The Western Ghats have a profound influence in maintaining a tropical climatic regime for the entire state of Kerala. The location of Kerala on the windward side of the Western Ghats helps receiving copious rainfall (average annual rainfall ranges from 1000-7000mm) from two distinct spells of monsoon. the south-west monsoon during June-September. and the north-east monsoon from September to December. Consequently; there is high incidence of atmospheric humidity with an average of 70%. The temperature is moderate and ranges from 19 to 37°C, often with less diurnal variation. The geological antiquity of the State is also equally interesting. The presence of ancient rock types (around 2500 million years old) like charnockites, gneisses and schists in the Western Ghats of Kerala supports the above. Geology, geography, climate and hydrology have helped Kerala in supporting a rich biological heritage, the finest expression of which is found at three major levels- *ecosystems, species* and *genes.*

Ecosystems diversity

The ecodiversity of Kerala is featured by the development of different types of ecosystems, each characterized by distinctive structural and functional components. The major types of ecosystems found in Kerala can be classed under forests, wetlands, mangroves and aquatic ecosystems.

Forest diversity Forests account for 24% (9400 sq.km) of the total geographic area of Kerala. They are home to a wide array of plants, animals and microorganisms. and are mostly confined to the mountainous tracts of the Western Ghats. Depending upon the altitudinal range. rainfall regime and soil types, the forests of Kerala are further classified into different sub-types (Table 2). The most outstanding feature of the forest vegetation in Kerala is the occurrence of 'tropical rain forests', which represent one of the 'climax types' of forests noteworthy of their biological exuberance. The rain forests in the southern Western Ghats, particularly in Kerala. are unique in featuring characteristic phytoassociation of two or three dominant species. Chandrasekharan (1962) in a series of paper has discussed in detail the ecology, classification and phytogeographical affinities of the major forest types of Kerala.

Table 2. Classification and extent of major forest types in Kerala

Classification	Area (in sq.km)
Tropical wet evergreen and semi evergreen forests	3449
Tropical moist deciduous forests	4100
Tropical dry deciduous forests	100
Montane subtropical and temperate sholas	70
Grasslands	130
Forest plantations	1551
Total	9400

Source - Forest Statistics. 1994 - Kerala Forest Dept.

Typical of any tropical forest ecosystem, the forests of Kerala represent a dynamic repository of a wide array of invaluable resources such as timber (teak. rosewood, sandal wood etc.) and important non-timber forest produces like medici-nal and aromatic plants, bamboos and reeds, canes, wild edible fruits, orchids, edible Dioscoreas. honey, wax, resins and gums, and wild game, besides wild progenitors and related species of several cultivated plants including rice, pepper, ginger, cardamom, jack fruit, mango. plantain etc. It was in fact the astoundingly rich biotic wealth that lured many Greek, Arab and European traders into Kerala.

The Malabar coast', as Kerala was known in the past, is the legendary land of spices. It has played an important role in shaping the history of human civilization, exploration, trade and commerce. Black pepper *(Piper nigruin)* is perhaps the oldest spice known to the world. Ginger. turmeric, cardamom. sandal wood, lemon grass oil and ivory were other commodities sought out by traders of the western countries. The only source of these much preferred spices and other aromatic plants was the west coast of India. particularly Kerala. In the past when there was absolutely no refrigration or preservation technologies spices. particularly pepper and ginger, were the only items used by people in the Old World for preserving food materials. In the temperate countries of the West, pepper and salt used to be essential requisites .for preserving and improving the palatability and digestibility of their winter foods, especially fish and meat. Historically these spices have been responsible for the rise and fall of empires, and they still continue to play a crucial role in maintaining the traditional linkages between the East and West through trade and exchange.

Forests of Kerala are still a repository of invaluable germplasm of some of the commercially important spices like pepper, ginger. cardamom and turmeric. The gene pool of these spice crops comprises innumerable cultivars and several wild relatives. For example. Kerala is remarkably rich in Piper germplasm which has a large number of cultigens of the black pepper and ten wild species related to it. The genetic variability in Cymbopogon (Lemon grass) is equally rich with six wild species and more than 3000 strains. Similarly, Zingiber (6 species), Cinnamomum (15), Curcuma (18) and cardamom (1) also contribute much to the crop plant genetic diversity in Kerala.

Apart from her immense wealth of spices. Keraia is also notable for plantation crops like teak, sandal wood, rose wood etc. The Conolly's teak plantation set up in Kerala in 1 840s was the first organised plantation in India. The State today grows a good number of plantation crops of both indigenous and exotic species like rubber. Eucalyptus, Wattle, Acacia, Artocarpus, Mahoeany, Rose wood, Sandal wood etc.

The faunal wealth of Kerala is equally rich and diverse with animals like elephant, tiger., gaur, Niigiri tahr, spotted deer, barking deer, panther etc. The pristine forest ecosystems in Kerala are also home to some of the endemic and endangered species like the lion-tailed macaque. Niigiri langur, Malabar civet, the giant squirrel etc.

The sacred groves found along the coastal villages and midland region represent the living testimony of the conservation ethos upheld by our forefathers. These isolated forest patches, which represent the relicts of the once luxuriant rain forests, act as refugia of many endemic and threatened plants and animals and a repository of plant genetic resources.

Wetlands The wetlands of Kerala constitute yet another productive ecosystem which supports unique aquatic flora and fauna including the waterfowl, fish, shell fish and other wild-life. Ecologically they constitute a transitional ecotone between dry land and open water. Besides supporting unique biota, the wetlands perform several ecological functions. Nevertheless, the ecoiogic and socioeconomic potentials of the coastal wet-land system in Kerala have not been properly understood. Lack of realistic assessment and inventory on the wetlands and their productive potentials has been largely responsible for intensive and indiscriminate reclamation ot wetland areas in Kerala. So there is an urgent need to initiate indepth study on the extent ot natural and man-made wetlands occurring in Kerala and to preserve the ecoloizical resilience of such fragile areas for conservation and rational utilization.

Mangroves The mangrove forests of the coastal zone represent highly productive ecosystems and specialized ecological niches for a unique assemblages of plants and animals. The mangrove vegetation in Kerala was spread over an area of about 700 sq.km. which has now been reduced to a few isolated patches covering less than 50sq.km. They render a good breeding ground for fish, shell fish and prawns and are therefore ideally suited for sustainable pisciculture and shrimpculture. The flora and fauna supported by mangrove vegetation also serve as a source of livelihood for the people who inhabit near these areas.

Aquatic ecosystems The aquatic systems in Kerala consist of fresh water rivers, lakes, ponds, estuaries and a chain of brackish waler lagoons.

The drainage system of Kerala is perfected by 44 rivers, all originating from the Western Ghats, of which 41 are west flowing and joining ultimately in to the Arabian Sea while 3 are east flowing and draining to the adjoining states of Tamii Nadu and Karnataka,

The marine zone and backwater systems represent highly productive ecosvstems which harbour unique wealth of plants and animals, and are notable for rich fisheries and mineral wealth.

Species diversity

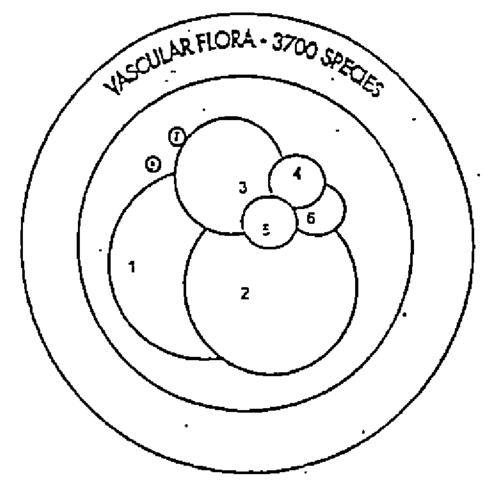
The various ecosystems in Kerala support rich flora and fauna. However, there is no comprehensive account that would give a realistic estimate of the number of species and their biogeocraphic distribution in Keraia. Extrapolation of available data indicates high richness and diversity in the flora and fauna of the State. Recent floristic studies carried out in some districts or phytogeographical divisions of the State reveal high incidence of species diversity [Manilal & Sivarajan (1982), Vajravelu (1990), Manilal (1988), Ramachandran & Nair (1988) Mohanan & Henry (1994)]. The tropical forests of Kerala far exceed in their biolgical wealth and this is substantiated by the pattern of floristic diversity supported by pristine areas like the Silent Valley which harbours about 1000 species of angiosperms in an area of 90sq.km (Manilal, 1988); Nayar (1995) in a recent review provided a concise account on the history of botanical studies, floristic diversity, endemism and conservation aspects of the forest flora of Kerala.

In all probability it would be a reasonable estimation that the flora of Kerala comprises as many as 3700 species of vascular plants (Flowering plants - 3500, Ptcridophytes - 200). Phytogeographical analysis shows that 8 genera (seven of them monotypic) and about 110 species of flowering plants are endemic to Kerala. Many of this endemics have very narrow distributional range and are threatened with extinction due to habitat destruction and other anthropogenic factors. Thirty species of flowering plants from Kerala have already been appeared on the Red Data list compiled by Nayar and Sastry (1987, 1988, 1990). Among fern and fern allies, as many as thirty species are considered to be extremely rare and endangered in Kerala (Madhusoodanan, 1991).

However, our knowledge on the diversity of the lower plant groups like algae, fungi, lichens, mosses and liver worts as well as the microflroa of Kerala is disappointing, despite their economic. horticultural, medicinal, industrial and ecological potentialities. No serious attempts have ever been made for understanding the taxonomy. ecology, distribution and productive potentials of such invaluable biolocical resources. The tropical forests of Kerala, as of the Western Ghats in general, might be rich in ferns, lichens, mosses and micro and macro fungi. Concerted efforts are therefore necessary to survey, inventorize and document the diversity of the lower plant kingdom and also the micro fauna of Kerala.

From a resource utilization point of view the species spectrum of the wild plant resources of Kerala flora can be classified as shown in Fig.1. About three fourths of the estimated 3700 vascular plants constitute a potential resource base with actual or potential values. These estimates arc rather tentative based on actual survey or extrapolation of data eathered through

Fig. 1. Wild plant resources of Kerala with actual / potential uses



1. Ornamental Plants (1000)
2. Medicinal Plants (900)
3. Wild Edibles (450)
4. Gum, Resin & Dye (175)
5. Timber / Wood (165)
6. Spices (150)
7. Bamboos & Reeds (14)
8. Canes (11)

Useful Plant Resources - 2865

economic and ethnobotanic programmes carried out by various research institutions, including the Tropical Botanic Garden and Research Institute (TBGRI). Thiruvananthapuram. The potential of utilization pattern of the listed plant resources often overlap as one species can often be found useful for two or more purposes. Hardly 10-15% of these plant resources have been well exploited while the rest remain as potential gene pool as yet untapped.

Genetic diversity

Kerala has been famous for her rich heritage of plant genetic resources for centuries. Being an integral part of the Western Ghats. the tropical forests of Kerala are equally rich in supporting an impressive array of crop plants and their wild relatives. Kerala is the land of spices and is an original home of the "black gold" (black pepper) ginger. turmeric, cardamom and cinnamon. It is also a notable centre of diversity and origin of rice, plantain, jack fruit, mango. pigeon pea and edible Dioscoreas. The important plant genetic resources of Kerala along with their potential wild relatives are listed in Table 3.

Table 3. Genetic resources of important crop plants and their wild relatives in Kerala

Cereals and millets		
	Oryza meyeriana subsp. *grannulata*	
	Oryza afficinalis supsp. *malampuzhensis*	
	Oryza rufipogon	
	Oryza sativa subsp. (100's of land races)	
	Paspalum scrobiculatum (Khodo millet)	
	Setaria italica (Fox tail millet)	
Tubers (yams)		
	Amorphophallus campanulatus (Elephant foot yam)	
	Colocasia esculenta	
	Dioscorea bulbifera (Air potato)	
	Dioscorea esculenta	
	Dioscorea hispida	
	Dioscorea oppositifolia	
	Dioscorea pentaphylla	
	Dioscorea spicata	
Pulses		
	Cajanus cajan (Pigeon pea)	
	Dolichos uniforus (Horse gram)	
	Dolichos lab-lab	
	Phaseolus vulgaris (Kidney bean)	
Fruits		
	Artocarpus heterophyllus (Jack fruit)	
	Emblica officinalis (Indian goosberry)	
	Ficus benghalensis	
	Ficus giomerata	+ 20 other species
	Ficus religiosa	
	Ficus retusa	
	Mangifera indica (Mango)	
	Musa acuminata (Plantain)	
Medicinal and aromatic plants and spices		
	Acorus calamus (The sweet flag)	
	Cinnamomun zeylanicum (Cinnamon)	+ 14 related species
	Curcuma amada (Mango ginger)	+ 15 related species
	Curcuma longa (Turmeric)	
	Cymbopogan caesius	
	Cymbopogon citratus (Lemon grass)	
	Cymbopogn flexuosus	+ 3000 wild strains
	Cymbopogon marinii	
	Cymbopogon nardus	
	Cymbopogon iravancorensis	
	Glettaria cardamom (Cardamom)	
	Gloriosa superba (Malabar glory lilly)	
	Gymnema sylverstre	
	Kaemferia galanga	
	Ocimum americanum (Basil)	

Table 3. (Contd....)

Ocimum canum	
Ocimum gratissinum	
Piper longum (Long pepper)	
Piper nigrum (Pepper)	+ 9 related spices
Rauvolfia serpentina (Rescrpine)	
Santalum album (Sandal)	
Terminalia arjuna	
Terminalia bellerica	+ 4 related species
Terminalia chebula	
Zngiber macrostachym	
Zingiber nimmonii	
Zingiber officinale (Ginger)	
Zingiber roseum	
Zingiber wighitanum	
Zingiber zerumber	

In a state like Kerala with high population density and low per capita income, the pressure on biodiversity has been so much so that several species have been driven to the verge ot extinction. Studies on the flora, fauna and fragile ecosystems of Kerala would show that there has been increasing incidence of loss of species. depletion of genetic base of important crop plants and their wild relatives and dergradation of pristine ecosystems across many parts of the State. This irreversible loss of biodiversity warrants more appropriate measures of conservation so as to ensure the protection of genes. populations, species and ecosystems that are of critical importance to the survival and sustenance of human kind.

Strategies for Conservation, Bioprospecting and Evaluation of Biological and Genetic Resources of Kerala

The most widely accepted scientific techniques of biodiversity conservation are the *in situ* and *ex-situ* methods.

***'In Situ'* conservation**

It has been well established that the best and cost-effective way of protecting the existing biological and genetic diversity is the *'in situ'* or on the site conservation wherein a wild species or stock of a biological community is protected and preserved in its natural habitat. The prospect of such econcentric', rather than a 'species centered' approach is that it would prevent species from becoming endangered by human activities and reduce the need for human intervention to prevent premature extinctions. Establishment of biosphere reserves, national parks, wild life sanctuaries, sacred groves and other protected areas forms examples of *in situ* methods of conservation. The idea of establishing protected area network has taken a central place in all policy-decision processes related to biodivesity conservation at national, international and global level.

Out of 9400 sq.km of forests in Kerala, 77,19 sq.km constitute 'protection forests" where any kind of logging is prohibited. There are 2 national parks and 12 wildlife sanctuaries which account for 2315 sq.km, ie., 24.6% of the total forest area of Kerala. Such conservation area, if managed scientifically, can contribute significantly towards conservation of biological resources of Kerala.

However, experiences have amply demonstrated that in a densely populated State like Kerala, where a sizeable human population are living in close proximity to forests, declaring protected areas will not entirely be sufficient to ensure the conservation of the fast eroding biological diversity. The success of any conservation programme vests solely on the efficient management of protectcd areas. The involvement of local and tribal communities in conservation activities has now been increasingly realized. A people-nature-oriented approach thus become highly imperative so that it will help generate a sense of responsibility among the local people about the values of biodiversity and the need to use it sustainably for their own prosperity and the maintenance of ecosystem resilience. Involving the local mass in all phases of conservation programmes, such as the planning, policy-decision process. implementation etc. will be a significant component in achieving efficient management and utilization of biological resources.

'*Ex-situ*' conservation

'In situ' conservation of biodiversity can be complemented by the *'ex-situ'* method through cultivation and captive breeding of plants or animals in botanic gardens, arboreta, zoos, biological parks, and through long-term preservation of organism / parts in bio banks (seed, pollen, semen, egg, embryo, genes etc.) and tissue culture repositories (Cryopreservation)

Botanic gardens play a key role in the *ex-situ* conservation of plants, especially those facing the imminent threat of extinction. The Tropical Botanic Garden and Research Institute (TB GRI), Thiruvananthapuram is one of the leading botanic gardens in India and South East Asia, which has accomplished tremendous progress in both *ex-situ* and *in situ* conservation of plant diversity in India, particularly of the Western Ghats of peninsular India. The garden today has a remarkable collection of over 10000 tropical wild plant species, including 2750 species (with genetic variants of over 100 species) of medicinal plants from all over India, particularly from the Western Ghats. The TBGRI has also initiated several integrated multidisciplinary research programmes focussing on cultivation, evaluation, conservation and sustainable utilization of plant genetic resources. These programmes are being carried out by a transdisciplinary forum comprising systematists. phytochemists. pharmacologists, conservation biologists, plant biotechnologists and economists.

Gene bank : The concept of establishing gene banks (DNA libraries and genetic gardens) provides ample options for long-term preservation of the genetic variability (infraspecific variability) of species that are critically endangered or those with immense, economic, medicinal or aesthetic importance.

In order to achieve the ultimate goals of biodiversity conservation, there is however a definite need of effective net-working and co-ordination from various sectors involving biologists. forestry experts, pharmacolocists, pharamaceutical manufacturers, economists, policy makers and the general public. International co-operation and global action plans are significant factors that can orient our conservation efforts in a much more meaningful way.

Need for bioprospccting and valuation

The potential of nature's *generic libraries* in providing us with new kinds of food, medicine and industrial products is enormous (Ehrilch & Ehrilch, 1992). The unknown potential of genes, species and ecosystem represents a never ending biological frontier of inestimable value. The prime focus of genetic conservation in the past was centred around the domesticated biodiversity (agrobiodiversitv, animal husbandry) and their wild relatives. Today about 80% of the wild genetic resources remain untapped. The scope of tapping the latent and patent potentials of tens and thousands of wild species or plants. animals, and microorganisms has been realized only in recent times, taking lessons from the Costa Rican Eperiment ie.. Merck - In Bio collaboration, the Australian Plant Evaluation Programme etc.

Bioprospecting is the most efficient means to explore and evaluate the economic, genetic and chemical potentials of biological resources through modern technological intervention. With recent advances in instrumentation and enzyme technology scientists can now undertake screening of plants on a massive scale for identifying and isolating potential bioactive compounds. Appropriate plant extracts can be screened for their biological activity by employing 'through put' techniuues using *in vitro* enzyme methods followed by isolation of active principles by modern chromatographic techniques such as HPLC (High performance Liquid Chromatocraphy), GLC Gas Liquid Chromatography), MPLC (Medium Pressure Liquid Chromatography) and LCMS (Liquid Chromatoeraphy Mass Spectrometry) aided by computer and robotics. Applying such innovative techniques hundreds of plant samples could be screened in a day where as it used to take almost 7 to 8 years to isolate biodynamic compounds from a single plant usine conventional techniques. Further the modern techniques require only bare minimum quantity (2-3 gm) of fresh plant samples when 20 to 30 kg of plant samples are used in conventional chemical screening programmes.

DNA finger printing technology using Random Amplified Polymorphic DNA (RAPD) has emerged as a powerful tool to assay diversity of the locus, chromosome and whole genome of an organism. The versatility and over all information of a finger print system determine its spread and range of application. This is fast emerging as a very innovative technology in bioprospecting in general. and pharmaceutical and gene prospecting in particular. Biomedical and biochemical research teams in the world over are pioneering into the new frontiers of pharmaceutical prospecting based on natural resources particularly plants and microorganisms. There can be no two opinion that gene and drug prospecting arce going to be the wo selling technologies in the coming

21st century. Because, it is these two challenging areas that hold key to human welfare through industrial and economic prosperity.

The efficient use of bioresources in consort with innovative genetic tcchnologies like DNA cloning, DNA finger printing, gene mapping, production of transsgenic organisms etc. can go long way to ensure conservation of rare and threat-ened biota in 'DNA Libraries", and open up new vistas of sustainable use of gendic resources with increased bioproductivity.

For many countries of the world, especially of the tropics, biodiversity represents the last remaining natural heritage. While the biodiversity poor but technologically rich countries of the North acquired high capabilities by making the best use of their biotechnology, the biodiversity rich but technologically poor countries of the South are far behind in framing efficient methods and strategies for better utilization of their biological wealth. So there is an urgent need to inventorize and evaluate the direct economic values of biodiversity in the Third World Countries including India. India's rich biodiversity, constitutes a potential resource base for all kinds of chemical, industrial, pharmaceutical and gene prospecting. This can be one of the most challenging areas for efficient utilization of Keral's biodiversity too.

Bioprospecting and economic evaluation of indigenous flora and fauna, including microorganisms occurring in Kerala will be highly rewarding in terms of industrial and economic progress. Besides helping to evolve new industrial, pharmaceutical and biochemical products, bioprospecting and evaluation of biodiversity will help significantly in framing efficient policies, plans and programmes for conservation and sustainable utilization of biodiversity. However, bioprospeeting is not an easy task. Setting up sufficient infrastructural facilities and strengthening technology base in biotechnology. biochemistry, molecular systematics and other related fields are the most essential requisites for a State like Kerala in venturing into such promising fields as bioprospecting and economic evaluation of biodiversity. Such high-tech capabilities will help a biodiversity rich State like Kerala in achieving more self reliance and acquiring better bargaining power while buying and selling biotechnology and its products.

Conclusions

Some of the basic issues inflicted upon bioresource management programmes in Kerala are (i) lack of a realistic estimate of biotic wealth including microflora and fauna (ii) absence of an integrated approach bridging 'ecologic resilience' and 'economic sustainability' into biodi versity policies (iii) conservation movements without people's participation at the grassroot level and (iv) failure to address biodepletion issues from socioeconomic perspectives.

It is imperative to streamline a dynamic *'system approach'* in which biologists, ecologists, economists, administrators, policy makers and representatives of local and ethnic communities should work together to evolve an efficient strategy to achieve realistic goals of conservation and sustainable development. This would envisage strengthening of inter-institutional collaboration between R&D organizations involved in biodiversity research, evolving new socioeconomic realms of biodiversitv management with people's participation and integrating science, industry and people to achieve sustainable human development.

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Rice productivity improvement in the coastal wetland ecosystem

Prof. (Dr.) V. G. Nair

The humic tropical zone in India comprise of the coastal plains of the peninsula running through the Arabian coast (the western coastal plains comprising of the Malabar and Konkan coasts) and the Bengal coast (the eastern coastal plains including the coramandal coast and the northern circars). The low lands in this coastal belt are some what discontinuous and in certain areas are placed at below mean sea level. These areas which are in continuity at several places with the coastal lagoon system got transformed through human interference into the present coastal wetland ecosystem.

The principal crop of this ecosystem is rice. In different situations the rice crop forms the major component of different farming systems such as rice with pulses and oil seeds, rice with fish culture, rice alternating with flooded fallows etc. This coastal wetland ecosystem characterised by different abiotic and biotic stresses such as flood, poor drainage, salinity, alkalinity, acidity, disease, pests, weeds etc. at different locations have already been identified as problem areas. Inspite of the fact that different farming systems have come to stay and continuing, these coastal wetland problem areas are low in productivity and hence have become non sustainable. These areas are therefore facing the threat of extinction through either reclamation as new upland areas or recession to their original coastal lagoon system. As such, improvement of productivity and thereby restoration of their economic sustainability as wetland rice based farming systems is the need of the day from the point of view of increasing food production and maintenance of ecological balance in the region.

The traditional rice growing areas in India are included in this coastal wetland eco system. Rice productivity in this region, limited by one or more stress factors enumerated above can be effectively improved through development and adoption of high productivity varieties tolerant to the stress or through correction of the specific stress in each situation through ecology management. Stress manipulation through the adoption of tolerant varieties is the easiest, effective, economical and ecofriendly and hence is an accepted priority approach. Inspite of the HYV programme in operation for the last three decades, the acceptance and adoption of such varieties in these regions is poor because of their low realised productivity consequent to sensitivity to the stress. Hence adapted high productivity location specific varieties have to be developed to reassure the sustainability of the rice based farming system in these problem areas.

Now let us look at the problem from a different angle. Food grain production in India has substantially increased from the level of 51 million tons of 1950-51 to 203 millon tons of 1998-99 ie., a four fold increase over a period of five decades. During this period our country's population increase was only three folds from 360 to 980 million and hence we have moved up from the begging bowl to the bread basket. Contrary to seven Indians sharing a ton of food grains in a year during the post independence period, only five of us need share a ton at present. India has become not only self sufficient in food grains but also reached a stage of food security through building up of sizable buffer stocks in recent years.

Inspite of such spectacular achievements in food grain production, there is a conspicuous disparity in the production increase in the two major cereal crops viz., rice and wheat which together contribute about 75 per cent of the total food grain production in India.

Food grains (Million tons)

Year	Total Food grains	Rice	Wheat
1950-51	50.8	20.0	7.0
1970-71	108.4	42.0	24.0
1990-91	176.5	74.3	55.1
1996-97	199.3	81.3	69.3
1997-98	193.1	82.1	66.0
1998-99	203.0	(Provisional)	
2006-07	243.0	(Requirement)	

It can be seen that wheat production increased to nearly 10 folds in 50 years whereas rice production increased to only four folds during this period. The main reason for this is a higher realised productivity in wheat as compared to that in rice eventhough there was an increase in wheat area to almost double in contrast to the area increase in rice by only one fourth. The wheat crop is usually grown in well managed situations in the subtropical region of India whereas the rice crop is largely cultivated in the coastal wet land problem situations in the tropical region where good management is not practicable. The HYVs of rice now available are best suited for the well managed situations and they do not withstand the stress characteristic of the problem areas, resulting in a dismal gap between potential yield and realised yield. Rice productivity improvement in the coastal wetland ecosystem through development of high yielding stress tolerant varieties can enable an overall increase in production in the problem areas leading to a further substantial increase in rice production in the country.

The rice based farming systems in the coastal wetlands of Kerala could be taken as a good example for the stress dominated problem areas and low productivity of HYVs. Eventhough the full length of the Malabar coast can be considered as a problem region, the specific situations identified for intensive technological interference are Kuttanad, Onattukara, Kari, Orumundakan, Pokkali, Kole and Kaipad regions. Several HYVs have been evolved and recommended for the different regions and seasons in the state but their acceptance and adoption by the farmers is very low. Moreover, the realised productivity of these varieties in real farming situations is much lower than their potential productivity. In a consumer state like Kerala where the sates annual production of 8.85 lakh tons food grains is able to meet only about a quarter of its requirements and the per capita food grain production is only 30 kg. against the national average of 207 kg. per annum, the poor impact of HYVs on rice production is a really grave situation.

Though the average yield of rice in Kerala is slightly better than the national average, the yield of high yielding varieties is lower at 3028 kg. grains/ha against 3465 kg at the National level and very much lower than their potential productivity of five to six tons/ha. This low realised productivity amply justifies the poor coverage of HYVs in the state at 36 per cent inspite of efforts made during the last three decades. The low realised yields and poor adoption of the recommended HYVs in the problem regions necessitate the identification of new varieties tolerant to the different stresses and adapted to the different situations and systems under which rice is grown in the coastal wetland ecosystems.

The technological approaches in rice varietal improvement for the problem areas may be outlined here under.

i) Conservation and utilisation of local germplasm

The diversity of rice growing situations in the coastal wetlands has lead to the evolution of several local varieties through natural selection. Some of them are being grown extensively because of their tolerance to the stress conditions. These local cultivars are already endangered consequent on efforts to spread the HYVs and hence have to be collected and conserved. The more promising ones have to be initially improved through selection. The genes for stress tolerance retained in these local cultivars could be later exploited for developing high yielding stress tolerant varieties.

ii) Developing new plant types for stress situations

The high productivity plant type of the present day HYVs may have to be redefined to satisfy the requirements of the problem areas. Specifications for developing new plant types will depend or the crop growing situations in the different regions and seasons. Genetic sources for this may be identified from the available germplasm resources or could be induced by employing appropriate breeding technology such as induced mutations.

iii) Back cross breeding

Most of the HYVs in India have been evolved through recombination breeding adopting the pedigree method utilising the DGWG dwarfing gene. It is probable that desirable genes conferring adaptability to the problem situations and resistance to stress contained in the local varieties used as parents have segregated out during the several selfed generations that followed hybridization. The selection pressure in favour of the plant type and associated characters conferring high productivity under favourable situations is likely to have hastened such eliminations. The derivatives logically will have high productivity under favourable situations but do not perform up to expectations is real stress situations.

In this context, the backcross breeding method becomes more appropriate in the recombination breeding programme. The chosen plant type variety may be used as the donor and local adapted variety as the recurrent parent. Repeated backcrossing with the local variety followed by selection for the donor plant type will lead to derivatives combining adaptability to local stress situations with high productivity.

iv) Biotechnology

Genetic manipulations in crop plants through molecular approaches have assumed great importance in recent years. Several economic traits in field crops have been incorporated through genetic transformation. Resistance to disease, pests, salinity, flood, herbicides, iron toxicity etc. are some of the traits amenable for manipulations in rice. Exploitation of somaclonal variation in combination with in vitro mutagenesis and genetic transformation for acquiring resistance to the various stress factors will be effective molecular approaches worth persuing. It is graftifying to note that such investigations in rice have already gained momentum in India.

Intensive efforts have to be made for increasing crop productivity in the coastal zone and this has been given due emphasis under the National Agricultural Technology Project. Agricultural Scientists working in this area may avail this opportunity to develop location specific varieties and other relevant technologies for better management of rice productivity in the coastal wetland ecosystem so that rice production in this country can be lifted to the anticipated requirement of 103.5 million tons making possible to achieve the target food grain production of 243 million tons by 2006-2007.

Recent concepts in soil producitivity management

R. Vikraman Nair

Soils of humid tropics are characterised by the acidic nature, coarseness of texture and low fertility status. These soils also have dominance of gravel in many cases. These basic factors decide the management of soil fertility in these soils. Emphasis was initially on amelioration of soil acidity and subsequently on management of soil fertility.

1. Soil acidity

The pH of Kerala soils which are taken as the example of humid tropical regions is normally in the range from 5 to 6.0. In some problem soils like the '*Kari*, pH of dried soil samples may go down to as much as 2-3. The very low values are attributed to be due to the presence of large amounts of sulphur and production of sulphuric acid through microbial oxidation of this element.

Based on the documented information on amelioration of soil acidity, early attempts were directed towards estimating the lime requirement and trying to amend the soil to varying pH levels. Advantage to such a liming practice was not very impressive and yield responses, when observed, were noted only upto very low levels of around 500 kg/ha which was much lower than the lime requirement values. It was generally concluded that raising pH of soils to near neutrality may not be necessary for most of our crops. The responses noted were often attributed to be because of the involvement of calcium as a nutrient.

Soil fertility management

Upto the 1960's fertilisers were not in common use and all the fertility management was through the conventional methods of manuring, green manuring and crop rotations. With the introduction of fertilisers, they became the important inputs and many of the traditional practices gave way to it.

The early fertiliser recommendations were made based on crop removal, fertiliser trials and soil test results. Recommendations on nitrogenous, phosphatic and potassic fertilisers were made primarily based on soil test data which showed that our soils were rated low for N, P and K. Experience over the years on fertiliser rate trials had shown that response to nitrogen was widespread and common, that to potassium was not uncommon but the response to added phosphorus was scanty. Recommendations on the three nutrients are continued even now on the justification that phosphorus added to the soil is practically not lost. One modification that was made in the 1980's is that we may skip application of phosphatic fertilisers for some time if levels in soils are high.

With large-scale use of fertilisers, there was neglect on the conventional methods like manuring. Though these did not result in immediate decline in productivity, the disadvantage arising out of this neglect became apparent later. Results of long-term fertiliser trials also supported this and indicated strong advantages of combined application of manures and fertilisers.

Secondary and micronutrients

Deficiencies of these were never noted as widespread and the only nutrients who deficiencies were noted atleast in some locations and for some crops were magnesium among secondary nutrients and zinc among micronutrients.

Toxicities of nutrients

Iron and aluminium toxities are reported in submerged soils. The basic reason is the high contents of these two elements in the soils. Toxicities arising from H_2S toxicity in rice soils of acid sulphate soils are common. Drainage is the suggested solution for all these.

Methods of increasing efficiency of fertilizers

Among the three groups of fertilisers, methods of increasing efficiency were made only in the case of nitrogenous and phosphatic fertilisers.

1. Nitrogenous fertilisers

A. Integrated nutrient management

i) Use of the blue-green algae

Mixed cultures from IARI were experimentally tested in rice soils of Kerala starting from the 1960's. The results were not impressive and adoption of the practice had been poor.

ii) Use of Azolla

Trials were taken up in the 1980's on the use of *Azolla pinnata* used both as organic manure and also through dual culture. Both these practices were found to be highly useful and varying quantities of fertiliser nitrogen for rice could be substituted. However, adoption of this practice also was poor because of the cost factor.

iii) Use of biofertilizers

Cultures containing symbiotic nitrogen fixing organisms of genus *Bradyrhizobium* and those of non-symbiotic nitrogen fixers of genera *Azotobacter* and *Azospirillum* were tested in the field since 1960's. There was emphasis on such field trials especially in the 1990's. The advantage to the use of such biofertilizers had been marginal in terms of nitrogen supplementation. However, use of such materials was of advantage in some crops like pepper the advantage arising mainly from better root growth. Such effects, when noted, were attributed to be either because of production of growth hormones or suppression of pathogenic organisms.

iv) Use or organic manures, green manures, green leaf manures and cropping systems

All these practices were found to be beneficial both directly and also indirectly by increasing the efficiency of fertiliser nutrients. However, there was neglect of these practices ever since fertilisers came to be the agricultural scene. Results of long-term experiments have consistently indicated the necessity for maintenance of organic matter status of soils to get the best crop performance and also best benefit from fertilizers.

B. Modified forms of fertilisers and treatment of fertilisers

i) Use of nitrification inhibitors

This practice with neem cake as the agent tested in the 1960's and 70's was of limited advantage eventhough substantial gain from this practice were expected arising out the heavy rainfall pattern and coarseness of soil texture. There are indications that the basic factor involved is the inherent lack of nitrification in the soils.

ii) Incubating urea with soil

This recommendation of mixing urea with five times the weight of soil and incubating for 24 to 48 hours was made to reduce loss of nitrogen through leaching in the form of urea prior to mineralisation. This recommendation was made based on theoretical considerations and limited experimental observations and its field advantage was not evaluated. Adoption of this practice also is poor and the main deterrent is the extra cost involved which does not often commensurate the extra cost of nutrient through fertilizer.

iii) Use of modified forms of urea

Modified forms of urea like granules, super granules and briquettes were made and tested. These were generally of advantage but adoption is poor mainly because of cost factor.

iv) Coated urea

Among the coated fertilisers, shell-lac coated urea was tested in some field trials and this material was generally found to be useful. However, the extra cost involved often did not match the benefit and the material did not take off on a commercial scale.

One novel material under testing now is the 'root contact packet' which is suitable for tree crops that need large quantities of fertilisers to be applied in plant basins. Such packets can be useful both for nitrogenous and potassic fertilisers. Initial trials for standardising packets for targetted release rates are in progress.

2. Phosphatic fertilisers

i) Use of powdered insoluble fertilisers

This is a practice often used as a substitute to the use of soluble fertilisers considering the acidity of soils especially for perennial crops. Exact assessment of the advantage to this practice was handicapped by the lack of response to this nutrient. Estimates of available phosphorus and crop removal have indicated parity of insoluble powdered fertilisers like Mussoriephos and Rajphos with soluble fertilisers.

ii) Use of biofertilisers

One of the major advantages of the use of arbuscular mycorrhizal fungi is considered to be the increased availability of phosphorus. In general, field use of AMF was found to be of some advantage. Separating the effects into its components had not been done. However, recommendations on combined application of insoluble phosphatic fertilisers along with AMF are made based on theoretical considerations.

Weather forecasting and contingency crop planning for aberrant weather situations

Dr. V. Muraleedharan Nair and Smt. L. Girija devi

Weather forecasting

Specialized weather forecasting for agriculture refers to forecasting weather elements viz., sunshine hours, occurrence of relative humidity, rainfall, drying conditions, temperature, wind etc. which are important in agriculture and farming operations. This is a specialized field to serve an important segment of a nations economy. Weather forecast/meteorological information is becoming more important for making many operational decisions in agriculture both strategic or long-range and tactical or short-range decisions. Thus development of this service is essential since modern day agricultural operations are becoming increasingly dependent upon detailed and accurate information of meteorological elements.

Out of all the factors which control the agricultural production, weather is the only factor over which man has hardly any control and hence it has dominance over the success or failure of agricultural enterprises. It is an accepted fact that food production is intimately linked with climate and weather. It is also reported that the weather induced variability of food production is more than 10%. In order to reduce risks of loss in food production due to vagaries of weather, weather should be taken as one of the major inputs in agricultural planning. Thus, forecast of weather parameters plays a vital role in agricultural production. These also help to minimize the crop losses to a considerable extent. It is estimated that about eight per cent of the total crop losses can be avoided through improved weather forecasts. The weather forecasts also provides guidelines for long range seasonal planning and selection of crops most suited to anticipated climate condition.

By forecasting of anticipated heavy rains, the irrigation from wells can be avoided by which we can save electricity; the harvesting could be advanced if the crop is in maturity stage: threshing of the harvested produce could be done before rains by which crop losses can be avoided. The losses in seed, diesel, labour and time can be avoided by not sowing the crops, if anticipated weather is not suitable for the operation. Saving of fertilizer by avoiding losses through leaching, gaseous loss and fixation loss could be achieved if farmers are informed well in time that the coming weather may not be suitable for fertilizer application. A sizable wastage can be minimized in the use of plant protection chemicals also.

Types of weather forecasts

Weather forecasts for agriculture can be divided into three categories viz., (i) short range forecast (upto 48 hours), (ii) medium range forecast (3 to 10 days) and (iii) long range forecast (above 10 days). Each has got a role to play in farm operations and planning of agricultural activities. However, the reliability of a forecast decreases with increasing period of its validity and decreasing area. Thus planning made well in advance has to be revised on the availability of the short range forecasts.

Short range forecasts

The short range forecast is based on synoptic situation prevailing at the time of forecast and is valid upto next 48 hours. It is issued twice a day based on synoptic conditions. Forecasts are normally issued for the following meteorological elements.

- Distribution of rainfall and warnings for heavy rainfall
- Day and / or night temperature and heat / cold wave conditions
- Important special hazardous weather like thunderstorm, hail storm, sand/dust storm, squall, tornado, snow, frost etc.
- Forecasts are also used for important atmospheric systems affecting the agroclimatic zones such as tropical depression / storm, mid-latitude systems and their induced vertices of the tropical latitudes.

In addition to the synoptic method, numerical weather prediction method is also used for short-range forecast in some countries. The use of computer techniques has made short range weather forecasting for agricultural operations potentially one of the more effective meteorological services. Such forecasts include in addition to the above mentioned elements, expected cloudiness, probability of rain and expected rainfall, wind speed and direction, dew duration and intensity and range of high and low temperatures. These forecasts are used jointly by agricultural scientists and agro-meteorologists to prepare explicit interpretive guidance for agricultural operations.

Medium range forecasts

Forecasting of meteorological elements over different agro climatic zones for periods ranging from 3-10 days is most important for agricultural operations and management of multi-purpose water management projects. In many countries, the medium range forecast aims at predicting the departures or anomalies of the weather elements (like rainfall, temperature etc.) from the long term averages, rather than the instantaneous weather. Such forecasts are operational in nature and in quantitative terms as well. Medium range weather forecasts can be used in scheduling farm work ie., in deciding whether to pre-pone / post-pone cultivation, sowing, cultural operations, harvesting etc. These decisions which would be realistic, limit the uses of resources to optimal levels, ie., there need be no over-supply of labour, power, water, chemicals, machinery etc.

Long range forecasts

In some countries, weather forecasts valid for more than ten days are issued by Meteorological services. In some other countries, weather outlook are also issued for a month sometimes, a season ahead. These outlooks are usually expressed in the form of expect deviation from normal conditions. Forecast emphasises on abnormality of temperature and precipitation. Long range forecasts can be used to decide on soil moisture management, irrigation, scheduling, selection of crop etc.

Agricultural weather forecasts

Weather forecasts for agriculture would involve the weather requirements for growing the crop and also weather requirements for carrying out the day-to-day farming operations. Forecasts need to be formulated by the agrometeorologial services and suitable advisories given in co-operation with the agricultural experts.

Elements of Agricultural Weather forecasts

Farm planning and agricultural operations are greatly influenced by the past, present and expected weather. Thus weather forecast should refer to all weather elements immediately affecting them. These elements are :

1. Sky cover, cloud and sunshine percentage
2. Rainfall probability
3. Temperatures
4. Winds
5. Humidity
6. Dew duration
7. Drying conditions
8. Drought

Generalized weather forecast for agriculture

Agriculture weather forecasts should include all elements in the same relative position in each forecast. This enables the farmers to become accustomed to a given flow of information. A commonly accepted forecast format is shown in Annexures 1 and 2; this forecast was based on consideration of the various parameters as follows:

i) Sky conditions

Actual coverage (average)	Forecast - day	Forecast - night
< 2/10	Sunny with more than 90 per cent sunshine	Fair
2/10 to 3/10	Mostly sunny with more than 75 per cent sunshine	Fair
4/10 to 6/10	Partly cloudy with more than 50 per cent sunshine	Partly cloudy
7/10 to 9/10	Mostly cloudy with less than 50 per cent sunshine	Mostly cloudy
> 9/10	Cloudy with less than 10 per cent sunshine	Cloudy

ii) Temperatures

Maximum and minimum temperatures covering the highest maximum and lowest minimum especially under hot and cold wave conditions respectively are important.

iii) Winds

Many high cost agricultural operations depend on direction and speed of wind. Thus forecasts on wind direction and speed (in Beaufort scale) and expected changes should be given.

iv) Rainfall

The probability of getting a certain amount of rain for each of the standard week is important for planning various agricultural operations.

v) Humidity

Relative humidity forecasts should include afternoon minima and night time maxima. Such forecasts are useful for many agricultural practices.

vi) Dew duration

The duration of dew occurrence is primarily used for estimating periods of leaf wetness for plant disease control and also for determining periods for applying chemical dusts. Thus the duration of dew should be indicated.

vii) Drying conditions

Expected drying conditions should be referred to in forecasts, this information is used to determine crop-curing conditions.

viii) Drought

The prolonged dry weather condition often leads to deficient soil moisture in the root zone reduces growth and development of crop and causes yield reduction. Drought forecasts would be of much use for irrigation planning and other crop management purposes.

Special Agricultural Weather forecasts

Weather forecasts in making certain special high-cost decisions are of great importance in agricultural operations. These forecasts are so specific in nature that they vary from crop to crop, from season to season and even during the season. They are normally issued for planting, applying agricultural chemicals, cultivating, harvesting, curing, chipping as well as for servicing other weather related agricultural problems associated with the crop and its location.

Agricultural Advisories and Dissemination

General agricultural weather forecasts provide information to the farmers so that they make their own decisions. This special type of advice is given only in advisories issued by agricultural meteorologists in co-operation with the agricultural experts. These advisories may recommend implementation of certain practices or the use of special materials to help effectively prevent or minimize possible weather related crop damage or loss.

Distribution of agricultural weather forecasts and advisories depends upon the available, communication facilities, eg. radio, television, automatic recorded (telephone) reply which is related at regular intervals, low cost pocket size battery operated radios.

Preparation of agro advisory bulletin

The weather forecast based agro advisory bulletin must contain :

- Medium range weather forecast information
- Crop management advisory consisting of standard agronomic management practices under normal weather conditions
- Suitably modified agronomic management advisory under forecast transient weather conditions.
- Any other crop related information benefited to the farmers.

Formation of agro advisory

Comparing the preceding periods, actual weather data with the weather normals, and combining with it the weather forecasts for next few days (as received from Super Computer Centre of NCMRWF) the agroadvisories are to be convinced about whether it is appropriate to formulate the agroadvisory under normal weather conditions or under transient weather conditions. Accordingly the following exercises are to be made to raise the final agroadvisory for communication to the farmers:

- Under normal weather conditions

  Phenology-wise standard agronomic management practices

- Under transient weather conditions

  Phenology-wise suitably modified agronomic management practices

- Other crop related informations of economic benefit to the farmer are also to be included in the agro advisory bulletin which will make it more acceptable, palatable and popular.

Agro Advisory Bulletins (English & Malayalam) prepared and issued from Vellayani Centre is shown in Annexures 3 and 4.

CONTINGENCY CROP PLANNING FOR ABERRANT WEATHER SITUATIONS

Several plantation crops and rice crop require special crop planning to combat the aberrant weather situations like drought, flood, chilling temperature etc. in Kerala.

Agricultural droughts

Agricultural drought occurs when the rainfall and stored soil moisture are not adequate to meet the water requirements of crops.

Early season droughts

The early season droughts occur either due to failure of rains after the early occurrence of sowing rains or due to delayed start of the rainy season. If a prolonged dry spell occurs immediately after sowing the crops, the seedling may wither and adequate crop stand cannot be established. In such cases, it is better to resow the crop otherwise gap filling has to be carried out to maintain adequate plant population to realise economically acceptable yield.

In the event of delayed start of the rainy season, traditional crops may have to be replaced by alternate crops / varieties. In case of cereals, it is better to raise a nursery and transplant the seedlings with the start of rainy season to compensate for the delay in sowing. Transplantation is a labour intensive operation.

Mid season droughts

Mid season droughts may occur due to break monsoon conditions after the establishment of crop stand. In the event of mid season drought, mulching will help in reducing soil evaporation and conservation of moisture in the top layers of soil. Mulching may not be effective after the crop canopy develops to the extent of shading the ground completely. Land configurations may be useful to conserve moisture to encounter mid season drought.

Terminal droughts

Terminal droughts occur due to early cessation of rainy season resulting in severe moisture stress during the reproductive and physiological maturity stages. In the event of terminal drought, the crop will continue to grow under receding soil moisture conditions. Therefore, the crop requires supplementary irrigation which may not be possible without generating additional water resources through rain water harvesting and recycling.

Flood

The heavy spells occurring particularly when the soil is fully charged with water from the previous spell of rain, can lead to floods. Flood management and prevention would require accurate rainfall measurements. In Kerala, rice in the first crop season is affected by flood in the middle or later stages, since the South-West monsoon is concentrated in June and July.

Low temperature effect

Weather conditions prevailing in the high altitude has significant influence on the growth and productivity of plantation crops such as rubber, coffee, tea, cardamom etc.

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Annexure 1

EXAMPLE OF AN AGRICULTURAL WEATHER FORECAST

(India Meteorological Department, Pune)

Sky condition	Partially cloudy
Temperature	Maximum 29-32" North to 32-350 South
Wind	Southerly statewide with speeds ranging from 10 to 19 km/h in the South-East to 29 to 40 km/h and gusty in the North-West
Precipitaton	Scattered showers and thunderstorms will occur over the State today through Saturday and will be more numerous over South-West and Central sections today. Rainfall amounts will average from 6 to 19 mm with local amounts up to 38 mm. Probability of rain will vary from 40 per cent in the South-West to 20 per cent in extreme East.
Drying conditions	Outside shower areas over the East fair to good during morning hours otherwise good to excellent over the State, minimum relative humidities will range from 40 per cent to 55 per cent in the South-East both today and Saturday.
Dew	Light in the West and Light to Moderate in the East drying off around 10 hours both today and Saturday.
Sunshine	7 to 9 hours today and 9 to 11 hours saturday
Outlook	Partly cloudy and continued warm Sunday through Tuesday with scattered showers and thunderstorms. Winds will remain southerly with light to moderate speeds.

Annexure 2

EXAMPLE OF AN AGRICULTURAL WEATHER FORECAST

(National Council for Medium Range Weather Forecasting, New Delhi)

(83

NATIONAL CENTRE FOR MEDIUM RANGE WEATHER FORECASTING

STATION: VELLAYANI
DATE: 13- 7-99 TIME: 03GMT

COORDINATES: 8.50 N 76.90 E
ALTITUDE: 16. meters
BASED UPON 00GMT ANALYSIS FOR: 12- 7-99

To Dr. V. Muraledharanair
NODAL OFFICER, AGRO DVISOR SERVIC UNIT
VELLAYANI , KERLI

SR. NO.	WEATHER PARAMETERS	DIRECT MODEL OUTPUT (INTERPOLATED) * ALT: 12.m				DIRECT MODEL OUTPUT (NEAREST GRID POINT) 9.10N77.34E ALT: 56.m				STATISTICAL INTERPRETATION				FAL			REMARKS
		12- 7 24hr	13- 7 48hr	14- 7 72hr	15- 7 96hr	12- 7 24hr	13- 7 48hr	14- 7 72hr	15- 7 96hr	12- 7 24hr	13- 7 48hr	14- 7 72hr	15- 7 96hr	- 7 hr	14 7 48r	15- 7 72hr	
1	MSLP hPa	1004.	1005.	1004.	1003.	1006.	1007.	1006.	1005.								
2	CLOUD okta E M	1. 2.	3. 7.	4. 4.	2. 6.	0. 0.	2. 5.	6. 5.	2. 5.					6	6	5	
3	PROB.OF PRECIP. PRECIPITATIONmm PPM eqn PRECIP.	2.6	2.2	1.0	9.8	2.5	3.7	2.4	11.1	1.00 13.4 13.4	0.89 9.9 9.9	0.85 3.6 3.6	1.00 12.6 12.6	5	5	10	
4	WIND SPEED kmph	19.	18.	19.	25.	15.	14.	15.	18.					6	6	7	
5	WIND DIR. deg	291.	248.	248.	248.	291.	248.	248.	248.					30	40	250	
6	MAX.TEMP. deg C	27.2	27.0 -0.2	26.7 -0.3	26.9 0.2	28.0	27.2 -0.8	26.8 -0.4	27.3 0.5	29.5	30.3 0.8	30.1 -0.2	29.8 -0.3	1	0	-1	
7	MIN.TEMP. deg C	25.5	25.6 0.1	25.3 -0.3	25.7 0.4	24.1	24.1 0.0	23.7 -0.4	24.3 0.6	23.0	23.6 0.6	24.0 0.4	23.7 -0.3	1	0	0	
8	R.H. MAXIMUM(%)	90.	90.	89.	89.	99.	99.	99.	96.								
9	R.H. MINIMUM(%)	86.	83.	84.	83.	90.	88.	87.	85.								
10	WIND DIR. FREQ. 0--45 45--90 90--135 135--180 180--225 225--270 270--315 315--360	 0.0 0.0 0.0 0.0 0.0 12.5 87.5 0.0	 0.0 0.0 0.0 0.0 0.0 100.0 0.0 0.0	 0.0 0.0 0.0 0.0 0.0 100.0 0.0 0.0	 0.0 0.0 0.0 0.0 0.0 100.0 0.0 0.0	 0.0 0.0 0.0 0.0 0.0 13.5 86.5 0.0	 0.0 0.0 0.0 0.0 0.0 100.0 0.0 0.0	 0.0 0.0 0.0 0.0 0.0 100.0 0.0 0.0	 0.0 0.0 0.0 0.0 0.0 100.0 0.0 0.0								

* MORE WEIGHT TO BE GIVEN AS COMPARED TO OTHER TYPE OF DIRECT MODEL OUTPUT

LTA: RECEIVED/NOT RECEIVED

Annexure 3

EXAMPLE OF AN AGRO ADVISORY BULLETIN (ENGLISH)

KERALA AGRICULTURAL UNIVERSITY
DEPARTMENT OF AGRICULTURAL METEOROLOGY
AGRO ADVISORY CENTRE, VELLAYANI - 695 522

AGRO ADVISORY BULLETIN No. 13/98

(ISSUED ON 15/09/1998 FOR VELLAYANI)

(Prepared by the AAS Project, KAU and Department of Agriculture, Kerala State)

WEATHER INFORMATION

Weather summary of the preceding week :

The highest maximum temperature observed was 31.10°C and the lowest minimum temperature observed was 22.90°C. The average wind speed was 6.29 km/h. Relative Humidity was high during the week. Monsoon was heavy and the total rainfall during the week was 80.4 mm in three days. The mean evaporation was 4.46 mm/day. The sky was cloudy during the week.

Forecast valid upto 17.9.1998

Sky will be cloudy. Light rains are expected in and around Vellayani. Change in maximum and minimum temperature is expected. Winds of average speed are expected.

CROP INFORMATION

Paddy (Virippu) is in harvesting stage. Basin opening and organic manuring is progressing in coconut. Vegetables are at different stages.

Agro advisory for the coming three days

Incidence of bud rot, coreid bug, red palm weevil and stem bleeding on coconut and pseudostem weevil on banana are noticed. In cucurbitaceous vegetables incidence of mite and fruit flies are noticed. Leaf spot disease is observed in amaranthus. Fruit and shoot borers are also observed in Bhindi and solanaceous vegetables. When the pest and disease incidence exceeds threshold level, adopt control measures in consultation with local Krishi Bhavan staff.

CONTROL MEASURES

Coreid bug on coconut

Apply carbaryl 0.1% or Endosulfan 0.1% suspension on the newly opened inflorescence after the receptive phase of the female flowers and spray the entire crown excluding the leaves and older bunches.

Red palm weevil

1. Field sanitation shoud be given prime importance.
2. Avoid making steps or any other injury on the tree trunks to reduce the foci of infestation.
3. Leaf axil filling as suggested under Rhinoceros beetle will be useful against the Red palm weevil also.
4. When green leaves are cut from the palms, stumps of not less than 120 cm may be left on the trees in order to prevent successful inward movement of the grubs through the cut end.
5. Inject attacked palms with Pyrocone E2/20 or Carbaryl at 1% concentration (Pyrocone 10 ml or 20g of Carbaryl 50%, WP in one litre of water/palm) or Trichlorphon 0.2% suspension at 1 litre/palm, using a funnel.
6. As an alternative, apply 1% DDVP or Aluminium phosphide at 1-2 tab/tree as a curative measure.
7. When the pest infestation is through the crown, clean the crown and slowly pour the insecticidal suspension.
8. Coconut log traps with fermenting toddy and pineapple or sugarcane activated with yeast or molasses can be set in coconut plantation to attract and trap the free floating populations of red palm weevil. Incorporate any of the insecticide to each trap to kill the weevils trapped.

Bud rot of coconut

1. In early stages of the disease (when the heart leaf starts withering) cut and remove all affected tissues of the crown and apply Bordeaux paste and protect it from rain till normal shoot emerges.
2. Burn all disease affected tissues removed from the palm.
3. Spray 1% Bordeaux mixture on spindle leaves and crown of disease affected as well as neighbouring palms, as a prophylactic measure.

Stem bleeding of coconut

1. Remove completely affected tissues by chiselling and thereafter dress the wounds with hot coal tar or Bordeaux paste. Avoid any mechanical injury to the same.
2. Improve general condition of palms through proper manuring, soil management and other cultural practices.
3. Application of Calixin @ 25 ml per 25 litres of water as soil drenching once in four months.

Banana pseudostem weevil

1. Field sanitation is the most important factor in the prophylactic and curative control of this pest.

a) Remove such plants along with the rhizome in full and destroy them by burning the life stages of the insect using karosine or by burying the material in deep pits in soil.

b) Destroy the parts of rhizome and pseudostem of harvested plants in the field and destroy them as described above.

2. Remove the dry outer sheaths of the pseudostem of all infested and uninfested plants in the endemic areas and spray any of the following insecticides. Drenching all the leaf axils, rhizome and surrounding soil and all round the entire pseudostem inserting the nozzle through the bore holes made by the larvae if any and also within the outer sheaths by slightly raising the same at different spots is also effective. -

Insecticides to be used (any one)

Quinalphos	:	0.05 %
Chloropyrifos	:	0.03 %
Carbaryl	:	0.20 %

Repeat the treatment after three weeks if the infestation persists.

Fruit flies (Bittergourd, Snakegourd)

Apply carbaryl 0.1% DP in pits before sowing of seeds to destroy the pupae. In homestead gardens the fruits may be covered with polythene, cloth or paper bags to ensure mechanical protection. In large gardens apply Carbaryl 0.2% or Malathion 0.2% suspension containing sugar and jaggery at 10 g/l at fortnightly intervals after fruitset initiation. Spray as coarse droplets on the ventral surface of leaves. Remove and destroy affected and decayed fruits.

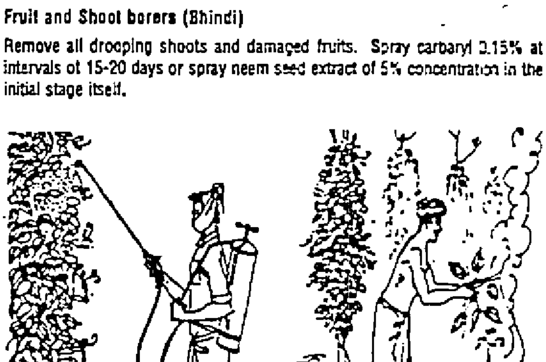
In snakegourd infestation of fruit fly can be effectively controlled by the use of banana fruit traps or oscimum traps with the removal and destruction of infested fruits. It is more efficient than two spraying with insecticides. The trap is prepared by applying Carbofuran granules at the cut ends of ripe banana fruits (variety Palayankodan). Traps are set at a distances of 2m after a border row and they may be replenished after 7 to 9 days. Start bait trapping just before flowering.

Leafspot disease (Amaranthus)

Destroy immediately if the spot appears on one or two leaves of one or two plants. Besides spray both sides of leaves with 10 litres of clear cowdung solution containing 40g Dithane M45.

Fruit and Shoot borers (Bhindi)

Remove all drooping shoots and damaged fruits. Spray carbaryl 0.15% at intervals of 15-20 days or spray neem seed extract of 5% concentration in the initial stage itself.



Copy to :
1. The Principal Agricultural Officer, Department of Agriculture, Govt. of Kerala, Trivandrum
2. The Director, NCMRWF, Department of Science and Technology, Technolgy Bhavan, New Mehrauli Road, New Delhi - 110 016
3. Assistant Director of Agriculture, Pallichal & Neyyattinkara 4. Krishi Bhavan Officers 5. Progressive Farmers

Annexure 4

EXAMPLE OF AN AGRO ADVISORY BULLETIN (MALAYALAM)

Remote sensing – a tool for natural resource management

K. Abdul Samad

Introduction

Population pressure and the consequent higher demand of life systems have led to the over exploitation of natural resources. Systematic and optimum land use planning is essential not only for improving the social conditions of the area but also for conservation of the environment for future. In the process of land use planning conservation, development and management of the available natural resources play an important role. This can be exercised at domestic, regional, national or international levels Any successful developmental activity needs a comprehensive inventory of human, economic and physical resources, an appraisal of the present situation, an analysis of the cultural and physical problems in resource development and also an estimate of their resource potentials in spatial and temporal terms. These are the basic aspects in the process of land evaluation of Land Use Planning, which helps to take up proper decision for future land use enabling a permanent ecological balance.

Proper resource management system needs timely and reliable information, which can be achieved by undertaking intensive inventories on the present "State of affairs". The future also deserves more importance, especially for those entrusted with the task of designing and implementing suitable plans for the conservation, development and management of the resources. Hence, forecasting is essential to evaluate whether the future state of affairs will be in accordance with the aspirations and objectives. It is of prime importance for any nation to formulate and develop a suitable **National Natural Resource Management System.** This will help in gathering reliable information about natural resources scientifically and disseminating the same to decision makers speedily and timely. Hence Natural Resource Information System is a vital component of the Management System. The data gathered through the information system can be utilised in the process of effective management of the natural resources.

An optimum land use plan is a prerequisite for proper **Natural Resources Management.** Scientific land use planning is of paramount importance especially for a nation like India in order to maximize the productivity of land to meet the needs of the growing population for food, fibre, fodder, fuel, etc. Eventhough land suitability studies may establish relative suitabilities of different developmental programmes, their implementation has to be based on the impact and effects of important spatial factors such as population density, distribution, social factors, physical infra-structure, present utilization of land, etc. Hence, to prepare an optimum land use plan for proper management of the natural resources, reliable and timely information of the available natural resources is a must.

Inventory of the resources include acquiring of reliable and timely information of the existing resources as well as the spatial distribution like distribution of forests, present land use, data on surface water, etc. By exploration of resources, we mean acquiring of data on resources such as oil and natural gas, minerals, ground water, etc. These are resources which are mainly seen underground and not distributed on the surface of the earth. Their location, distribution and quantification, etc. has to be done through indirect methods, i.e., relating it to certain surface features such as vegetation, faults, fractures, lineaments, etc.

2. Remote Sensing

Remote Sensing is the acquisition of information about an object which is not in intimate contact with the information gathering device. The human eye is one such remote sensing system. Camera, Spectro-radiometers, Radar, Seismographs, etc. are examples of remote sensing.

Remote Sensing is a scientific tool for acquiring reliable and timely information of the available natural resources. It helps in the inventory, exploration, exploitation and also the monitoring of the resources.

In natural resource management this is achieved mainly by detecting the reflected or emitted portion of EMR. This is obtained with the help of aerial cameras or well developed sensors mounted on aircrafts or satellites. This technique is based on a fact that each object on the earth's surface has a unique spectral signature. In addition, it gives temporal and spatial informations.

Remote Sensing also provides information on the renewable and non-renewable resources. This technique also helps in the evaluation of the natural resources management system. Hence, remote sensing yields reliable and timely information for proper land use planning which is a must for effective natural resource management.

In addition to aerial surveys conducted for specific purposes, a number of satellites such as LANDSAT, SPOT, IRS, etc. belonging to different countries provide information about natural resources on different resolution, scale and periods. The data can be visually or digitally analysed to generate valuable information of the resources.

3. Application of Remote Sensing for natural Resource Management

Application studies for resource management using remote sensing techniques have been conducted successfully in the different parts of the world as well as in many parts of India, a brief outline of few applications in the field of land and water resources is given below.

3.1. Land Use/Land Cover Mapping

Information on the present land use/land cover such as agriculture lands, forest lands, wastelands, mining areas, etc. is essential for proper land use planning. Knowledge of the present extent and distribution of the different forms of land use/land cover and information on their changing properties are required by administrators and planners to take decision on land use policy, urban development, establishment of human settlements, providing adequate transportation facilities as well as to implement effective plans for regional development. Comprehensive land use/land cover data will also help in solving the competing and conflicting demands of the natural resources. Remote Sensing data on different scales and resolutions yield valuable information.

3.2 Water Resources Mapping

The conventional methods for identification, investigation, assessment, planning and utilisation of water resources are rather slow and are almost difficult for inaccessible areas. Perspective planning for the optimum utilisation of the available water resources calls for reliable methods of identification and utilisation of the potential resources. In this context remote sensing provides synoptic three dimensional view which provides an over all picture of the terrain facilitating the location of probable and suitable areas with ground water potential, prominent faults, lineaments, fractures, etc. from the remote sensing data which helps in locating probable ground water zones.

Besides, the repetitive coverage of the satellites is advantageous to observe the same area at periodic intervals and thereby providing the information at fixed intervals of time.

3.3 Geology/Geomorphology/Mineral and Natural Gas Exploration Studies

Geological/Geo-morphological studies carried out in India so far by the Geological Survey of India and other organizations have been able to project the scope, utility and limitations of this technique. The capacity of viewing the terrain over large area, helps the geologist or geo-scientist for better understanding of the geological conditions. Small scale regional thematic maps, useful for reconnaissance planning and execution of various geological surveys, can be prepared by adopting this technique. The additional information obtained thus can be used for updating the already available data and to provide a firm data base. Experience in different parts of the world has shown that the application of remote sensing techniques in the field of geology/geomorphology is more advantageous in terms of time, cost, coverage, content and scope.

Mineral and natural gas deposits are the resultants of geological processes. An expression of the geological processes gets reflected in a geological map without which any exploration programme is hardly possible. This technique has now been widely used in the preparation of maps which project the basic geo-morphological features, distribution of rockout crops, etc. Mapping of the earth's magnetic field was also attempted from the satellite based systems. A well known project of 'Magsat' has yielded information for understanding the sub-surface geological features of intercontinental magnitude. Similarly certain data relating to the gravitational field of the earth was gathered from the satellite mounted sensors - 'Avisat'. The data yielded from the above two prospects help the geologists and geo-scientists to have better understanding of global tectonics. The tectonic features do host mineralisation and thereby helping the exploration of targets which prima facie are indicative of resources.

3.4 Natural Disaster Studies

Many types of disasters are recurring in the world every year possibly due to natural reasons or by deliberate human intervention or by both. Some of the common disasters are earthquakes, floods, landslides, drought, and the like. Studies on the types, distribution, movement, temperature and height of the clouds from the satellite data help in quantifying the anticipated rainfall over an area for which conventional methods are not found to be feasible or efficient. Similar is the case with the forecasting of cyclones and landslides for which meteorological satellites supported by Radar data provides useful and reliable information.

3.5 Urban Planning

Though more than 70 per cent of India's population live in villages, urban and urban dependent population is increasing rapidly. This suggests the immediate necessity for proper and realistic urban development plans.

An appropriate data base is a pre-requisite for regional and urban planners/administrators at the different stage of planning. This is very essential for finalisation of the objectives, fixing up priorities for development, allocation of funds, etc. It is in this context that aerial photography, satellite remote sensing and computer assisted information systems play an important role for suitable urban development programmes.

Urban study includes both dynamic and static phenomena. The dynamic phenomena are population, traffic flow, socio-economic condition, etc. while the city size, water bodies, institutions, vegetation, distribution, etc. can be grouped under static. Different thematic maps showing the existing infrastructure, drainage network, road network, residential and non-residential distribution, vegetal cover, etc. can be prepared using aerial photographs and proper techniques. Even measurements can be taken using suitable instruments.

Madras Metropolitan Agency was the first in India to use aerial photographs for urban planning. Most of the important cities are covered by large scale photographs. Karnataka and Andhra Pradesh have also adopted this technique. Studies on slums, encroachments and unauthorized structures can be made using very large scale aerial photographs. With proper and systematic study of large scale photographs it is possible to make a fairly good estimate of even the population of cities, attempts on which have been done in Coimbatore and Ujjain.

The recently available high resolution satellite data base such as, SPOT, PAN, etc. yield reliable and valuable informations for urban planning. With the availability of better resolution data in future, satellite remote sensing will have an important role in area.

3.6 Study on Coastal Management and Marine Resources

Studies on coastal management and marine resources have been undertaken using satellite imageries and aerial photographs. This is gaining momentum in our country. Studies on shore line change, coastal land forms and morphology, sediment distribution, dispersal and movements, coastal erosion, ecological studies of coastal vegetation,etc.

Satellite (e.g. US NOAA) imageries are able to provide synoptic view of the area where field surveys are not possible.

Attempt to estimate the marine resources have also been carried out through the technique of remote sensing. There are instruments such as ocean colour radiometers with suitable bands in the visible - near infra-red regions. With this, estimation of phytoplakton pigment (Algal bloom) and suspended sediment distribution is possible. Airborne thermal scanners help for sensing sea surface temperatures. Studies using SEASAT data had shown encouraging results in the use of this technique for marine resource estimations. Many parameters, viz. Sea-state, chlorophyll, sea-surface temperature, sea-surface-wind, atmospheric water vapour, oceanic rainfall rate, ocean wave current, etc. have to be studied for estimating the marine resource. The recently launched Indian Satellite namely IRS-P4 (OCEANSAT) is mainly for this purpose.

3.7 Agriculture and Soil Studies

The major step in this direction is preparation of crop, soil water and other natural resources inventories. Presently space borne remote sensing data are being regularly used to study crop, soil and water resources. Remotely sensed data from space borne sensors, viz. **LANDSAT MSS, TM SPOT and IRS** are being used for this purpose especially by digital analysis techniques. Major emphasis in crop studies is to develop yield models based on spectral indices (Vegetation Indices) of crops and agro-meteorological parameters. In India similar studies are being carried out in SAC Ahmedabad and NRSA Hyderabad for cotton, wheat, soyabean, sunflower, etc. and results are provided to user well before the harvest of the crop. To overcome the problem of cloud cover during Kharif season, R&D experiments by using microwave (SAR) remote sensing data is being attempted. Attempts are also being made to use remotely sensed data in the study of horticultural crops.

Remotely sensed data was found to be extremely useful in mapping the soils on operational basis. This has been successfully used in India also by various national/ state level organisations. Mainly visual interpretation technique is used which is supported by required field studies. Physiographic analysis is the best method for the purpose. Satellite data were found to be extremely useful in mapping and monitoring various degraded lands like saline soils, eroded soils, etc.

In addition to the above, this technique can be effectively used for the following studies also.

a) Assessment of potential arable lands, wastelands and rockout crops
b) Classification of agricultural lands
c) identification of different crops
d) Acreage estimation of crops
e) Assessment of periodic changes in crops or farming patters
f) Detection of crop damage and crop vigour
g) Evaluation of different types of erosion
h) Watershed management studies

3.8 Integrated Studies

Integrated management of the natural resources is the best way to achieve a sustainable development process. Sustainable development means development of the natural resources to meet the immediate needs of the present population and also the needs of future generation without endangering the ecology and environment. Remote Sensing technique can play an effective role in this direction. Studies are being carried out in different parts of the world.

In India, a project termed as 'Integrated Mission for Sustainable Development'(IMSD) was launched in 1992 by Department of Space. The project aims at integrating the remote sensing data obtained from satellites with the data generated by conventional means and also socio-economic data. Different resource maps such as land use/land cover, soils, slope hydro-geomorphology, surface water resources, drainage and watersheds and transport network are generated. Then these data are integrated with meteorological and socio-economic data for the generation of an **Integrated Land And Water Resources Development Plan.**

4. Geographic Information System (GIS)

This is a technology concerned with the representation and manipulation of geographic data which has physical dimension, geographic locations and qualifying parameters. It is basically an integrated data base management system in which large volume of geo-referenced data are stored, organised, manipulated, retrieved, analysed and displayed with the objective of efficient and sustainable management of the natural resources. The data generated through remote sensing can be effectively used for this technology.

5. Conclusion

Remote Sensing technology is found to be an effective tool for the generation of reliable and timely information on the available natural resources problems, potentials and problems of the area which is very essential for the proper conservation, development and management of the natural resources. This technology is successfully operationalised in ground, space and in various application areas.

The future advances especially with better spatial and spectral resolution will not only help in the sustainable management of natural resources but also shall address some of the challenging areas such as real time disaster management, bio-diversity, 3D modeling, etc.

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Biotechnology as a tool for crop improvement

Dr. K. Rajmohan

Biotechnological tools can be very effectively utilized for crop improvement. They can be integrated into an existing breeding programme for the improvement of new genotypes. Possibility exists to alter the nature of future crop species. The various fields of application of biotechnology in crop improvement include the following:

Exploiting somaclonal variation

Callus cultures are potent sources of structural and numerical chromosomal variations. The method permits regeneration of plants with altered phenotypes (somaclonal variation) which can be used to increase the existing variability through sexual crosses. Desirable variants can be recovered and used directly. The prospect of obtaining limited changes in well adapted plant types without resorting to hybridization is attractive to plant breeder. The most desirable somaclonal variants are those which provide improvement in characteristics such as yield or resistance to stresses, not already available or not easily transferable to the existing lines. Plants showing resistance or tolerance to stress conditions like salinity, drought, herbicide toxicity etc. can be produced by this method.

In sugarcane several useful somaclones were recovered, including those with high sucrose yield and resistance against several diseases. Protoclones were recovered in potato varieties for growth habit, tuber colour, fruit production, maturity date, tuber uniformity, photoperiod requirements and resistance against early and late blight. Somaclonal variation has also been observed in rice for tiller number, height, improved seed protein and yield. In tomato and wheat also several desirable variants for yield traits could be recovered. Attempts are under way to apply the technology in crops like pepper, ginger, banana and ornamental plants.

Among the mechanisms for the origin of somaclonal variation are karyotypic changes, cryptic changes, gene amplification, transposable elements, somatic gene rearrangements, epigenetic events and regulatory gene action. Somaclonal variation occurs at a higher rate than spontaneous variation.

Gametoclonal variation represents the variation in plants regenerated from haploid cell cultures, derived from gametes. It has been employed for development of new varieties in rice and wheat. Gametoclonal variation is useful in the isolation of homozygous diploid from inter and intra-specific hybrids.

In vitro mutagenesis

Callus cultures can be exposed to physical or chemical mutagens for increasing the genetic variability. Then the cultures are placed under conditions which allow the rapid screening of mutants. The main types of mutations are: (a) heterotrophic, which require nutritinal supplements for normal growth, (b) resistant, which resist specific drugs, anti-metabolites or abnormal environmental / nutritional conditions and (c) autotrophic, that grow in deficient media and are capable of synthesising some substances normally required for the wild lines. Other kinds of mutants exhibiting specific characteristics may also be selected.

Mutants that are useful to agriculture include those resistant to pathogenic toxins, pathogens and herbicides and tolerant to salt and drought. Resistant mutants for fungal and bacterial toxins are selected using disease including toxins in cell culture. Cell suspension cultures are first prepared. These may be subjected to physical (gamma rays, UV rays etc.) or chemical (ethyl methane sulphonate) mutagens at half lethal doses. The cells are then washed and grown for several cycles before subjecting to selection. Crude toxin extracts from cultured pathogenic bacteria are filtered, sterilised and incorporated into the selective medium. Resistant mutant cells are screened by continuous increase in the concentration of toxin. Plantlets regenerated from the resulting cell lines are further subjected to screening for resistance.

In vitro fertilisation

In vitro fertilisation could be resorted to bring pollination and embryogenesis under artificial conrol. It is useful to produce interspecific and intergeneric hybrids which otherwise would not be formed in nature. It can also be used when seeds are difficult to be obtained under unfavourable environmental conditions. Thus, there is scope for obtaining novel and useful hybrids. In vitro fertilisation including that of pistil, ovule and placenta helps in overcoming the various types of sexual incompatibility. The pollen and ovules used should be at suitable developmental stages and the optimal culture medium should be selected to ensure normal growth of the pollen tube and fertilisation of ovule. *In vitro* pollination and fertilisation have been successfully employed in crops like ginger.

Embryo culture

Embryo deneration is commonly observed in crosses, involving distantly related parents. This may be due to inhibitors, immature embryos or degenerated endosperm. Although, successful fertilisation and early embryo development may occur, a number of irregular events follow which cause the eventual death of the embryo. Culturing the embryos in vitro helps in their rescue by eliminating the inhibitory factors of pre- and post- zygotic incompatibilities. The problem of improper development of the endosperm (as in orchids) can also be overcome through embryo rescue. It is also useful to combat seed dormancy and related physiological problems.

In order to meet the progressively changing nutrient requirement to the developing embryo it is necessary to transfer the embryo from one medium to another. Several basal media like MS, White's, Heller's, Nitsch and Knudsons's are useful for the culture of embryos. Coconut milk has a promotive role in embryo culture, in a number of cases. Cytokinins, auxins and gibberellic acid are also used. Growth and survival of cultured embryos are favoured by the addition of sucrose (0.5 to 3.0 per cent) in the medium. Embryo culture has been tried successfully with interspecific crosses in crops like tomato, cotton, rice, cabbage and melons and intergeneric crosses in wheat & rye and barley & rye.

Haploid culture and production of homodiploids

Germ cells, usually the immature pollen, are cultured to produce new plants. Since the germ cells are haploid, the derived callus or plants are also haploid. Such callus or plants can be treated with colchicin and made diploid. During the process, the plants become homozygous at all the loci. Plant breeders often have to self pollinate their strains for many generations to produce true homozygous lines in a single step. This is especially valuable in perennial crop breeding. Haploid culture, in combination with conventional breeding helps the breeding process and enhance selection efficiency.

Protoplast culture and somatic hybridisation

Plant cell can be treated with cell wall degrading enzymes (pectinase, cellulase and hemicellulase) to dissolve the rigid cell wall, and obtain naked cells called protoplasts. These protoplasts under appropriate conditions can regenerate the cell wall and divide again. Protoplasts can be genetically manipulated and used for regenerating whole plants with altered genotypes.

The simplest way to combine genetic information of two cells is through fusion of their protoplasts. The resulting product is the sum of the two nuclear and cytoplasmic genomes. Somatic crosses are useful in overcoming asexual incompatibility between related species. It is possible, through somatic hybridisation, to make crosses wider than that can be made by conventional means. The cytoplasm also contains genetic information which is located in sub-cellular bodies such as chloroplasts and mitochondria. Usually the cytoplasm of pollen is not transferred to the egg during fertilisation. During protoplast fusion, cytoplasm in the nuclei of the parents is mixed. This method enables the transfer of cytoplasmic traits such as male sterility, from one plant species to another.

Genetic transformation

Plant transformation provides the opportunity to introduce any gene from any source into plant cells. These cells then can be regenerated to produce transgenic plants that contain the new genetic information in every cell. Over the past 20 years, it has become possible to isolate genes from microbes, plants, and animals and to insert them into a range of plant species. Most transgenic plants produced so far have been obtained using two general methods which are Agrobacterium-mediated and direct DNA uptake, the latter including such specific methods as particle bombardment; electroporation and PEG permeablization. The commercialization of plant transgene-based products is on the increase. A number of transgenic products have been commercialised. Tomato with delayed-softening and ripening, canola and soybean lines with low linolenic acid content, high oleic acid content and high palmitic and stearic acid content; canola with high laurate and increased phosphorus availability; corn and soybeans with improved amino acid content; and potatoes with increased starch content are some of them. Transgenic products with novel agronomic traits include: resistance to herbicides like glyphosate, phosphinothricin, bromoxinil, and the sulfonylureas and imidazolinones; crops carrying B. *thuringiensis* genes for insect resistance, genes conferring resistance to viral, fungal and nematode pathogens; and nuclear male-sterile crops used to create inbred lines for hybrid-crop production. Future products are anticipated to include plants developed as sources of modified enzymes, industrial feed stocks, biopharmaceuticals, antibodies and antigens for vaccines.

Recent trends in plantation crops research

Dr. K.U.K. Nampoothiri

Plantation Crops occupying an area of 4.11 million hectares (2.2% of the total cropped area) and generating an annual income of Rs. 1,29,042 million form an important group of crops in India. The research support for the overall development of the crop is provided by Research Institutes under various Ministries of Government of India and State Agricultural Universities. Salient attempts made to improve the production technology of plantation crops such as coconut, arecanut, cocoa, oil palm and cashew are discussed in this paper.

COCONUT (Cocos *nucifera*)

Coconut occupies a unique position in the socio-economic scenario of India and is related to prosperity of a very large number of small and marginal growers. About 10 million people in the country are engaged in coconut cultivation, processing and marketing.

India with an annual production of 13,963 million nuts is the largest producer in the world. The area under the crop increased from 0.626 million ha during 1950-51 to 1.716 million ha during 1996-97. The projected demand for coconut by the end of IX Plan is 24,000 million nuts. The gap of 10,000 million nuts between demand and supply can be bridged only by increasing the production and productivity of coconut.

The basis of every improvement in crop productivity is good planting material. Systematic evaluation of various cultivators and long term hybridisation programmes have resulted in release of 15 improved types/hybrids. They give as much as 90% more yield than the local West Coast Talls. Special types for tender nut purposes like Chowghat Orange Dwarf have also been released for cultivation. The seedlings of selected and prepotent local talls are also in great demand. In view of the low multiplication rate, seed gardens are raised to increase availability of quality planting materials.

Possibilities of breeding drought tolerant types were indicated by identifying desirable traits for tolerant ones under field conditions. Among these criteria, accumulation of epicuticular wax on leaf surface, low stomatal frequency, low stomatal resistance and leaf water potential are important. WCT x WCT, Federated Malaya State, Java Giant, Andaman Giant, Laccadive Ordinary x Chowghat Orange Dwarf and Laccadive Ordinary x Gangabondam are found to be drought tolerant. The reduction in overall yield during drought affected years is only 15-44% in drought tolerant coconut hybrids compared to 75% in drought susceptible hybrids.

Realising the advantages of clonal propagation various attempts were made in tissue culture. Although clonal plantlets could be produced from spindle leaves, plantlets could not be obtained when adult palm explants are used. Embryoculture technique has been standardised and has been successfully used in germplasm collection of 15 accessions from Indian Ocean Islands. Protocols have been standardized for DNA extraction and PCR amplification. A partial genomic library of coconut has been constructed and 130 recombinant clones have been identified by colony hybridization. Future lines of work will include characterization of coconut genotypes using molecular markers, in vitro conservation of coconut embryos, and tagging of genes for resistance to root (wilt) disease in coconut.

Coconut is a perennial crop which exports nutrients to the parts above ground level continuously from a limited volume of soil throughout its life. 56 kg of N, 12 kg P, 70 kg K, 34 kg Ca and 12.5 kg Mg are estimated to be removed from a hectare of coconut plantation. The order of importance of nutrients is K>N>P>Ca>Mg. Fertilizer application has been recommended based on long term experiments. However it will be necessary to judiciously apply them based on soil and leaf analysis.

Coconut based cropping/farming systems involving cultivation of compatible crops in coconut gardens and its integration with other enterprises like dairy, poultry etc. leads to considerable productivity increase by efficient utilization of sunlight, water and labour.

In coconut, initiation and differentialization of vegetative and reproductive primordia and enlargement of cells are very sensitive to moisture stress. Drooping of leaves, breaking of petioles and even death of palms are noticed under drought conditions. Even in well managed gardens, drought reduces the yield upto 30 per cent. A coconut palm removes 30 to 45 litres of water per day. The yearly irrigation requirement is estimated to be 465 litres per palm spread over the non-monsoon months. Irrigation experiments indicate that drip irrigation with at least 66 per cent of EO (32 1 $palm^{-1}$ day^{-1}) is sufficient.

Integrated control measures are available for the major pests like rhinoceros beetle (*Oyster rhinoceros*) and Leaf eating caterpillar (*Opisina arenosella*). Bud rot (*Phytophthora palmivora*), Stem bleeding disease (*Thielaviopsis paradoxa*) and Thanjavur wilt (*Ganoderma lucidum* and *G. applanatum*) are also controllable. However there is no curative treatment for root (wilt) disease since it is of phytoplasmal etiology. A strategy for containing and managing the disease especially through proper agronomic practices and resistance breeding is envisaged.

In the present International trade scenario with stiff competition among various countries, India is at a disadvantageous position because of International prices of many of the plantation crops and their products are below compared to domestic prices. To overcome this, long term strategies are to be evolved for product diversification and higher productivity. Coconut being a palm of multivarious uses there is great scope for coconut based economy if product diversification is attempted integrating the whole processing for fuller utilization of its byproducts.

ARECANUT (*Areca catechu*)

Arecanut palm is an important cash crop in India sustaining nearly six million people. The economic produce is its fruit called betel nut or supari which is mainly used for masticatory purposes. The estimated area and production of areca are 2.64 lakh hectares and 3.13 lakh tonnes respectively. Its cultivation is concentrated in the Southern States viz., Kerala, Karnataka and Tamil Nadu. Arecanut provides immense scope for intensification of cropping systems which provides not only for ecological sustainability of land but also ensures economic stability to the farmers.

The research on the crop has resulted in development of technologies for increasing production and productivity through which India became self-sufficient and production is always on the increase. Six varieties have so far been released with yields upto 4.60 kg chali per palm. In order to overcome the difficulties of height of the palm efforts are underway to breed dwarf types, the source of dwarfness being the Hirehalli Dwarf which is a natural mutant.

Agrotechniques for seed production, nursery, spacing, fertilizer application and intercropping have been standardised. High yielding varieties have been found to favourably respond to double the fertilizer dosage. Several areca based multiple cropping systems have been recommended, the most viable of them being arecanut-cocoa-pepper-banana combination for West Coast, arecanut-pepper-coffee-acid lime-betelvine in maidan parts of Karnataka and areca-betelvine-pepper-cocoa-banana-ginger/turmeric/dioscorea in north-east.

The major pests and diseases are controllable. However Yellow Leaf Disease prevalent in Kerala and some of the districts in Karnataka still eludes a satisfactory control.

Betel nut is used mainly for chewing purposes. But it is necessary to have alternative uses and utilise the byproducts fully. Tannins in areca can be used in leather industry as well as in manufacture of plyboard. The nut fat (8-12%) can be made edible after alkaly-refining. Activated charcoal, husk, hard boards, boxes and disposable cups and plates from husk and leaves are other uses which can be exploited for maximum returns.

COCOA (*Theobroma cacao*)

Cocoa was introduced to South India during early 20th Century as an intercrop in coconut and arecanut gardens. Even today it continues to be an ideal intercrop giving encouraging yields and net income. The requirement of the domestic industry is expected to be about 16,000 to 20,000 tonnes as against the present grinding capacity of 9,250 tonnes. The area and production targets for 2002 are 24,000 hectares and 20,000 tonnes respectively.

Evaluation of 136 exotic accessions for yield and bean characteristics led to the identification of 11 high yielders of Malaysian origin with more than two kg of dry bean weight/tree/year. The clonal progeny has been established for hybrid seed production. A few drought tolerant hybrids have also been identified.

Since grafts are more uniform and better in productivity, grafting techniques are adopted for large scale production of quality planting material. The diseases to be reckoned with are the black pod disease and recently reported Vascular streak disease.

CASHEW (*Anacardium occidentale*)

India, with a production of 4.30 lakh tonnes of raw nuts/year, is the largest producer (43%) in the world. During 1997-98 Rs. 1390.64 crores was earned from the export of 76,323 tonnes of cashew kernels and 4,181 tonnes of cashewnut shell liquid. India is the largest producer, processor, exporter and second largest consumer of cashew kernels in the world. The bane of the industry is the acute shortage of raw cashewnuts within the country. We have a processing capacity of over seven lakh tonnes of raw nuts as against a production of less than four lakh tonnes per year forcing us to resort to imports. The crop is mainly grown in Kerala, Karnataka, Andhra Pradesh, Tamil Nadu, Orissa, Maharashtra and Goa.

From commercial point of view, the ideal cashew plant should have dwarf and compact canopy with intensive branch habit, short flowering and fruiting phase, more than 20 per cent perfect flowers, 8-10 nuts/panicle, medium to bold (8-10 g) size, more than 28 per cent shelling with high potential yield of more than 20 kg/tree/year and it should preferably be resistant to major pests and diseases.

Twenty three selections and 11 hybrids have been so far released for cultivation. In 1970's and 1980's the seed propagated planting materials were used for area expansion programme. During 1990's the commercial viability of vegetative propagation was confirmed. Consequent to this a number of nurseries were established many of them with Government of India assistance. Replanting of the low productive orchards is considered to be a better option to achieve an yield of 2 tonnes/ha for which quality planting material is now adequately available.

The quality of fertilizer to be applied to an adult tree as per the present recommendation is to supply 500 g N, 125 g P_2O_5 and 125 g K_2O per tree/year. The farm yard manure application at the rate of 4 T/ha (*25* kg/tree) is also recommended. Though it is essentially a rainfed crop irrigation increases the yield by 30%. The main problems in cashew cultivation are the incidence of Tea mosquito bug and Stem borer.

The growing demand for kernels in international market and the availability of cheap, skilled labour (mainly women) in India are important favourable factors for rapid growth of cashew processing industry in India. Optimization of every processing step has become urgent. Efficiency in production of unscorched kernels and maximum recovery of CNSL are very important. Simple mechanisation to increase the whole nut yield, without creating social upheaval, is the most ideal.

OIL PALM (*Elaeis guineensis*)

The increasing gap between demand and production of vegetable oil made it imperative for us to look for an alternate oil crop. Oil palm is a preferred crop because of its high oil production potential of 3 MT to 5 MT per hectare. Although introduced and cultivated in the country since 1964, a policy on its expansion was taken only in 1988 consequent to the report of the Government of India Team. It was estimated that a total area of 7.96 lakh hectares are suitable for the cultivation of this crop. At present more than 40,000 hectares is covered under oil palm mainly in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. The main constraints are the requirement of irrigation and necessity for a processing unit in the vicinity of the plantation.

Palm oil of commerce is obtained from the mesocarp of the fruit whereas the kernel gives kernel oil. Only tenera hybrids are planted commercially. Till 1982 the seeds had to be imported. Now four to five lakh seeds are produced indigenously through establishment of seed gardens. The palm needs copious irrigation during summer months since water deficit leads to increased male inflorescence production resulting in low production. A pollinating weevil (*Elaedobius kamerunicus*) has been introduced to increase fruit set and yield.

Polybag nursery technique has been standardised. The recommended nutrient doze for adult palm is 1200 g N, 600 g P2O5 and 1200 g K2O per palm per year. Intercrops can be raised during the first three years. There are no serious pests or diseases recorded in India so far. However avian pests take a high toll of the fruits and spear rot disease of phytoplasmal etiology is reported from Kerala state.

The most important factor to be taken care of in palm oil industry is the processing requirements. The fruits should be processed at least within 24 hours after harvest lest the free fatty acid content goes beyond the permissible limit due to action of lipase enzyme. The processing involves sterilization, stripping, digestion, pressing and classification. Small scale processing units of one tonne FFB/hr are suited for smaller plantations of 200 ha while palm oil mills which can process 20 to 30 tonnes of fruits/hour are available which can produce refined palm oil. Oil palm cultivation offers scope at least in certain states since it gives high oil yield per unit area, it is ecofriendly, offers sustainable steady income, and enjoys buyback guarantee under Government support.

Future strategy for spices development in India

E. Velappan and K. Sivaraman

India occupies a predominant position in the production, consumption and trade of spices since time immemorial. The present annual production of spices in the country is around 25 lakh t valued at Rs 7000 crores. Over 90 per cent of the production is consumed within the country and the rest being exported. During the year 1997-98 the country earned foreign exchange worth Rs 1352.10 crores by exporting 2,18,750 tonnes of spices as whole, powdered or value added items, The world export of spices is estimated at 4,50,000 tonnes valued at $ 1600 million. The annual growth rate in the world import is in the order of 3 per cent to 4 per cent. Pepper and capsicum account for 57 per cent of the total quantity, seed spices 17 per cent, cinnamon and cassia 7 per cent, turmeric 7 per cent and ginger 4 per cent.

Presently over 50 spices are grown in India, although International Standards Organizations (ISO) catalogued 109 spices and condiments. In India, Kerala, Tamii Nadu, Karnataka, Maharashtra, Guj rat, Rajasthan, Orissa, Madhya Pradesh and West Bengal are the important spices growing states.

Spices production was very stagnant in the pre-independent and early post independent years. Initiatives for spices developments were taken from the IV Five Year Plan onwards with the allocation of some funds. A Centrally Sponsored Scheme for the development of spices mainly pepper and to a small extent ginger, turmeric and chillies was drawn up and implemented in the VII Plan. As a result of this initiatives taken an annual growth rate of 4% in production was achieved during the VII Plan period. Considering the trend in demand in domestic consumption and export an annual growth rate of 8% was fixed in the VIII Plan. A Centrally Sponsored Integrated Programme for the Development of Spices (IPDS) was implemented in the VIII Plan in *25* states and two Union Territories covering 27 commercially important spices grown in the country with a financial allocation of Rs. 125 crores. The impact on production and productivity through the implementation of the scheme was quite encouraging and the target could be frilly achieved.

Considering the growing demand for spices within the country and abroad for culinary, cosmetics, pharmaceutical and other uses and the country's potential for production of spices an average annual growth rate of 10 per cent has been envisaged in the IX Plan as against the achievement of 8 per cent in the VIII Plan. Based on the experience gained, the research inputs and infrastructure developed the future strategy for spices development in the country on a wider perspective are : identification of varieties suitable for different end uses, production of better quality disease free planting materials using bio control methods, adoption of integrated crop management technologies, encouraging export onented production, programme for the control of major diseases, on-farm processing, better attention for spices development in the NE Region, creating a strong data bank on spices statistics etc.

Medicinal and aromatic plants - Problems and Prospects

J. Thomas

Introduction

Over 30% of the world's plant species have at one time or another been used for medicinal purpose. Of the 2,50,000 higher plant species on earth, more than 80,000 are medicinal. Two third of plant species used for medicinal purpose comes from developing countries. The products relating to about 20,000 higher plant species are being marketed world over. About 120 chemical compounds of plant origin have been developed into modem pharmaceuticals. The natural essential oils and their fragrance are perhaps the most remarkable products of plant metabolism and these products have influenced human thoughts and emotions since the beginning of our civilisations. A realisation of the therapeutic value later made use of these materials in medicine as curative, cooling, antiseptic and preservative.

It is estimated that world market for plant derived drugs may account for about Rs.2,00,000 crores. Presently, Indian contribution is less than Rs.2000 crores. Indian export of raw drugs has steadily grown at 26% to Rs.165 crores in 1994-'95 from Rs. 130 crores in 1991 -'92. The annual production of medicinal and aromatic plants raw materials is worth about Rs.200 crores. This is likely to touch US $1150 by the year 2000 and US $5 trillion by 2050. In respect of essential oils, aroma chemicals, natural flavours and fragrance, the demand projections of industrial raw material are valued at US$ 12 billion. In the world-wide flavour and fragrance market, essential oils constitute about 17 per cent. The estimate of world production of essential oils varies from 40,000 60,000 t/annum. The world essential oil production at raw material level was around US$ 1 billion in 1994, of which 55-60% goes to food flavours and 15-20% to fragrance.

The world population is likely to reach 11.5 billion by the year 2020. Assessing the culTent status of health care system, inadequacies of synthetic drugs are likely to be more glaring in the corning years. Increased emphasis on the usage of plant material, as a source of food, medicine, fragrance and flavors, dyes, and other items of daily use will be imminent.

India is known for its plant resources from time immemorial and is one of the world's 12 bio-diversity centers sheltering over 45,000 different plant species. India's diversity is unmatched due to the presence of 16 different agroclimatic zones, 10 vegetation zones, 25 biotic provinces and 426 biomes. Of these, about 15,000-20,000 species have good medicinal value. However, traditional communities use only 7000-7500 species for medicinal purpose. The trade of medicinal plants in India is estimated to be to the tune of Rs. *550* crores/annum. Total turn over of *ayurvedic* and herbal products is around Rs. 2300 crores. About 1300 species of plants native to the country are known to possess aroma. However, India produces limited items of commercial value both from wild and cultivation. Export of essential oils from India during 1996-97 is Rs. 27.7 crores. Total production of fragrance in the country was to the tune of 8400 tonnes in 1997. Domestic demand for fragrance and flavours is increasing in tune with the increase in the purchasing power. The internal demand for flavours during 1996 was 33188 tonnes. It is predicted that India is growing to be one of the world's largest economies in the next millennium. Our plant genetic resources and technological skill will play a significant role in attaining this enviable position.

Constraints in development

Market flexibility

In spite of regular internal demand and growing export, the trade in this sector is largely unorganised. This is largely because of fluctuations in the national and international prices on account of variable supply and demand that bring into conflict the interest of the growers and user industries. So far, India has been involved in the export of only large volume of raw materials. To achieve competitive advantage, we need to resort to low volume high cost trade through value addition to the raw kind unfinished products.

With respect to raw drugs, the market demand continues to be fed largely from wild though isolated cultivation has taken off due to the concentrated efforts of various governmental and non-governmental organisations. China, which has taken lead in utilising its plant genetic resources and traditional system of medicine, has already eliminated the dependence on the supply from wild, whereby demand and supply of raw materials could be favourably adjusted.

Deforestation

The treasure house of medicinal and aromatic plants is undoubtedly the forests. In India, a forest cover of 71 .803mha during 1950-'51 is at present disappearing at an annual rate of about 1.5 million ha/year. What is left now is only 8% as against the mandatory 33% of the geographical area of 328.73 million hectares. It is estimated that with the present rate of destruction of tropical forest, *20-25%* of the world's plant species will be lost by the year 2000. It is also reported that 10% of India's flowering plants come under threatened categories. The "Red Data Book of Indian plants" gives bare passport data on 620 species. About 1080 species under threat require enlisting and categorizing in the new I.U.C.N. red list. If this destruction of plant resource is continued unabated, it would undoubtedly undermine our indigenous systems of medicine which cater to the health care of over 80% of our rural mass.

Lack of modern approach

Harnessing the plant resources for the benefit of humankind was taught to the world from the time of Indian civilisation, which dates back prior to 6000 BC. About 8000 herbal remedies have been codified in *ayurveda*. The *Rigveda* (5000 BC) has recorded 67 species, *Yajurveda* (5000-4500 BC) 81 species, *Atharvaveda* (4500-2500 BC) 290 species, *Charak samhita* (700 BC) 1100 species and *Sushrut samhita* (200 BC) described 1270 species of medicinal value. The art of perfume making was first conceived and employed in the East, especially in India, Egypt, Persia and China.

We ourselves are to be blamed for losing the traditional knowledge passed on to us by our ancestors. Local communities hold the utilisation of bio-diversity in different languages and in their diverse epistemological frameworks. Lack of proper documentation, verification, conservation and short-sighted policies and laws resulted in this state of affairs. There has so far not been an over all guiding frame work to bring harmony and coherence in the protection of our plant resources and utilisation of our indigenous knowledge systems. China has demonstrated the best use of traditional medicines in providing health care. China has pharmacologically validated and improved many traditional herbal medicines and eventually integrated them in formal health care systems.

Challenges Ahead

The burgeoning population, limited natural resources and expanding biotic and abiotic stresses to the environment have made it imperative to boost agricultural productivity continuously using environmentally sustainable technologies. Sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources. Accordingly, the research and development on medicinal and aromatic plants should be reoriented, infrastructure developed, short, medium and long term result oriented action plan chalked out and skilled man power developed for meeting the emerging challenges in the new millennium.

Bio-conservation

Bio-diversity is the vital factor for improving biological productivity. To ensure availability of raw materials of medicinal and aromatic plants in future, its intra-specific genetic resources must be conserved. For effective conservation, it is vital to identify the plants, outline their distribution and assess the scarcity or abundance. Steps should be taken to reintroduce the highly depleted species into those areas where they once grew wild. Priority for *ex-situ* conservation should be given to species whose habitat has been destroyed or cannot be safeguarded. Considerable traditional knowledge (both documented and undocumented) on use of these plants for human benefit is available but needs revitalization. Comprehensive data base is to be generated with all the pertinent data for judicial use and conservation, like scientific/vernacular/trade names, geographical distribution, status of availability, description of plant part used, method of collection, uses, major chemical constituents and biological activity, pharmacological/ toxicological data, source of planting materials, demand/ supply status etc. The gene banks thus created have to be put to in-depth characterization from conventional taxonomy to cellular and molecular levels. Future exploitation and utilization of genetic diversity of conserved resources mainly depends on the level of characterization and comprehensive understanding of genetics. The main components of such analysis include genetic identity (molecular fingerprints), relatedness (molecular diversity), structure (genotype) and gene location (DNA sequence). Techniques using "molecular markers" has direct utility right from identification, documentation to IPR protection and management of biological wealth.

Bio-production

The conserved genetic variability of commercially potential medicinal and aromatic plants may be utilized for evolving better varieties for higher production of superior quality raw drugs. Conventional genetics and plant breeding methods are to be further supported by genomics research, which seeks to unravel the structure, function and evolution of whole genomes. Application of genomics in *mediculture* would make metabolic pathways for the synthesis of pharmaceuticals, industrial and agricultural chemicals more efficient in host plants. *Mediculture* genomics will provide plant genotypes for economic production of a spectrum of valuable compounds through cropping in the field or tissue culture in bio-reactors. Appropriate production technology with emphasis on organic and eco-friendly farming should be developed in term with *Good Agricultural Practices* (GAP). Safety limits of pesticide residues, heavy metals and microbial and radioactive contaminants for all plant materials used in herbal medicines should be laid down conforming to these guidelines. Each plant including its parts, which are being used in formulation of herbal drugs, should be standardized using modern scientific tools. Emphasis on cultivation of medicinal and aromatic plants in homesteads, wastelands, avenues, public places, creation of groves, etc should be integrated with social and cultural life. Domestication and cultivation form the most formidable challenge for the use of medicinal plants as many species are still gathered from the wild and continued exploitation can endanger the survival of the species.

Rio-prospecting

It is high time that we initiate a concentrated attempt for bio-diversfty prospecting (bio-prospecting) for meeting the challenges of health care systems and natural product based industries in the coming years. Bio-prospecting integrates the systematic research of new sources of economically valuable products. This will help in the sustainable use of genetic resources and their conservation and help the socio-economic development of the bio-diversity rich India. This would help to create regulations on access to our genetic resources, to develop technologies for value addition to our genetic resources and create new sources for industrial utilization. Plants, especially those related to traditional systems of medicine need to be screened for pharmaceuticals. Biosynthetic pathways for the formation of secondary metabolites have to be studied. The structure and functions of specific enzymes involved in the synthesis of secondary metabolites will have to be investigated. The emerging information will be useful for the manipulation of the genetic control mechanisms of biosynthetic pathways to obtain higher yields of economically important metabolites.

Isolation of natural food colorants, fragrance and flavors hold an exciting industrial utilization of our bio-diversity. The research will lead to identification of high yielding natural resources of aroma, flavour and dyes and development of economically viable and efficient process technologies. This potential area of development needs substantial input from biotechnology and phytochemistry and the infrastructure are to be developed accordingly.
Market Intelligence

To ensure continued supply of raw materials to meet the growing market demand, constant surveillance is inevitable. The market intelligence agencies should be able to provide demand-supply projections, sourcing, internal and international pricing and liaison between the producer and the end user. Out of the large number of species being used in indigenous systems of medicine and perfumery, only less than 60 species have been introduced for cultivation. This situation has to be changed whereby major share of raw materials should come from cultivation. It should be ensured that the cultivators' interest is protected without prejudice to the industry.

Quality Assurance

This is one area where much attention needs to be given in order to push our natural products to international market. Quality control guidelines for raw materials with respect to their collection, storage, packaging etc for maintaining international standards should be strictly laid down. Quality control parameters (both physical and chemical) right from raw material stage, through processing stage, to final product stage have to be standardized, This involves modernization of processing procedures and phytochemical screening of raw materials and final products. The most modern analytical tools should be used in line with ISO standards for strict quality control.

Technology Management

In the coming millennium, nature, humanity and technology must work in harmony. Proper linkage between every ring of the production system is to be assured through effective technology management. The fruits of research are to be linked with farmers who are the producers of raw material to the industry who are its end users. The management system should ensure fair sharing of profits, build mutual trust and effective multidirectional flow of information. This involves resource generation for research and development, patenting of technology and marketing of technologies developed. This is further enabled by the great information technology advancements allowing systematic assimilation and dissemination of relevant and timely information and dramatically improving the ability to access the universe of knowledge and communicating through low cost electronic networks.

Scientific man power development

A multi-disciplinary team should be built up at the national and regional levels involving plant taxonomists, agronomists, phytochemists, biotechnologists, pharmacologists, industrialists, practitioners and technology managers. They should work out areas of collaboration with other Research and Development institutions and industries for commercialization of technologies and resource sharing. The team should ensure continuity of the Research and Development efforts by grooming future generations of multi-disciplinary teams laying out short term, medium term and long term policies in judicious management of our plant genetic resources. The team should be able to stop *biopiracy* and *intellectual piracy* and evolve a foolproof protection system for bio-diversity and indigenous knowledge systems

Intellectual Property Rights

It is a reality that the economic future of any country lies in the number of patents it holds. In fact it is the number of patents and not the quality of patents that is going to add value to the market oriented research. There is an urgent need for public debates and educational programmes involving the scientists, judiciary, legislature and the people to bring in patent literacy and to establish ownership rights of the biological resources of the country. The decision of the World Intellectual Property Organization (WIPO) to explore the intellectual property needs, rights and expectations of holders of traditional knowledge, innovations and culture is an important step in widening the concept of intellectual property. Principles of ethics and equity demand that this invaluable component of Intellectual Property Rights (IPR) gets included when the Trade Related Intellectual Property Rights (TRIPs) agreement of the World Trade Organization (WTO) comes into force. Food and Agriculture Organization (FAO) has been a pioneer in the recognition of the contributions of farm families in genetic resources conservation and enhancement by promoting the concept of "Farmers Rights". Like WIPO, the Union for the Protection of New Varieties of Crops (UPOV) should undertake the task of preparing an integrated concept of breeders' and farmers' rights. In a unipolar world, patent literacy is going to decide the economic winners of tomorrow.

Seed Security

Today genetic engineering is capable of introducing genes for desirable traits transgressing species barriers. Significant progress has been made in developing transgenic plants with the desired characters like resistance to pests and diseases. Simultaneously, 'terminator gene' technology- a concept in recombinant DNA technology gave birth to 'terminator seed' which does not produce viable seed for the farmer to raise the next crop. Recently, Traitor seed technology has surfaced. Traitor seed will not produce economic yields without using the input packet supplied by the multinational. This is obviously a means to make the farmer dependent on multinational forever for seeds. It is a common phenomenon observed in practise that unexpected shoot up in market price of a plant raw material is always succeeded by a shortage and rise in market price of seeds for the succeeding crop. Unscrupulous trades take advantage of the situation, making the seeds beyond the reach of common farmers. For farmers, the right to seed is a fundamental right, not a concession. To overcome such difficulties, a system should be evolved to take care of such contingencies to help the real cultivators.

Emerging opportunities

Biocides

Biocide preparations from herbs, extraction and production of plant growth regulators and allelo-chemicals, etc are other areas of utilization of our indigenous knowledge and bio-diversity resources. The failures and non-sustainability of the chemical route to agriculture and health care provides an opportunity to re-evaluate our traditional knowledge systems on safe use of plant extracts for pest and disease management. Use of neem, other non-edible oils and extracts of many medicinal plants are well known.

Aromatherapy

It is gaining importance all over the world. It is an alternative system of medicine visualizing the use of aromatic essential oils to prevent and cure diseases in man and animals. Bucheur (1994) has proposed a universal definition of *Aromatherapy*. "The therapeutic use of fragrances or volatile substances to cure and to mitigate or to prevent diseases, infections and indisposition only by means of inhalation." This can easily be integrated with eco-tourism and will help to find domestic market for indigenous essential oils thus gearing up cultivation and production sectors.

Eco-technology

The ecological foundations essential for sustained advances in biological productivity and the atmosphere are experiencing gradual degradation or depletion. There is much to learn from the past in terms of the ecological and social sustainability of technologies. New developments have opened up new opportunities for developing technologies, which can lead to high productivity without any adverse effect on the natural resource base. Blending traditional and frontier technologies leads to the birth of eco-technologies with the combined strength of economics, ecology, equity, energy and employment. There is need to conserve traditional wisdom and practices which are often tending to become extinct. Eco-technologies enable adoption of ISO 9000 and ISO 14000 standards of environmental management.

Eco-tourism

Australia is the first country to have an eco-tourism strategy and Malaysia has followed suit. The diverse ecological zones of India offer tremendous scope for developing eco-tourism in the country. Development of eco-tourism can generate substantial foreign exchange without the usual disastrous ecological degradation associated with general tourism. It will help to promote and popularize the various indigenous systems of medicine, take people closer to nature and above all promote the overall well being of the people.

Conclusion

Diversity and pluralism are the characteristics of Indian environment and Indian society. The rich bio-diversity of plants and diverse knowledge systems in harnessing the plant bio-diversity provide an opportunity to meet the future challenges in agriculture, health care systems, fragrance, flavours and allied areas. The failures and non-sustainability of the so-called modem approaches to agriculture and health care systems could be re-assessed through our knowledge heritage and natural resources. If information technology holds today's fate, biotechnology will determine the future of the coming millennium. Our rich bio-diversity will provide the base for the revolution to take off.

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Spice production – Problems and prospects

S.N. Potty

Spices valued for their pleasant flavour and aroma are essential components of food preparations of almost all segments of people world over. Apart from use in culinary preparations and as a food colouring material, spices find place in medicinal applications, cosmetics and beauty products, perfumery industry, botanical pesticides and though to a limited extent in religious rites. Even in spite of' the varied uses of spices, they are required only in very low quantities and therefore the average daily consumption is far less than other consumables. 109 plant species and their produces are listed as spices by the International Standards Organisation of which 63 are produced in India. Currently 52 species have been enlisted by India and a few more are being added.

Global Scenario

The global production of all the spices put together is estimated to be around 90- 100 lakh tonnes per annum.

Name of spice	Major Producing Countries
Pepper	India, Indonesia, Vietnam, Malaysia, Brazil, Sri Lanka, Thailand
Chilli	India, Pakistan, China, Bangladesh
Ginger	India, Bangladesh, Nigeria, Jamaica
Turmeric	India, China, Peru, Thailand
Cardamom	Guatemala, India, Sri Lanka, Tanzania., Papua New Guinea
Large cardamom	India, Nepal, Bhutan
Garlic	India, Korea, Spain, Thailand, Egypt.
Saffron	India, Spain, Iran
Vanilla	Madagascar, Indonesia. Comoro islands, Reunion. Uganda, Tongo, Mexico, French Polynesia, India

Out of the nearly 100 lakh tonnes of spices produced globally, the volume of international trade is limited to only around 4.5 lakh tonnes. Only 5 percent of the global production is exported by the producing countries. In terms of value, the global export is estimated at 1500 million US$. The growth rate of world import has been 2-3 percent per annum.

The major importers of spices are North American countries (USA, Canada), European Union(Germany, France, The Netherlands, UK) and Japan.

Indian Scenario

India has a unique position as a major supplier of spices in the international trade. Blessed with varied agro-climatic conditions, perennial water source, different altitudes, humid subtropics and nearly temperate zones, India is in advantageous position as a producer of a large variety of spices. No other country in the world has such a broad supply base. 52 spices having different agro-climatic requirements are grown in the country. India is not only the largest producer of spices, producing around 27-30 lakh tonnes per annum, but also the largest consumer of spices. Out of the nearly 30 lakh tonnes of spices produced, India exports only 7-8 percent of its production which is estimated at a little over 2.1 lakh tonnes during 1998-99, the balance being domestic consumption. It is worth pointing out that even with this 7-8 percent export of the total production, India contributes to about 45 percent of the global trade in spices which as mentioned earlier is 4.5 lakh tonnes.

It is difficult to get a precise estimate of the area and production of various spices in India. The data relating to major spices collected from Spices Board for cardamom and from Directorate of Economics and Statistics, New Delhi, State Agricultural and Statistics Departments are frirnished in Tables 1 & 2. The area under all the spices put together is estimated to be around 22.5 lakh ha. It could be seen that the area under spices remained almost static and minor shift in the area has been seen only in the case of annual spice crops. Chillies alone accounts for nearly 42 percent of the area under all the spices put together. Seed spices account for another 35 percent of the total area, the major crops being coriander (5.2 lakh ha) and cumin (2.89 lakh ha). The area under cardamom has been

Table 1. AREA OF MAJOR SPICES IN INDIA

(Area in Hect.)

SPICES	AREA 1992-93	AREA 1993-94	AREA 1994-95	AREA 1995-96	AREA 1996-97	AREA 1997-98
PEPPER	1,89,390	1,90,990	1,93,270	1,98,030	1,80,260	1,81,550
CARDAMOM SMALL	82,392	82,960	83,651	83,802	73,593	72,444
CARDAMOM LARGE	26,430	26,645	26,131	26,130	26,129	26,358
CHILLIES	9,62,100	9,30,000	8,29,000	8,83,700	9,44,200	8,31,500
GINGER	59,870		61,090	66,890	70,290	67,200
TURMERIC	1,30,200	1,48,400	1,49,400	1,39,300	1,35,200	1,24,600
GARLIC	85,500	76,200	98,900	1,14,800	94,300	98,500
CORIANDER	4,02,600	4,64,800	4,30,400	4,07,600	4,52,700	5,21,600
CUMIN	3,13,895	4,20,755	2,82,027	2,20,343	3,07,046	2,88,832
FENNEL	14,700	11,100	16,687	12,821	25,107	26,807
PENUGREEK	24,629	35,778	45,1?3	38,321	38,455	33,590

SOURCE : CARDAMOM : SPICES BOARD.
OTHERS : DTE. OF ECONOMICS STATISTICS, NEW DELHI / STATE AGRICULTURAL OR STATISTICAL DEPTS.

Table 2. PRODUCTION OF MAJOR SPICES IN INDIA

(In Tonnes)

SPICES	1992-93 Production	1993-94 Production	1994-95 Production	1995-96 Production	1996-97 Production	1997-98 Production
PEPPER	50,760	51.320	60.740	61,580	55,590	52,720
CARDAMOM SMALL	4,250	6,600	7,000	7,900	6,625	7,900
CARDAMOM LARGE	3,550	3,725	3,600	4,750	5,150	5,265
CHILLIES	8,62,100	8,00,100	7,94,700	8,09,700	10,66,000	8,21,800
GINGER	2,01,630	1,86,200	1,97,650	2,19,300	2,32,510	2,33,660
TURMERIC	4,07,700	7,07,400	6,22,000	4,62,900	5,28,900	4,87,400
GARLIC	3,55,800	3,06,000	4,03,300	4,90,000	4,37,900	4,64,000
CORIANDER	1,91,200	2,03,700	1,93,000	1,96,100	2,55,500	3,08,100
CUMIN	1,35,189	1,66,524	1,18,877	75,250	1,17,122	1,15,344
FENNEL	19,000	13,100	17,438	15,696	28,380	36,581
PENUGREEK	25,372	37,872	56,846	46,668	49,968	31,413

SOURCE : CARDAMOM : SPICES BOARD.
OTHERS : DTE. OF ECONOMICS STATISTICS, NEW DELHI / STATE AGRICULTURAL OR STATISTICAL DEPTS.

shrinking steadily from 82,392 ha in 1992-93 to 72,444 ha in 1997-98. Though the area under pepper has been showing a marginal reduction from 1996, large scale planting of this crop is noted in recent years.

The total production of the major spices has been showing marginal increase from about 22.55 lakh tonnes in 1992-1993 to 24.98 lakh tonnes in 1997-98. Chillies account for nearly one third of the total production. Other major contributors are ginger, turmeric, seed spices (mainly coriander and cumin) in terms of volume of production. Even in spite of a gradual shrinkage of area under cardamom, the production of this crop is showing a steady increase over the years, obviously because of the Increase in productivity. In the case of large cardamom, the area remained at a little over 26,000 ha through the last 6-7 years, but the production has increased from 3,550 tonnes in 1992-93 to 5,265 tonnes in 1997-98.

In the export front, India has been performing well during the last five years. In terms of volume, the export increased from 1.55 lakh tonnes in 1994-95 to 2.29 lakh tonnes in 1997-98. During 1998-99, however, the quantity reduced marginally to 2.10 lakh tonnes. However, there has been a quantum jump in export earning both in terms of rupee and US dollar. During 1998-99, india exported spices worth Rs. 1650 crores (3 93.4 lakh US$).

Till a decade back, India was exporting spices in raw form and in bulk, mainly as bulk packing. The trend has now changed and export of spices in value added form has now a share of 30 percent of the total export of spices from India which was only around 5 percent a decade ago. This is also one of the reasons for the phenominal increase in value of export in comparison to quantity exported. Spice oils and oleoresins, curry powders, different spice blends, dehydrated green pepper, pepper in brine, frozen green pepper etc are some of the important value added items of spices exported from India at present.

Problems

Even though the export performance in the spice sector has been given a rosy picture, the spices production and export scenario faces a series of problems. The increasing export performance has been due to the advantage our country could tap due to short supply of one commodity or other in the international market. The best example is that of pepper, which became dear in the global market for the last two years because of the low production in the competing countries, mainly Indonesia. So is the case of India during 1996-97 and 1998-99. However, in order to establish as a regular supplier of spices, the country will have to address itself to meet the challenges ahead. A brief account of the current problems are given below.

1. Exportable surplus

As mentioned earlier, India is the largest producer, consumer and exporter of spices. Consequent to large domestic demand for meeting the requirement of nearly one billion people, the export surplus becomes a hurdle in boosting export of spices. For the last two years inadequate exportable surplus of pepper was a major concern of our exporters. A shift towards more and more natural products in Western countries and simultaneous search for new foods and ethnic foods offers great potential for increased spice consumption world over. It is estimated that international demand of spices may go up by about 4 per cent per annum. Increase in domestic population to the extent of 1.2 per cent per annum coupled with improved purchasing power of the people would also substantially increase the domestic demand. Therefore inadequate supply of spices would be of a major concern in the years to come.

2. Price competitiveness

India is not in a position to offer spices in the global market at competitive prices. The high unit cost of production and the large domestic demand have resulted in relatively higher domestic prices for most of the spices. Therefore India is in a portion only to exploit the situation when one commodity or other is in short supply in international market. In order to offer steady supply and constantly compete in the global trade, India will have to offer spices at internationally competitive rates. This can be achieved only by increasing productivity through use of high yielding varieties and better agro-techniques.

3. Productivity gap

There exists a large gap between potential and achieved productivity in almost all the spices. Even though more than 70 high yielding varieties of various spices have been evolved throughout the country to suit different agro-climatic situations, not even 5 per cent of the area has been covered with these high yielding varieties. Programmes for multiplication and distribution of improved varieties to growers by the developmental agencies are also quite inadequate.

4. Rising cost of production

Cost of labour and other inputs is raising day by day and there appears little scope to reduce the cost of production of any spice crop substantially. A lot of research is required for evolving cost effective I PM, and I DM, to reduce crop loss due to pests and diseases so that optimum productivity can be ensured. Mechanisation of farm operations, taking care of social concerns etc. appear to be other potential areas of research to face the challenge of rising cost of production.

5. Quality

The intrinsic quality of most of the spices is accepted as superior or at par with those of the other global suppliers. However, upgradation of quality by introducing varieties with superior intrinsic qualities is essential for at least some of the spices like coriander, fennel, fenugreek, ginger, paprika etc.

Another important aspect of the quality is freedom from physical, microbiological and chemical contamination. Consumers world over are becoming more and more conscious of the quality. The physical contaminants like extraneous matter, filth, animal exereta etc. can very well be avoided at farm level itself by appropriate post harvest operations. Proper storage and hygenic handling would lead to low microbial load. Lack of concern on pesticide residues due to indiscriminate usage of pesticides has been one of the problems. The steps taken by the Spices Board in the direction of upgrading the quality have improved the quality of Indian spices substantially. On post harvest improvement, supply of polythene sheets and bamboo mats for drying spices, construction of drying yards and quality improvement training programmes have helped in reducing the physical contaminants and enhancing other quality parameters. Another step taken in this direction is the introduction of Spice Logo and Spice House Certificate. The Logo is awarded by the Spices Board for consumer of institutional packs only to units that conform to the stipulated standards prescribed in terms of quality, hygiene and sanitation; right from raw material stage to the point of export. The spice house certificate denotes that the unit has facilities of prescribed high standards for cleaning, grading, packaging, ware housing and quality assurance.

Potential for Export of Indian Spices

As mentioned elsewhere, the international demand for spices is expected to grow to the tune of four percent per annum. This increased market can be captured by India if we take timely steps in the following direction

- Make Indian spices competitive in the international market
- Produce exportable surplus to match the increased demand
- Value addition
- Adoption of improved technologies for extraction, sterilization, micro-encapsulation, dehydration, cryogrinding, super critical extraction.
- Production of organic spices
- Production of clean spices at farm level through improved post harvest operations
- Lower pesticide residues through good agricultural practices, forceful implementation of rules and regulations on pesticides.
- Extensive quality awareness campaigns for producers, traders and consumers.

Production of traditional vegetables in the humid tropics

Dr. L. Rajamony

Vegetables comprise a complex group of edible plants with diverse forms of breeding systems and propagation. There is universal recognition that vegetables are important food considering them as the natural sources of fiber, trace minerals, vitamins, carbohydrates and proteins. Economic trends suggest that vegetables will increasingly contribute to the improved diets of the developing countries.

India is the second largest producer of vegetables next to China. Though, Kerala produce only 5.70 lakh tonnes of vegetables annually, its present total requirement is 15.0 lakh tonnes in a year considering 135 g as the requirement / day / head. This requirement is met exactly by importing vegetables from the neighbouring states (P.P.M.C, 1996). This will never continue as such considering the political and geographic situations.

Vegetable wealth of the humid-tropics

Kerala, the humid-tropic state of India has its own unique system of homestead farming, a special type of agricultural production system around the home with multispecies of annual and perennial crops with livestock and poultry (Jose and Vasanthakumar, 1994).

Kerala is unique both in terms of crop and varietal specificity. This is more experienced in the case of vegetable crops. The humid-tropic ecosystem favours the adaptation of a number of vegetable crops in the family *viz.*, Cucurbitaceae, Solanaceae, Papilionaceae and amaranthaceae, and other vegetables like bhindi and perennial vegetable like drumstick. A list of traditional and popular vegetable crops of Kerala with their features is furnished below.

Cucurbitaceous vegetables

1. Melon/Vellari

This is one of the popular and profitable cucurbits grown throughout the state especially as a summer crop both in the rice fallow and in open garden land (Rajamony, *et al.*, 1985). The traditional vellari (oriental melon) is the non-dessert or culinary form of the Cucumis melo where the popular muskmelon, cantaloupes, netted melons and longmelons are included (Rajamony, 1996). Different landraces are seen destributed in the humid tropics in terms of yield and yield attributes, colour, size and shape, keeping quality and even resistance to pests and diseases (Seshadri and Chatterjee, 1996).

2. Cucumbers

Though it is not a traditional vegetable in Kerala, the same has been introduced in the farming system recently. The crop is highly suitable to grow in the rice fallow and the garden land during the rain free period (November - February). Since the plant is a mild shade loving ones, cultivation is possible even as an intercrop in coconut garden (Gayathri, 1997). Considering the export potential, both the salad cucumbers as well as the gherkins are grown in Kerala.

3. Bittergourd

This is the most popular cucurbit of Kerala. Unlike to different parts of the country, bittergourd is grown on pandal in Kerala. Similarly, the consumer preference in Kerala is also unique. Varieties with medium long and white fruits with broken ridges are preferred as an exemption (Vahab and Gopalakrishnana, 1993). Considering the steady demand, the crop is grown both as the irrigated (in the rice fallow) and the rainfed (in the garden land) crops.

4. Snakegourd

It is grown giving importance equal to bittergourd. When the green cloured or green striped fruits are preferred more in majority of the states, here in Kerala the demand is found more for the white fruits. The crop is more suitable for growing during the summer season than in the rainy season. Medium long fruits get priority over the long ones.

5. Pumpkins

Cucurbita moschata is the traditional pumpkins distributed in the humid-tropics. Variability is rich in Kerala for this crop in terms of size, shape, skin colour and keeping quality of fruits (Gopalakrishnan *et al.*, 1980). The fruits with light brown colour skin has got more shelf life than those with green coloured skin. Small size fruits are preferred now largely by the housewives in most of the nucleus family.

6. Ashgourd

This is also a traditional cucurbit of Kerala. Giant size fruits with ashy coating, long fruits without any ashy coating and small size fruits with ashy coating are the landraces that can be seen in this crop. The crop is well adapted in various sacred groves and other undisturbed areas (Roy, 1972). Growing ashgourd upto the height of a coconut, jack and other perennial trees is a common scene in the rural places.

7. Coccinia

Though coccinia is a crop highly adapted in Kerala, this perfectly an under-exploited one. The humid-tropical parts of South India is considered as the secondary centre of origin of this crop (Varghese, 1973). Coccinia has got more medicinal, social and historic importance among the people of Kerala. A wide variability has been recorded in most of the places and the crop is seen flourishing well even in the neglected areas of the cities and towns. Intensive cultivation can be seen in rice fallow of central Travancore and the coastal ecosystem of the north Kerala.

8. Bottlegourd

Many traditional varieties were grown in the uplands of Kerala both as rainfed and irrigated crop. However the crop is out of place as for as the vegetable cultivation is concerned probably because of the introduction of many new vegetables in the farm sector.

9. Luffa

Both the sponge/smooth gourd and ridge gourd is seen in Kerala. When the sponge gourds are distributed in many parts of Quilon, Allappey, Kottayam, Idukki and Ernakulam, the ridgegourd is proved as a potential vegetable of the north Kerala where tremendousm variability is seen (Anitha, 1998).

10. Chow-cho

Though it is a native of humid-tropical regions of Central America and Caribbean (Seshadri, 1989), commercial level cultivation is recorded in the Wynad areas. The vegetable is highly adapted as a summer crop and grown after clearing the scrub jungles. Since it is shade-loving plant, it comes very well under the filtered light of the forest. Most of the harvested produce is sold in the markets of Calicut.

11. Watermelon

This is the one and only dessert vegetable crop of Kerala. Though the demand for this fruit is very high in Kerala during the summer months, its cultivation is seen limited in districts *viz.*, Malappuram, Calicut, Cannanore and Kasargode. The crop is traditionally grown in large scale in the Thelicherry, Cannanore district. Preliminary trials showed that variety Sugar Baby performs very well in the northern and southern regions of Kerala (Shibukumar, 1995).

Solanaceous vegetables

1. Chillies

This is one of the popular vegetable crops throughout the state. All the forms *viz.*, medium pungent, pungent and highly pungent chilies are common. The most pungent type, bird eye pepper (*Capsicum fruitescense*) and the shade loving types (*Capsicum chinense*) are traditional to Kerala (Heiser and Pickersgill, 1969). Among these, the fruits of *C. chinense* are chiefly exported to the Maldives.

2. Brinjal

Brinjal or eggplant is also popular in the humid-tropics. The crop is grown throughout the year either as annual or as a semi-perennial plant. Variability of brinjal is rich in Kerala in terms of size, shape and colour and the giant cultivar of the Wyand has been used as a parent in many improvement programme (Vijayagopal and Sethumathavan, 1973 and Gopimony, 1983).

3. Tomato

Though tomato is a crop with high potential in Kerala, the incidence of bacterial wilt caused by Ralstonia solanacearum can be stated as the only field problem limits the cultivation (Sreelathakumari, 1983; Narayanankutty and Peter, 1986). The crop can be fitted into the farm sector of Kerala either as a pure crop in the rice fallows or as an intercrop in the coconut garden.

Papilionaceous vegetables

1. Yardlong bean

The cowpea is a well adapted crop of humid-tropical India and Kerala is considered as the land of yardlong bean, Vigna unguiculata var. sesquipedalis (Summerfield *et al.*, 1974). This is the most popular pulse vegetable of the humid tropics and the chief source of protein to all classes of people. The variability is rich in terms of size, shape, colour, and reaction towards pest and diseases.

2. Winged bean

This is protein rich vegetable also known as goa bean, four angled bean and asparagus pea. Portuguese travelers through Goa introduced the crop, native of

South Pacific Islands, Papua New Guinea in India (Indira and Peter, 1988). The crop grows well in the highlands of Kerala.

3. Dolichos bean

The crop is traditionally grown in many parts of Kerala especially in the central region. Planting of this crop is a regular agricultural practice during the period of May - June in many homesteads of Trichur. Many landraces are seen distributed in the highland (Pandey and Dubey, 1972).

Other vegetables

1. Amaranthus

This is the most popular annual leafy vegetable of Kerala. Its cultivation in rice fallows is a common practice during the summer months. Though many species are adapted in the humid - tropics, red types (Amaranthus triclor) is preferred over the others (Priya, 1998). The cropping is practiced either as direct sowing or by transplanting.

2. Bhindi

Bhindi is also a traditional vegetable of Kerala where cultivation is possible throughout the calendar year. Traditional varieties are mostly with long and white fruits. As this genotypes are highly susceptible to the yellow vein mosaic virus disease (Rajamony *et al.*, 1995), the farmers shifted to cultivate the varieties with green and small fruits surrendering the consumer preference.

3. Agathi

Agathi a native of Malaysia is grown in parts of Punjab, Delhi, Assam, Tamil Nadu and Kerala (Oomen and Grubben, 1978) This is a tropical tree crop valued for its leaves and flowers. This quick growing, soft wooded tree has ornamental food and fodder values. It is grown as a standard for pepper and betlevines, as shade plant for coconut seedlings an as a wind-break for banana plants.

4. Chekkurmanis

The plant a native of India and Burma, is found in the Sikkim, Himalayas, Khasi, Abor and Arka hills at 1200 m elevation and in the Western Ghats of Kerala from Wynad northwards at altitudes of 300-1200 m. (Indira and Peter, 1988). It is small shrub, popularised as a leafy vegetable. Due to its high nutritive value, it is commonly known as "multivitamin and multimineral packed leafy vegetable". The crop is highly shade and drought tolerant.

5. Clove bean

This is an annual fruit vegetable grown in isolated parts of Kerala. The name clove bean is given for its resemblance of cloves of tree spice. It is 'michi' in Hindi, 'garayo' in Gujarathi, 'Kattuthali' in Tamil and 'nithya vazhuthana' in Malayalam. The clove bean grows from sea level as in Western coasts of Kerala to an elevation of 1700 m in the Himalayas (Joseph *et al.*, 1982).

6. Drumstick

Muringa (drumstick), *Moringa olifera* is a vitamin rich, mineral packed nutritious vegetable of the tropics and subtropics. The tree is indigenous to India and found well adapted in the humid tropical regions. This is one of the traditional as well as popular vegetables of Kerala (Ramachandran *et al.*, 1980).

7. Jack

Though jack is classified as a fruit vegetable originated in the Western Ghat, it served always as a potential vegetable during the famine period. The tenders as well as the unripe fruits are used as vegetables. Developing protocol on the post harvest aspect and processing in jack has got tremendous scope.

Tuber crops

1. Cassava

Cassava or tapioca is a perennial shrub, which produces a high yield of tuberous roots in one to three years after planting. Among the tropical staples, it produce exceptional carbohydrate yields much higher than those of maize and rice and second only to yams (de Vries *et al.*, 1967). For a long time research on the crop was neglected but its exeptional capacity to produce high yields of calories is now recognised and the crop is receiving appropriate attention from breeders and agronomist (Jennings, 1976).

2. Sweet potato

The sweet potato is basically a starchy vegetable, subsidiary or complementary to the Solanum potato in most of the diets. The cultivation is restricted mainly to tropical and sub-tropical regions. Agronomically, there is a striking difference between subtropical and tropical practices. In the first, the plant is treated as an annual with winter storage of tubers for consumption and of seed for subsequent vegetative reproduction while in the tropics, it is virtually perennial, stem cuttings being made from standing crops in a continuous planting procedure (Yen, 1976).

3. Coleus

Coleus, Chinese potato is an important tropical tuber crop in Kerala. Coleus believed to have originated in Africa, is widely grown in India, Sri Lanka, Malaysia, China, Indonesia and parts of Africa. In India, Kerala leads in the production. Main cultivation has been seen in north Kerala (Rajmohan, 1978).

4. Colocasia

Colocasia (taro, cocoyam, and dasheen) belongs to family Araceae. It is grown mainly for its underground corms and cormels. In Kerala the leaves are also used as a vegetable (Indira and Peter, 1988). It is commercial crop in Egypt (Purseglove, 1975). As the crop is shade loving, the cultivation is so traditional in the coconut gardens. There are many local cultivars in colocasia deffering in petiole colour, tuber flesh, tuber size etc.

5. Yams

Yams are mainly natives of Asia and Africa. They are cultivated throughout the warm humid tropics (Coursey, 1967). In India yams are mainly cultivated in Kerala, Tamil Nadu, Karnataka, Maharashtra, Uttar Pradesh, Bihar, West Bengal and the whole of north-eastern India (Onwevme, 1978). Similar to colocasia, yams are adapted well in the coconut garden as a homestead vegetable because of the shade loving nature.

Location specificity in crops

Though a number of warm season vegetable crops deserve consideration, few of them receive location specific attention. When the cucurbits like vellari, bittergourd and snakegourd get more priority throughout the state, watermelon, coccinia and ridgegourd receive special attention in Kannur and Kasargode. These crops are so popular in the vegetable sector of the northern region. Cultivation of watermelon in Edakkad (near Thalasseri) and coccinia in Kasarkode are the traditional practices in the farming sector of this region.

Coccinia deserves few more considerations. This is a crop originated in the Western Ghat region and a rich genetic wealth is seen in Kerala. It is well adapted throughout the length and breadth of the state and the cultivation is seen increased. Moreover, the vegetative means of propagation practiced in coccinia favour the easy multiplication of the hybrids once developed.

Special attention can also be given to chow-chow (in Wayanad) and dolichos bean (in Thrissur). Cool season vegetables *viz.*, cabbage, cauliflower, carrot, radish and beans deserve special attention exclusively for Wayanad and eastern parts of Idukki (Vattavada, Marayur, and Kanthalur).

Priority for variety

Location-specific varietal preference is common and rigid in majority of vegetable crops in Kerala. A blanket recommendation of a hybrid of a particular vegetable crop throughout the state will be a meaningless programme. A number of varieties are found popular and recommended for cultivation throughout the state. A thorough analysis on the location-specificity in terms of vegetable variety is a pre-requisite in evolving and popularising hybrid vegetables in Kerala.

Variety of vellari with green mixed cream coloured fruits is preferred in Thiruvananthapuram, whereas variety with yellow coloured fruit (kanivellari) preferred in all other places of Kerala. When the round or oval shaped and purple coloured fruits of brinjal is preferred in south, variety with long white fruits liked in the central Kerala. Specific demand is noticed in Thrissur and Palakkad for purple coloured yardlong bean (vegetable cowpea). Similarly, extra long white bittergourd has got special preference in Kannur and Kasargode areas (Rajamony, 1999).

R & D programme

Although, research activities on vegetable and tuber crops were initiated in the mid 70's by the Kerala Agricultural University and the Central Tuber crops Research Institute respectively, systematical developmental programmes for the farm sector was framed on in late 90's. The state Department of Agriculture, Kerala is also giving importance to vegetable crops equal or above to any of the crops. A number of varieties have been identified by the Kerala Agricultural University in vegetable crops for popularising the cultivation. However location specific vegetable varieties are not available in various zones of Kerala.

A clear understanding on the problems and prospects is a must in developing high yielding/hybrid vegetables so as to formulate a sound strategy for Kerala. Special attention has to be given for evolving vegetables with genes for tolerating the stress situations. Resistance to pests and diseases and stress situations like shade and high rainfall deserve special attention.

A high yielding/hybrid vegetable with extra yield potential (at least 25% more yield to the prevailing local cultivar) without any resistance to pest and diseases may get only the initial attraction among the farmers of Kerala. However a hybrid with good yield potential (at least 10% more yield to the prevailing local cultivar) coupled with resistance to pest and diseases will definitely get the long-term attraction among the growers. The farmers of Kerala will surely give a whole heart support for popularising the latter ones considering both their economy and environmental safety. In the case of bhindi, it has been proved beyond doubt. Most of the farmers presently grow the bhindi varieties with small and green fruit, surrendering the traditional consumer preference of long and white fruit. This is exactly because of the tolerance nature present in the bhindi varieties with small green fruits. A systematic collection and characterisation of the available vegetable wealth of the state in terms of yield, quality and resistance to biotic and abiotic stresses should be considered as a pre-requisite for evolving production technology exclusively to the farming sector of Kerala.

Locating land for vegetable production in Kerala

Genetic manipulation alone can not be treated as a tool to increase the vegetable production in Kerala. An ideal blend of research and developmental activities is the need of the hour in this context to reach the target production at least in the near future. A balanced approach by increasing the present area to 2.0 - 3.0 lakh ha by multiple cropping and achieving a potential productivity of 15-20 tonnes per ha (Fig. 1) can only be recommended as the available strategy for Kerala.

Though the per capita land available in Kerala is very low, some of the following lands that are not in full use can be utilized for vegetable and tuber crops.

1. Rice fallow

In most of the rice growing tracts of Kerala, the land is left as fallow during the second and/or third crop season. This can be utilized effectively for growing summer vegetables like cucurbits, chilli, bhindi, amaranthus etc.

2. Homesteads of urban and sub-urban areas

A homestead is the traditional farm model evolved in Kerala for a particular agroclimatic situation to meet the fundamental requirement of the farm family in the urban and semi urban areas. This is a potential area that can be utilized for growing vegetables both during the summer as well as in the rainy seasons. Concept of the 'nutrition garden' and 'roof garden' can be effectively implemented in most of the homesteads.

3. Interspace of coconut palms

Eight lakh ha of coconut garden is reported in Kerala (F.I.B, 1998). The peculiar crop geometry and the growth pattern of coconut permits the growth of annual floor crops in the interspaces of the palm especially during the initial seedling stage and the period after 35 years (Nelliat, 1979). This land can effectively be utilized for growing a number of shade loving vegetables like chilli, tomato, amaranthus, chekkurmanis and other minor tuber crops.

4. Coastal sandy belt

This is an additional land that can be attempted for growing vegetables. This sandy land belt is virtually out of any cultivation. However this is a new area where most of the cucurbits and solanaceous vegetables can be attempted provided it is supplemented with organic manures. Utilization of the sandy coastal areas of the Kanchangad and Kasargode for growing watermelon, coccinia and other cucurbits during the summer months along with tobacco is a clear evidence in this regard. Farmers grow vegetables in this leased land and harvest bumper crop with heavy fertilizer application.

5. River beds and river banks

After the cessation of monsoon and cosequent of inundation, riverbeds are formed in most of the rivers in Kerala. The cultivation of vegetables is an ideal one that can be adopted in this area for getting good profit. Cucurbits are specifically suited to this indigenous technology because of the long taproot, which can reach the subterranean moisture levels underneath the sand (Seshadri and Chatterjee, 1996). A number of farmers practice this system of vegetable cultivation in pamba, Manimala, Achankovil and Bharathapuzha rivers OF Kerala (Rajamony, 1999).

6. Sub-tropical zones of high ranges

Consumers demand for the cool season vegetables *viz.*, carrot, beet, cabbage, cauliflower and beans is getting increased tremendously in Kerala during the recent years (P.P.M.C, 1996). However most of these vegetables reaching our market from the neighbouring states is of poor quality with residue of toxic chemicals. Hence the necessity arises now, to locate some of the land for growing this vegetables at least in small scale.

The availability of fertile land in the high ranges of Wayanad and eastern parts of Idukki (Vattavada, Marayur, and Kanthalur) attracts a number of farmers to grow many cool season vegetables. Cultivation of tropical strains of the cool season vegetables has to be

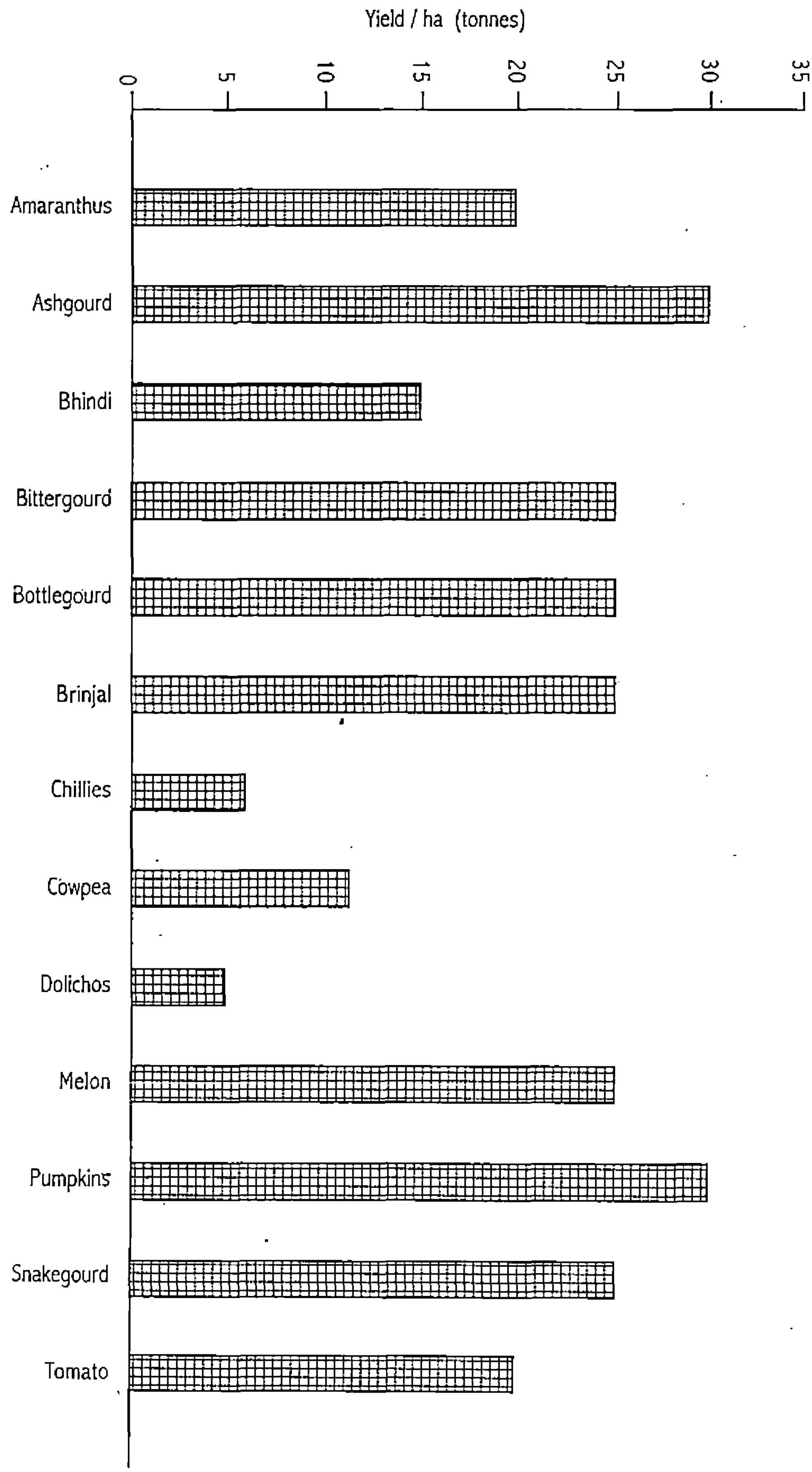

Fig. 1. Productivity of vegetable crops in Kerala

popularised in this region. An effective cropping schedule should be formulated to utilise this sub-tropical area profitably for growing vegetable crops.

Summary

Though paddy and coconut are the prominent crops in the farming system of Kerala, a number of traditional vegetables like bhindi, brinjal, bittergourd, snakegourd, culinary melons, pumpkins, ashgourd, amaranth, cowpea, muringa and minor tubers like colocasia and elephant foot yam have occupied an important place in most of the homesteads. Since the vegetable production in Kerala is far below to the requirement, priority is given to strengthen the research and developmental programmes in vegetable crops equal to any major crops of the state. A clear understanding on the location specific problems and prospects with special emphasis to consumer preference is a must in developing vegetable production technology to suit the humid tropical environment. A systematic collection and characterization of the available vegetable wealth of the state in terms of yield, quality and resistance to biotic and abiotic stresses should be considered with priority so as to restrict the cultivation of varieties released for other states. Vegetable cultivation in the areas viz., rice fallow, coconut interspaces, river beds, and coastal sandy belts etc can be considered as the ad-hoc steps to increase the area under vegetable crops. The concept of 'nutrition garden' or 'kitchen garden' has got relevance not only in the homesteads but also among the housewives of the urban areas.

Table 1. List of vegetable varieties recommended for cultivation in Kerala

Name of Vegetable	Varieties
Bittergourd	Preethi, Priyanka, Priya
Snakegourd	Kaumudi, TA 19
Melons	Mudicode local, Saubhaghya
Ashgourd	Local
Cucumber	Sheetal, Poinsette
Pumpkins	Ambili
Watermelon	Sugar Baby, Arka Jyothy
Ridgegourd	Pusa Nasdar, Co 2
Cowpea	Sharika, Malika, Vaijayanthi
Chilli	Jwalamukhi, Jwalamukhi, Ujwala
Brinjal	Surya, Swetha, Neelima
Tomato	Sakthi, Mukthi
Okra	Arka Anamika, Arka Abhay, Kiran
Amarantus	Arun, Kannara local
Winged bean	Revathy
Dolichos bean	Pusa Early Prolific, Arka Vijay

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Tuber production : Problems and prospects

Dr. S. Edison

Tropical root crops are regarded as the third most important food item of human beings, the first two being cereals and legumes. They are estimated to meet the calorific requirements of about 500 million people of the tropics. Owing to the preponderance in the global area and production, cassava and sweet potato are the most important among tuber crops. Tubers of cassava and sweet potato find application in the food, feed and industrial sectors. Cassava is produced mainly from Africa, Asia and South America, while sweet potato production is confined mainly to China, Japan, Vietnam, Indonesia and India. Other tuber crops like yams and aroids are considered as vegetable crops only and their industrial potential remains to be exploited. In addition to the tuber crops which find application as food or feed source, there are also a number of minor tuber crops many of which possess medicinal and pharmaceutical applications.

Generally, tuber crops have wide agro-ecological adaptability and tolerance to biotic and abiotic stresses. Nevertheless, they are labour-intensive crops and 30-64% of the total production cost of various tuber crops is accounted for by the labour cost alone. This is one of the factors contributing to the shrinkage in the area of cultivation especially in states like Kerala. Among other factors are a well-organized public distribution system for rice and wheat, increased purchasing power of the people of Kerala due to influx of gulf money, rapid change in the life style and replacement of the area under tuber crops by more cash earning crops like spices or rubber.

A change from the present paradigm is possible only though creating an awareness about the vast utilization potential of tuber crops. An organized marketing system for tuber crops is also necessary to ensure remunerative and assured prices to tuber crop farmers. In order to sustain the tuber crops like cassava and sweet potato in the agricultural system of Kerala, some of the vital issues related to production and utilization have to be addressed. Realizing the challenges ahead, CTCRI has developed several production and utilization technologies for tuber crops. These technologies are popularized though several extension activities like the Lab to Land, Institution Village Linkage Programme, training programmes, exhibitions, etc.

Production constraints for tuber crops

Cassava is cultivated in India in about 13 states with major production from Tamil Nadu and Kerala. Whilst cassava is mostly cultivated as a rainfed crop in Kerala with a productivity of 18.73 t/ha, it is an irrigated crop in Tamil Nadu, with a productivity of 33.7 t/ha. The high productivity of cassava in Tamil Nadu could be achieved mainly through the introduction of the two high yielding cassava varieties, H *165* and H 226, released by CTCRI in 1971 coupled with the efficient management of the crop though irrigation. Despite the high productivity, there are several specific production constraints for cassava which include the low multiplication rate, high bulk of planting material needed, rapid drying of stakes and high susceptibility to cassava mosaic disease (CMD) and scale insects. Whilst one hectare of rice and corn can generate seeds for 1600 ha, one hectare of cassava can generate stakes for only 10 ha. One of the emerging trends to overcome the low multiplication rate in cassava is the true cassava seed programme (TCSP). The programme, initiated in India, a decade ago has several advantages viz., the propagation rate is enhanced by 150 times, the propagating material (seed) has longer viability than stakes and possibility of containing cassava mosaic disease is more as TCS is not known to transmit CMD. The biggest advantage of TCSP is that it can substantially reduce the quantity of planting material needed; 1.5 kg of cassava TCS is only needed for planting one ha of land while 1000 kg stakes are needed for the same area. TCSP offers scope as one of the rapid techniques to spread cassava cultivation in poverty-stricken areas of India eg. Bihar.

Cassava mosaic disease, though not a devastating disease from the point of view of yield reduction, is gradually reaching alarming proportions in Kerala and Tamil Nadu. Integrated management strategies are needed to contain the disease. These include production of disease free planting material through meristem culture, multiplication of sett material in vector free zones, periodical review to eradicate fresh infection, mass scale multiplication of healthy stakes with participation of farmers etc. Studies conducted at CTCRI have indicated some resistance in the crosses between *Manihot esculenta* and *M caerulescence*. These are being further studied by the grafting technique.

Simultaneously, attempts are also made to characterize the virus and develop anti-serum and finally transfer genes that can impart resistance to CMD. The poor post harvest life of cassava, lack of awareness about low cost appropriate technologies and extension support are specific utilization constraints for cassava.

Cassava is a major industrial crop of Tamil Nadu and is fetching importance in the adjoining State of Andhra Pradesh as well. There are a number of problems faced by the starch sago industrialists of Tamil Nadu like the poor shelf life of tubers, non-availability of tubers round the year, poor performance of age-old equipment that need to be modernized with more efficient machines, high labour involvement in the peeling operation, effective disposal of the toxic effluents discharged by the factories, etc. These are being tackled through research interventions wherever needed. Two imminent problems faced by the traditional starch sago manufacturers of Tamil Nadu are the disposal of the primary and secondary effluents and the quality assurance of the starch sago produced by them. In this context, CTCRI has developed a low cost effluent treatment system which is being tested at the starch factories at Salem.

As different from cassava, inconsistency in tuberisation and seasonal instability in yield are major production constraints for sweet potato. Lack of weevil resistant lines and non-availability of planting material of high yielding varieties are complementary constraints. Among the tuber crops, sweet potato is the most amenable and can be moulded to a number of food products that can be made on a home level or cottage level. However, creating awareness about such potentials is a major task in the successful dissemination of research know-how.

The dioceous nature of plant and non-synchronization in flowering are major production constraints for yams. Presence of acridity in several accessions and erratic flowering behaviour are stumbling blocks in the improvement of aroids. Appropriate technologies to enhance the utilization potential are also lacking in these crops.

Prospects for tuber crops

Improved production technologies

The CTCRI has a rich collection of germplasm of all tuber crops which has provided the base material for the development of several improved cultivars. Twenty nine new varieties of tuber crops have been released from the Institute, comprising 9 in cassava, 8 in sweet potato, 3 each in greater yam and white yam, 2 each in lesser yam and taro and one each in elephant foot yam and chinese potato. The recently released short duration varieties, Sree Jaya and Sree Vijaya are ideal for planting in paddy (fallow) fields. Sweet potato varieties, Sree Nandini, Sree Vardhini and Sree Bhadra with high yield and quality are ideal for north Kerala. Sree Dhanya, is a highly promising dwarf yam which eliminates the cost of staking, due to the non-climbing nature. Sree Shilpa, is the first hybrid in greater yam with high yield. Sree Padma is a newly released variety of elephant foot yam with a yield potential of 41 t/ha.

Integrated production systems have been evolved for all the major tuber crops at CTCRI. These include intercropping, multiple cropping and sequential cropping. Profitable legumes that can be intercropped with cassava include groundnut, french bean and vegetable cow pea. Soil loss and run off in cassava fields can be effectively controlled by growing multiple crops like banana and coconut. Yam and elephant foot yam are ideal as intercrops in banana fields. Two-thirds the fertilizer dose can be saved by growing elephant foot yam as an intercrop in coconut garden. Organic manuring using coir pith compost, press mud, mushroom spent compost, etc., mycorrhizal inoculation to enhance phosphorus uptake in tuber crops and *in situ* green manuring with cowpea are emerging management strategies.

The major pests of tuber crops are spider mites, white flies and scale insects on cassava, weevil on sweet potato, defoliators, aphids and mites on taro, scales and mealy bugs on yams and elephant foot yam. Crop rotation studies in the management of sweet potato weevil have shown that paddy - sweet potato - cowpea can minimize weevil damage. A very effective IPM package using synthetic sex pheromone as the major component has also been evolved at CTCRI for the control of sweet potato weevil. A recent finding at CTCRI that boehmeryl acetate, a pheromone present in the periderm of sweet potato can attract both male and female sweet potato weevil offers immense scope in its control. Nematode, which is a major pest of yams and chinese potato, can be controlled by growing sweet potato variety, Sree Bhadra, in between the crops.

Phytophthora leaf blight tolerant varieties of taro Jhankri and Muktakeshi, identified at CTCRI Regional Centre, Bhubaneswar, have scope for improving taro cultivation. Integrated disease management strategy for three diseases of elephant foot yam include use of virus free seed material, mulching with paddy straw/polythene sheets to reduce collar rot and foliar sprays with Mancozeb (0.2%) and monocrotophos (0.05%) at 90 and 120 days after planting.

Utilization technologies

Tuber crops offer immense scope as food, feed and industrial raw material. A wide variety of instant and ready-to-eat food products viz., cassava rava & porridge, sweet potato energy drink, sweet potato jam, pickle and sauce, etc. can be prepared from cassava and sweet potato which can enhance market appeal for tuber crop products. Likewise, there are several food products like cutlets, puffs and samosas, etc., where tuber crops can be substituted for potato. Industrial technologies enhancing the utilization potential include alcohol from cassava, gums, dextrins, cold water soluble starch, etc. Cassava ensuing technology developed at CTCRI is expected to become popular as an *in situ* utilization technique as cattle feed. Besides, byproduct utilization of cassava fibrous waste (thippi) as broiler feed can help to combat the problem of disposal of the solid waste at Salem & nearby districts. Of late, the biodegradable plastics developed at CTCRI from cassava starch have received wide scale media attention, due to its ability to reduce the pollution load from plastics.

Extension activities to enhance the prospects of tuber crops cultivation

Creating awareness about the prospects of tuber crops production and utilization is essential to raise the status of these crops and to sustain them in the cropping system of marginal farmers. CTCRI has organized several outreach programmes like Lab to Land, Institution Village Linkage Programme and On-Farm Trials. Tuber crop technologies are also popularized among tribal farmers by conducting On-Farm Trials of cassava, sweet potato and yam varieties in tribal settlements. Popularization of tuber crop varieties is also done through multi location trials conducted at the District Agricultural Farms through the cooperation of the Department of Agriculture, Government of Kerala.

Expansion of cassava cultivation to non-traditional areas is a major mandate of CTCRI during IX Plan. As a part of this, a technology upgradation programme called 'PROJECT UPTECH' has been launched in Andhra Pradesh in collaboration with State Bank of India. Under this programme, technical expertise will be provided to modernize the starch factories, to instal low cost effluent treatment systems etc. Farmers' Day and exhibitions organized from time to time also help in the effective dissemination of the tuber crop technologies.

Export Promotional Research

This is almost a neglected area of tuber crops research in India. Market survey and assessment of export prospects/demand are planned to promote the utilization avenues for tuber crops.

Perspective planning for future

CTCRI has developed a number of production technologies that can fit into the existing cropping system. Several programmes have been planned for the next two decades which are certain to expand the production and utilization of tuber crops in India. Some of these include expansion of cultivation to non-traditional areas, development of CMD resistant varieties through gene transfer and other means, integrated management strategies to enhance production, compatible and profitable cropping systems for tuber crops, diversification for value addition and export promotion research. These approaches are expected to create a proper arena for tuber crops development in the coming decades.

Cashew plantation - establishment and management

Dr. M. Abdul Salam

INTRODUCTION

Cashew (*Anacardium occideniale* L., Family, *Anacardiaceae*) is one of the most important commercial crops of our country, that has not received the required attention so far. It continues to be a neglected crop for years, primarily due to lack of awareness regarding its economic, ecologic and biological potential. The internal production of raw cashew nuts meets only about a third of the requirements of the processing industry. On an average, India produces 4,17,830 t of raw cashew nuts per annum. The present level of productivity of cashew is extremely low (658 kg/ha all India). To enhance the production and productivity of cashew it is necessary to encourage establishment and management of commercial plantations. Attempts are meagre to establish cashew plantations in a scientific manner.

Plantation management in cashew is an area that has not received attention so far. In this paper, an attempt is made to compile the critical inputs, operations, technologies and management strategies that are essential for the successful establishment and maintenance of commercial cashew plantations so that it may help the cashew planters at large to gain more productivity and income from this crop.

A. CRITICAL DECISIONS IN PLANTATION MANAGEMENT

a. Site selection-climatic factors

Selection of suitable sites considering its agronomic, climatic and ecologic requirements is very important in the success of commercial plantations. Performance of cashew is much affected by the climate and soil. Therefore, while going for commercial plantations, site selection is to be done very carefully giving due consideration to the optimum soil and climatic requirements of this crop. The important climatic factors that are to be considered are listed below.

1. Altitude

Performance of cashew is generally good upto an altitude of 450 metres and satisfactory upto an altitude of 700 metres from MSL. Therefore sites at altitudes above 700 m are to be avoided for commercial cultivation of cashew

2. Temperature

Cashew is able to bear seasonal and daily changes in temperature to a greater extent. Areas receiving extremely low (less than 18°C) and high temperatures (more than 40°C) for prolonged periods are also less suitable. (Prasada Rao and Gopakumar, 1994).

3. Humidity

In areas with less than 60% relative humidity, the performance of cashew will be low.

4. Rainfall

An average annual rainfall of 1300-2000 mm is necessary for rainfed cashew culture. In areas with less rainfall cashew requires irrigation to obtain good performance.

5. Water-logging and drought

Cashew is Sensitive to water logging and tolerant to soil moisture stress to a greater extent. Areas prone for water logging may be avoided for commercial plantations.

b) Site selection - soil factors

1. Texture of soil

Cashew grows in almost all types of soils. However, it performs well in well drained red sandy loams and light coastal sands. Heavy clay soils and poor drainage conditions are unsuitable for cashew. Sites prone to excessive alkalinity and salinity are to be avoided.

2. Soil pH

Soils with pH more than 8 are not suitable for commercial cashew plantations.

c) Variety selection - a crucial decision

Successful Cashew cultivation depends up on the selection of the best varieties suited for the agro-climatic condition and adoption of right package of practices recommended for the region. Varietal selection is the most critical decision in plantation management. The crop improvement work done in India under the ICAR and at the various State Agricultural Universities led to the development 30 high yielding varieties of cashew suitable for different regions.

B. CRITICAL INPUTS IN CASHEW PLANTATIONS

1. Planting material

Planting material is one of the critical inputs in cashew cultivation. Soft wood grafts are the best planting materials in cashew.

2. Nitrogen

Among the fertilizer nutrients, nitrogen is the one to which cashew responds to the most universally. Beena *et al.* (1995)[b] quantified the annual offtake of major and micro nutrients through harvested dry matter (apple, kernel and shell). While harvesting a kg of nut, the tree looses through apple and nut 64.1 g N, 2.05 g P, 24.7 g K, 4.19 g Ca, 1.57 g S, 525.7 mg Fe, 63.6 mg Mn, 87.8 mg Zn and 26.5 mg Cu. This means that a tree yielding on an average 10 kg nut removes 641 g of N, 20.5 g P and 247 g K. Considering 50% efficiency of the applied nutrients, double the quantity of removal is to be applied. These results indicate that a productivity based nutrition strategy would be more rational than a uniform dose disregarding the productivity of trees.

Potassium comes second in order. Generally cashew is shy towards phosphorous in terms of response. Therefore it is essential to apply sufficient quantities of N and K to cashew depending on the age of crop and the fertility status of the soil. To balance the nutrition phosphorous and other micro nutrients may also be applied at recommended quantities.

3. Water

Irrigation water is a critical input capable of increasing cashew yields considerably. It has been realised that cashew yields can be doubled by applying irrigation water during summer months.

C. CRITICAL MANAGEMENT PRACTICES IN CASHEW

1. Season and method of planting

The season of planting is veiny important for the establishment of a good plantation. In Kerala, the best planting season is June-July or September-October, coinciding with the monsoons. Planting is done in pits (60 cm cube), filled with top soil and organic manure (5-10 kg) to 3/4 of the pit capacity. The grafts are planted after carefully removing the polythene bag. Care should be taken to see that the graft union is at least 2.5 cm above the ground level.

2. Pit size

Pit size influences considerably the growth of the grafts. The generally recommended pit size is around 60 cm x 60 cm x 60 cm. Enhanced growth and performance were observed with plants grown in larger pits (size 90 cm x 90 cm x 90 cm or more)

3. Planting density

Planting density differ within the agro-climate, soil nutrient status and level of management adopted. Selection of an optimum population is an important decision making in the success of commercial plantations. For this purpose, an assessment of the soil fertility evaluation and a decision regarding the type of agriculture to be followed (rainfed/irrigated) are necessary. The normal spacing recommended for cashew for Kerala is 7.5 m x 7.5 m (177 plants in square system of planting and 204 plants in triangular system of planting) for poor and 10 m x 10 m (100 plants in square system of planting and 116 plants in triangular system of planting) for rich and deep soils and sandy coastal areas (KAU, 1993).

4. High density planting

High density planting is a technique capable of enhancing the productivity of cashew plantations to a greater extent. This involves planting of more number of grafts per unit area initially and thinning out at later stages. Instead of 177 plants per hectare (spacing 7.5 m x 7.5 m) 312 to 625 plants are planted per hectare (spacing of 4 m x 4 m or 8 m x 4 m or 7 m x 4 m). Considering the soil fertility status, climate, and the level of management in terms of fertilization, irrigation etc. the initial plant population is to be decided carefully, for every agroclimatic environment. During later years, as the canopy develops, plant population is to be regulated by selective felling in order to minimise competition so that there will be 625 or 312 plants initially. This population can be retained for a period of seven to nine or ten years depending upon the canopy expansion rate. High density planting technique would be more useful in poor soils where the rate of canopy expansion is slow. When the plants attain full growth, the spacing between the plants can be regulated at 8 m x 8 m or 7 m x 8 m.

Uniform management practices must be adopted to all the plants. During early years, the per tree nut yield will be more or less the same with all the trees, irrespective of the density of planting. But the per hectare yield will be more from high density plantations (due to higher plant population. Later, when the plant population of high density plantation is equalised to that of the conventional system of planting, the productivity of both the plantations would be more or less the same. The bonus yield obtained from high density plantations during the early years would be substantial. Large quantities of firewood can also be obtained while cutting excess plants which may fetch additional revenue. The weed growth in the plantation can also be checked effectively to a greater extent.

At CRS, Madakkathara, the total yield obtained from a high density plantation (312 trees per hectare 8 m x 4 m) for a period of five years (5th to 9th year) was the highest (5874 kg/hectare). The yield level obtained from the spacings of 8 m x 4 in (312 plants/hectare) and 4 m x 4 m (625 trees / hectare) were on par. The productivity of cashew was the lowest with the conventional spacing of 8 m x 8 m (156 trees/hectare).

5. Chemical weed control

Weeds are one of the most important pests of cashew plantations. Considerable expenditure is required to keep the plantation weed free. Effective chemical weed control methods are available for cashew plantations (Abdul Salam et *al.*, 1993). Depending upon the type of weeds and intensity of weed growth, weeding is to be done during June-July and September-October, either chemically or manually. Application of Paraquat @ 0.4 kg/ha twice at bi-monthly intervals starting from July will effectively control all types of weeds. Application of Glyphosate @ 0.8 kg/ha, in June-July can also control the weeds effectively (Abdul Salam *et al.*, 1993).

Chemical weed control is economical than manual weed control, especially in areas where the labour wages are high . Application of Paraquat twice costs Rs. 1600/- per hectare (@ 0.4 kg ai per hectare per weeding i.e., 2 litres of Paraquat per hectare, @ Rs. 250 per litre, 500 litre of water per hectare, five men per hectare for spraying, wage Rs. 60 per day) whereas manual weed control twice costs Rs. 3000 per hectare (@ 25 women per hectare per weeding, labour wages @ Rs. 60 per day).

6. Time and method of fertilization

It is generally recommended that fertilizers are to be applied twice a year, coinciding with the Southwest monsoon and Northeast monsoon. About 72% of the total active roots of cashew reside within an area of 2 m radius around the tree (Wahid *et al.* 1993). These results suggested that in shallow lateritic soil, surface broadcasting of fertilizers within an area of 2 m radius around the tree would result in the most effective utilization of applied nutrients. Fertilizer recommendations are available for cashew for different states. The root activity of cashew in relation to four phenological phases was studied by Beena *et al.*, (1995)[a] employing ^{32}P soil injection technique. Highest root activity and peak absorption of N, P and K were observed during the "flushing and early flowering phase" which extended from September to December. It is suggested that the onset of this phase is the most appropriate time for fertilizer application in cashew orchard. Instead of applying fertilizers twice a year the frequency can be restricted to once an year coinciding with 'flushing and early flowering phase", which may enable to save the application cost to some extent.

7. Method of irrigation

Drip irrigation is the most common method that is being followed. Recently flow-tech irrigation, an improved method over drip irrigation is being adopted. Application of water @ 200 litres/tree, once in a fortnight, is recommended by National Research Centre for Cashew, for increasing cashew yield (Bhaskara Rao *et al.*, 1994)

8. Fertigation

Fertigation (combined application of irrigation water and fertilizers) is another management practice which can save water as well as nutrients to a greater extent. While adopting irrigation in cashew plantations care should be taken to see that irrigation is cut during the nut development period in order to suppress the vegetative growth amid to enhance nut maturity.

9. Intercropping

Cashew seedlings or grafts are normally planted at a spacing of 7.5 m x 7.5 m. The wider interspace available in between trees offer opportunities for raising other crops, as a source of additional income to the growers. During first year, about 90% of the area is available for intereropping whereas during second and third years 80 and 70 percentage of the plantation is available for intercropping. During these years a systematic inter cropping system involving compatible crops having varying micrphological frame and rooting habits will be desirable. Biennial Horticultural crops like pineapple and papaya and annual food crops like cowpea and tapioca, are suitable inter crops in cashew (Mandal, 1992). One advantage of inter cropping with annual crops is that it keeps the ground free of weeds and thus reduces the cost of weeding. While selecting intercrops care should be taken to avoid competing perennials. In moisture stressed areas under rainfed agriculture intercropping may depress the growth of cashew.

10. Harvesting and drying

For getting a better crop harvesting is to be done at the right time and the nuts are to be dried properly and stored well. Unripe fruits should not be harvested. The ripened fruits will fall down which can be collected manually. The nuts can be extracted from the apple, dried in sun (to a moisture level less than 8 per cent) for about two days and stored temporarily till marketing. While drying nuts frequent turning of nuts in the drying floor is necessary to ensure uniform drying of the kernel, to maintain the quality.

D. CRITICAL OPERATIONS

1. Removal of polytapes from time graft joint

Removal of polytape present in the graft joint is essential lest, it may cause girdling and breakage of the plants at the graft joint. About 90% of the grafts were lost by breakage at the graft joint from a farmer's field in Tamil Nadu due to failure in removal of the polytape from the graft joint.

2. Staking

Staking is an important operation especially in wind prone areas. About 40% loss of planted grafts were noted when grafts were left unstaked.

3. Mulching

Mulching at the plant base with organic waste results considerable improvement in plant growth. This is mainly due to the conservation of soil moisture, prevention of weed growth in the plant base, maintenance of soil temperature, activation of soil microflora and addition of mineral nutrients and organic matter through the mulch materials applied.

4. Trenching

Digging trenches at the centre of four plants, especially in plantations of sloppy lands helps considerably to conserve soil and water and to enhance the plant growth. This is very useful in rainfed agriculture where availability of rainfall is less. The pits act as a sink to collect run off water and soil which enable to maintain soil health. The sub soils of such plantations will have more soil moisture especially during summer months which helps to enhance plant growth.

5. Pruning

Pruning is an important practice in cashew. Pruning facilitates proper light penetration and helps in production of vigorous productive laterals to enhance nut production.

6. Control of tea mosquito

Among the major pests of cashew, tea mosquito is considered to be most notorious. Effective methods of tea mosquito control have been developed for different states. It was reported that spraying against tea mosquito results yield increase ranging from 59 to 80% compared to the unsprayed control, in different states (Mandal, 1992). The young plantations (1 to 3 years) are more susceptible to tea mosquito damage, and therefore they are to be sprayed regularly. Studies conducted by Mini Abraham (1994) revealed that spray applied nutrient absorption was the highest through the lower side of the younger leaves suggesting that the spray solutions may be directed accordingly to obtain high efficiency. For spraying it is essential to obtain chemicals which are not expired. Application of right quantity of spray solution in right concentration at right time adopting an insecticide rotation, is important.

E. ECONOMICS OF CASHEW CULTIVATION

1. Cost of establishment of a cashew plantation

Based on current prices, time cost of establishment of one hectare of cashew (200 trees) during first year is Rs. 14819. Its maintenance cost is Rs. 9318 during second year, Rs. 11187 during 3rd year, Rs. 12118 during 4th year, Rs. 13549 during 5th year, Rs. 14980 during 6th year, Rs. 16411 during the 7th year and Rs. 17042 from 8th year onwards.

The costs of manuring of cashew per tree is worked out to be Rs. 12.89 during 1st year, Rs. 17.78 during 2nd year and Rs. 22.82 from the 3rd year onwards. The plant protection cost per tree is worked out to be Rs. 5.21 during the 1st year, Rs. 10.41 during the 2nd year, Rs. 15.62 during the 3rd year, Rs. 18.77 during the 4th year, Rs. 21.93 during the 5th year, Rs. 25.08 during the sixth year, Rs. 28.24 during the 7th year and Rs. 31.39 from the 8th year onwards.

2. Input requirements of cashew

Based on the recommendations of the Kerala

Agricultural University the input requirement per hectare of cashew plantation during the first year, 200 cashew grafts, 200 bamboo baskets, 4000 kg of organic manure, 108 kg of urea, 134 kg of mussoriphosphate, 99 kg of muriate of potash, 300 ml of Endosulfan, 400 gram of Ekalux, 400 gram of Carbaryl and 5 kg of Sevidol are required. This requirement increases with age.

3. Input cost of cashew

During first year an amount of Rs. 4411 is required for purchasing grafts, Rs. 1000 for purchasing basket, Rs. 1280 to purchase organic manure, 366 to purchase urea, 268 to purchase mussoriphosphate, 149 to purchase muriate of potash, Rs. 69 to purchase Endosulfan, Rs. 104 to purchase Ekalux, Rs. 98 to purchase Carbaryl and Rs. 250 to purchase Sevidol. In total an amount of Rs. 7984 is required towards input cost during the first year. This requirement increases with age.

4. Labour requirement

For one hectare of cashew during first year it requires 21 labourers for land clearing, 17 labourers for pit making, 7 labourers for planting, 6 labourers for organic manuring, 3 labourers for fertilizer application, 9 labourers for pest control, 50 labourers for weed control and 3 labourers for pruning. In total it requires 114 labourers to complete the work of the first year. This requirement of labour decreases during the 2nd year and increases thereafter, with the commencement of harvest.

5. Labour distribution

During the first year, labour required is maximum during May-June, August to October and December for various operations. In an adult plantation peak requirement of labour is during June, September-October, and December to April.

6. Yield expected and net income

On an average a nut yield of 100, 400, 800, 1200 and 1600 kg of nuts per hectare is expected during the 3rd, 4th, 5th, 6th and 7th year respectively. Thereafter a minimum yield of 1600 kg nuts per hectare is expected in all the years. A net income of Rs. 52.26, Rs. 105.1, Rs. 158, and Rs. 154.8 per tree is expected during 4th, 5th, 6th and 7th year respectively. From the 8th year onwards a net income of Rs. 154.8 per tree is expected.

7. Cost of production per kg of nut

The cost of production per kg of nut is estimated to be Rs. 30.29 during 4th year, Rs. 16.94 during 5th year, Rs. 12.48 during 6th year, Rs. 10.26 during 7th year and Rs. 10.65 from the 8th year onwards.

F. ECONOMIC ANALYSIS OF A PROJECT FOR THE ESTABLISHMENT AND MAINTENANCE OF 100 HECTARES OF CASHEW PLANTATION

The economic viability of a project for the establishment and maintenance of 100 hectares of cashew plantation is prepared following the techniques suggested by Pitale (1987). The Benefit-Cost Ratio (B-C ratio) and Internal Rate of Returns were worked out based on the following assumptions.

1. The cashew plantation is raised and maintained scientifically as recommended by the Kerala Agricultural University
2. Cashew grafts are purchased at the rate of Rs. 20/- per graft and Rs. 2/- per graft is provided for transportation, loading and unloading.
3. Provision is made for 10% gap filling during second year.
4. High yielding varieties recommended by the university is cultivated (October 96).
5. The cost of cultivation is estimated based on the prices of October 1996, for inputs (fertilizers, pesticides, organic manure etc.)
6. The wage of labourer is assumed as Rs. 60/- per day.
7. The crop is raised rainfed.
8. The price of raw cashew nut is assumed as Rs. 30/- per kg
9. Inflation rate both for cost of cultivation and price of raw cashew nut is assumed at the rate of 6%.
10. The project is implemented in own lands.
11. The project is financed by borrowed funds at an interest of 18%
12. The crop has a gestation period of two years and the crop starts yielding from the third year onwards.
13. All the investments are incurred at the beginning of the year.
14. Discounting factors is assumed as 18%.
15. The economic life span of cashew is assumed as 20 years.
16. The yield level assumed is around 50 per cent of the yield realised in the research station under rainfed conditions.
17. The residual value of cashew tree is calculated assuming a current price of Rs. 200 per tree with an annual inflation @ 6% per annum.

1. Non recurring expenses

Non recurring expenses to the tune of Rs. 10 lakhs is provided to meet the cost involved in hand development, purchase of tools, implements etc. (@2 Rs. 10000 per hectare).

2. Recurring expenses

In addition to the cost of cultivation provision is made for meeting the pay of staff (Rs. 3 lakhs per year with an annual inflation @ 10% to meet the salary of three farm managers (a) Rs. 2500 per month, six field assistants @ Rs. 1500 per month and six watchmen @ Rs. 1200 per month and to meet the TA and DA) and office expenses (@ 0.3 lakh per year, with an annual inflation @ 10%.

3. Cash flow

The details of the cash flow, showing the non-recurring and recurring costs involved in the establishment and maintenance of 100 hectares of cashew. During the first year, an amount of Rs. 14.82 lakhs is required for the establishment of 100 hectares of cashew, purely for cultivation purposes. For a period of 20 years, the cost involved for the establishment and maintenance of 100 hectares of cashew is estimated to be Rs. 596 lakhs, considering an annual inflation in costs @ 6%.

The total Non-Recurring Costs (NRC) of the project is worked out to be Rs. 10 lakhs. The Net Present Value (NPV) of NR investments at 18% discount rate is estimated to be Rs. 8.48 lakhs. The total receipts during the project period (20 years) is Rs. 1648 lakhs leaving a net profit of Rs. 867.4 lakhs. The NPV of the net receipts is Rs. 107 lakhs.

a) Benefit cost ratio

The benefit cost ratio of the project is arrived as a ratio of the NPV of net receipts (Rs. 107 lakhs) to the NPV of non-recurring investments (Rs. 8.48 lakhs) and it was estimated to be 12.61. The benefit cost ratio indicate that the investor can expect Rs 12.61 per every Rupee invested, suggesting that the project is economically viable.

b) Benefit cost ratio-capitalised

In order to test the tolerance of the project, the total investment (recurring and non recurring) upto the end of fourth year, were capitalised at 18% interest and its NPV worked out (Rs. 38.82 lakhs). The BC ratio capitalised was them worked out as the ratio of NPV of net receipts (107) to the NPV of capitalised investments upto time end of 4th year, (38.82) and it was estimated to be 2.76.

c) Internal Rate of Returns (IRR)

Aim attempt was also made to estimate the internal rate of returns of the project following the procedure described by Pitale (1987). The IRR of the project was estimated to be 37.27%. This means that the earning power of the investments of the project is @ 37.27% annually.

The price level assumed for time cashew nut is quite realistic (Rs. 30/kg) and less than time current market prices. The price trend of cashew in time past decade show a steady increase and the same can be expected in future also. On an average there was about 15 per cent annual increase in price during the past five years. In the present project, an annual price increase of only 6% was considered for calculating time economics. The cost escalation was also assumed at 6% annually. The yield level assumed is also reasonable. As such, the estimates are realistic and modest and profits are attainable. The data on B/C ratio (both non-capitalised and capitalised) and IRR gives clear indications that the project is economically viable.

d) Sensitivity analysis

Any agricultural enterprise would be liable to uncertainties, mainly due to the involvement of unpredictable weather conditions. As such there is possibility of yield reductions mainly due to aberrant weather conditions. Moreover, price fluctuations of products may also cause concern. To assess this sensitivity of the project in terms of its economic viability, a sensitivity analysis was done assuming 4 levels of yield reductions (10%, 20%, 30% and 40% yield reductions compared to the yield assumed for calculating the economics).

The BC ratio decreased from 12.61 to 9.67 when 10% yield reduction was assumed from the normal. The BC ratio further decreased to 7.42, 6.19 and 4.05 when yield reductions were assumed in the order of 20%. 30% and 40% respectively, from the normal. The sensitivity analysis gives clear indication that this project can tolerate natural calamities and possible yield reductions to the extent of 40% from time normal. Thus the economic potential of the project in terms of risk tolerance is well indicated.

e) Summary of expenses and receipts

The abstract of the cash flow statement is given below

1. Total cost of establishment and maintenance of 100 hectares of cashew for 20 years (RC) = Rs. 596 lakhs

Table 1. High yielding varieties of cashew released by different state Agricultural Universities / ICAR and their yield potential (kg / tree)

Varieties released by Kerala Agricultural University	
Anakkayam-1 (BLA 139-1)	12.1
Madakkathara-1 (BLA 39-4)	13.0
Madakkathara-2 (NDR 2-1)	17.0
Kanaka (HI 598)	12.8
Dhana (HI 1608)	10.Z.
Priyanka (H 1591)	16.9
H-3-17 (Dhanasree)	18.6
K-10-2 (Sulabha)	21.6
Varieties released by Tamil Nadu Agricultural Univesity	
Vrindhachalam-1	7.1
Vrindhachalam-2	8.1
Vrindhachalam-3	14.2
Andhra Pradesh	
BPP-1 (H 2/11)	17.0
BPP-2 (H 2/12)	19.0
BPP-3 (3 / 3 Sch)	16.0
BPP-4 (9 / 8 EPM)	13.0
BPP-8 (Hybrid 2 / 16)	21.5
Karnataka	
Ullal-1 (8/46)	19.0
Ullal-2 (3/67)	18.0
Ullal-3 37 (Hajjery-Kerala)	15.0
Chinthamani-1 (B/46)	7.2
NRCC-Selection-1	10.0
NRCC-Selection-2	9.0
Orissa	
BHB-1 (WBDC-V)	16.0
West Bengal	
Jhargram-1 (BLA-39-4)	10.0
Maharashtra	
V-1 (Ansur-1)	23.0
V-2 (WBDC-VI)	24.0
V-3 (Ansore-1 x Vetore-56)	14.0
V-4 (Midnapore Red x Vetore-56)	14.0
V-5 (Ansur early x Mysore Kotekar)	21.0
V-6 (Vetore-56 x Ansur-1)	16.0

2. Total receipts from 100 hectares for 20 years = Rs. 16.48 lakhs

3. Total Net receipts from 100 hectares for 20 years = Rs. 867.4 lakhs

4. NPV. of NR investments with 18% discount = Rs. 8.48 lakhs

5. Net Present Value of the net receipts = Rs. 107 lakhs

6. B-C ratio = Rs. 107 / 8.48 = 12.61 lakhs

7. The NPV of total capitalised investment upto the end of the fourth year (beginning of yield) = Rs. 38.83 lakhs

8. B-C Ratio based on capitalised investment upto the end of the 4th year (beginning of yield) = Rs. 107/ 38.83 = 2.76

9. IRR = Rs. 32.27 %

Conclusions

Scientific establishment and management of cashew plantations involves certain vital decisions and skilful integration of efficient management strategies. In this paper an attempt has been made to identify the critical decisions, involved in selection of plantation sites, critical inputs, operations and management practices involved in the scientific establishment and management of cashew plantations . The cost of establishment and maintenance of cashew over years, and the economics of scientific cashew cultivation are also worked out and analysed. The input requirement, the input cost, the labour requirement and distribution for one hectare of cashew plantation are estimated and presented. The expected yield and net income from cashew plantations are also worked out. The economic analysis of a project for the establishment and maintenance of 100 ha of cashew plantation is also presented. The B-C ratio (12.61) and Internal Rate of Returns (37.27%) from cashew plantations suggest that it is an economically very viable venture. The sensitivity analysis gives clear indications that projects on cashew plantation can tolerate natural calamities and possible yield reductions to the extent of 40% from the normal. The economic potential and risk tolerance of cashew plantations are well indicated.

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Modern crop production techniques for fruit crops

Dr. C.S. Jayachandran Nair

By the turn of this century, world population is estimated to touch 6.2 billion. In order to meet the demand for food, current agriculture production is to be enhanced by 40 per cent. A corresponding increase in production of fruits is expected since they are sources of protective principles for maintenance of good health. Development of modern technologies for increasing production and productivity is therefore the need of the hour. Some of the achievements in these lines are discussed below:

I. Development of varieties for specific situations

Crop improvement is one of the identified tools to enhance production and productivity. In recent years, remarkable achievements have been made in the development of varieties of fruit crops for meeting specific problems. Some of the achievements are high lighted in Table 1.

Table 1. Improved varieties of fruit crops

Variety	Improved characters
MANGO	
Varieties from IARI	
Amrapali	Dushehari x Neelum. Dwarf, regular, suited for close planting (1600 trees/ha)
Mallika	Neelum x Dushehari. Regular, good quality
Varieties from IIHR	
Arka Aruna	Banganapally x Alphonso. Regular, dwarf, suited for close planting, free from spongy tissue
Arka puneet	Alphonso x Banganapally. Regular, prolific, free from spongy tissue
Arka Anmol	Alphonso x Janardhan Pasand. Regular, free from spongy tissue, suitable for export
Arka Neelkiran	Alphonso x Neelum. Regular, suited for close planting
varieties from TNAU	
PKM-1	Chinnasuvarnarekha x Neelum. Regular, cluster bearing
PKM-2	Neelum x Mulgoa. Very sweet, fibreless
Paiyur-1	Selection from Neelum. Dwarf, suited for close planting (400 trees/ha)
Varieties from FRS, Vengurla	
Ratna	Neelum x Alphonso. Regular, precious, attractive colour and quality, free from spongy tissue
Sindhu	Neelum x Alphonso. 'Seedless', free from spongy tissue
Varieties from FRS, Sangareddy	
Manjira	Rumani x Neelum. Regular, precocious, high yield, dwarf
Au Rumani	Rumani x Neelum. Regular, prolific
Varieties from FRS, Pariya, Gujarat	
Neelphonso	Neelum x Alphonso. Dwarf, superior quality
Neelshan	Neelum x Baneshan
Neeleshwari	Neelum x Dushehari
variety from Parbhani	
Niranjan	Regular, off-seasonbearing
GUAVA	
Varieties from IIHR	
Safed Jam	Allahabad safeda x Kohir. Large fruits, few soft seeds

Kohir safeda	Kohir x Allahabad safeda Large fruits, white fresh, few soft seeds, high yield, suited for semi-arid tropics
Arka Mridula	Seedless x Allahabad safeda High yield, white flesh, few soft seeds, good keeping quality

SAPOTA

Varieties from TNAU

CO-1	Cricket Ball x Oval. Large fruit, granular pulp, few seeds
CO-2	Selection from baramasi. Soft and juicy pulp, high yield
PKM-1	Selection from Guthi. Dwarf, high yield, buttery pulp
PKM-2	Guthi x Kirthi Bharti. High yield, large fruits
PKM-3	Guthi x Cricket Ball. Upright growth, suited for high density planting, large fruits, cluster bearing

Varieties from UAS, Dharwad

DHS-1	Kalipatti x Cricket Ball High yield, granular and mellowy pulp with orange colour
DHS-2	Kalipatti x Cricket Ball High yield, orange brown pulp, granular and mellowy

POMEGRANATE

Jyothi	From UAS, GKVK. Large fruit, deep red aril, soft seeds.
Ruby	From IIHR. Medium to large sized fruit, Dark red aril, soft seeds, high TSS
Mridula	From MPKV, Rahuri. Large fruit, blood red aril, soft seeds, high TSS
P-23	From MPKV, Rahuri. Large fruit, light pink aril, medium soft seeds.
P-26	From MPKV, Rahuri. Large fruit, light pink aril, soft seeds.
CO-1	From TNAU, Soft seed, good yield
Yercaud-1	Easily peelable rind, soft seed deep purple aril

PAPAYA

Varieties from TNAU

CO-1	Selection from Ranchi. Free from papain odour
CO-2	Dual purpose variety. Good for papain production
CO-3	CO-2 x Sunrise Solo. Gynodioecious, high sugar content.
CO-4	CO-1 x Washington. Suited for home garden
CO-5	Selection from Washington. Good Papain yield
CO-6	Selection from Pusa Majesty. Dwarf, high yield, dual purpose variety.

Varieties from FRS, Pusa, Bihar

Pusa Delicious	Gynodioeceous. High yield
Pusa Majesty	Gynodioeceous. Low bearing, high yield, good keeping quality
Pusa Giant	Suitable for vegetable purpose and canning
Pusa Dwarf	Dwarf, low bearing, suited for high density planting and home garden
Pusa Nanha	Dwarf, low bearing, tolerant to water logging, suited for high density planting.

Variety from IIHR

Surya	Sunrise solo x Pink Flesh Sweet. Gynodioeceous, good yield quality

BANANA

Dessert varieties

Nendran	Dual purpose variety. Suited for making chips and banana flour. Commercial variety of Kerala

Njalipoovan	Suited for homestead cultivation, intercropping in coconut garden
Mysore (Palayankodan)	Suited for rainfed cultivation and semi-perennial system. Resistant to panama wilt.
Karpooravally	Heavy yield, tolerant to bunchy top
Robusta	Suited for intercropping in coconut garden and ratooning and high density planting. Resistant to panama wilt.
Dwarf cavendish	Dwarf, good yield and quality
Gold Finger	Resistant to burrowing nematode, some races of fusarium, black sigatoka. Fruits ripen slowly
Grand Nain	Less duration than other cavendish varieties, medium tall, high yield, good quality.

Culinary varieties

Monthan, Chetty, Peyan, Batheesa, Razavazhai, Kanchikela (tolerant to bunchy top)

PINEAPPLE

Kew	For large scale commercial cultivation suited for processing
Queen	Good fruit qualities suited for dessert purpose
Mauritius	For general cultivation. Good yield and quality

II. Leaf analysis for nutrient management

Leaf analysis technique has emerged as one of the most efficient method for monitoring the nutrient requirement, especially of the perennial crops. The technique is based on the logic that within certain limits, there is positive relation among the dose of nutrient applied, leaf content of the nutrient yield and quality. The time of sampling, sample tissue etc. have been standardised in major fruit crops. These details are furnished in Table 2.

Table 2. Tissue sampling techniques in fruit crops

Crop	Index tissue	Stage of sampling	Type of tissue for sampling
Grapes	Petiole	Bud differentiation	Fifth petiols from base for yield
		Bloom	Petiole opposite to bloom for quarter
Banana	Middle portion of lamina	Bud differentiation	Third open leaf from apex
Ber	Leaf	Two months after pruning	Sixth leaf from the apex of secondary or tertiary
Acid lime	Leaf	June	3-5 months old leaf from new flush. First leaf of the shoot
Papaya	Petiole	6 months after planting	Sixth petiole from apex
Sapota	Leaf	September	Tenth leaf from apex
Pomegranate	Leaf	Bud differentiation In April for February crop In August for June crop	Tenth leaf from apex

III. High density orcharding

The method consists of planting size controlled plants in higher population per unit area, diverting energy to the eonomic parts.

The advantages are

- Better utilization of solar radiation interception
- Increase in fruit bearing area
- Decrease in distance of translocation
- Increase in productivity
- Early returns
- Easiness in cultural operations
- Less injury in harvest
- Better quality of produce
- Possibility of mechanisation

Practices followed :

1. Pruning
2. Use of dwarf root stocks

Crop	Rootstock
Apple	EMA, P-series
Sweet cherry	Mahaleb Cherry
Plum	St. Julian, Pixy
Pear	Quinee
Citrus	Flying Dragon
Mango (Alphonso)	Vellaikolamban

3. Use of chemicals — Alar, CCC, PBZ
4. Development of dwarf varieties
5. Other methods — Bark inversion, double grafting, interstocks, root pruning

Modern systems of high density planting :

1. Medium high density planting
   500 to 1500 plants/ha
2. Optimum high density planting
   1500 to 10,000 plants/ha
3. Ultra high density planting
   (Meadow orcharding)
   20,000 to 1 lakh plants/ha

Performance of fruits in high density planting

Crop	Plant/ha	Yield (t/ha)	Varieties	Rootstocks
Mango	1600		Amrapali	
Apple	2222	68	Jonathan	MM106
Sweet cherry	1250	10	Regina	GM-61
Pear	2500	33	Contessa-de-Paris	Quinee
Peach	1110	35	Yanco Queen	
Orange	2020	40	Valencia	Rubidous
Banana	4444	120	Robusta	
Pineapple	63,300	60	Kew	
Papaya	4262	146	Coorg Honey dew	

IV. Use of root stocks for specific situations

Root stock studies in fruit crops have lead to development of stocks for tackling various crop growing situations. Some of the results are highlighted in table 3.

Table 3. Use of rootstocks in important fruit crops

Problem	Important rootstocks
Grapes	
Phylloxera	*Vitis aestivalis, V.riperia, V.rupestris*
Nematode	*V. rotundifolia, V. longi, V. candicons*
Salinity	Dogridge, Salt Creck, No.1613
Citrus	
Salt and Cold tolerance	Cleopatra mandarin for sweet orange
Tristeza, light sandy soil	Rough lemon for mandarins, lime, sweet orange and grape fruit
Heavy soil, cold tolerance	Sour orange for sweet orange, grape fruit and mandarins
Cold tolerance, tristeza	Trifoliate orange for grape fruit, sweet orange
Seab, tristeza	Sweet orange for lemon, grape fruit
Mango	
Dwarfing	Totapuri red small, Vallaikolamban
Semi dwarfing	Neelum, Bombay Green
Apple	
Dwarf trees	M-9, M-8, M-26
Dwarfing interstock	M-7, M-8, M-9
Resistance to wooly aphis	Northern spy, Merton-778

V. Use of growth regulators

Growth regulators are effectively utilized in fruit plants for various manipulations. Some of the important uses of growth regulators are furnished in Table 4.

Table 4. Use of growth regulators in fruit crops

Purpose	Growth regulator used
Rooting of cuttings	IBA 2500 ppm in softwood cuttings of guava
	IBA 5000 ppm in lanolin - Juvenile cuttings of mango
	IBA 5000 ppm for 10-20 seconds in semi hard wood cuttings of pomegranate
	IBA 2500 ppm for 15 seconds in hardwood cuttings of grapes
Rooting of layers	IBA 1000 ppm in bread fruit and guava
	IBA + NAA 10,000 to 15,000 ppm in equal concentration
	IBA 10,000 ppm in mango
	IBA 5000 ppm for pomegranate
	IBA + NAA 3 to 5 per cent in lanolin for branches of papaya
Induction of flowering	25 ppm ethepon, 2 per cent ureá and 0.04 per cent calcium carbonate in pineapple
	200 ppm ethephon and 0.1 per cent urea in 5 sprays from mid September at monthly intervals for mango
Increase of fruit size	Dipping of bunches in 60 ppm GA for 10 seconds in grapes
	Spraying 2,4-D 15 ppm at flowering in valeneia orange
	NAA 10 ppm in Apple

Control of fruit drop	NAA 10-30 ppm second week after fruitset in mango	
	GA 10-15 ppm in mandarins	
	GA 10 ppm in sweet oranges	
Improvement of quality	50 ppm GA on panicles 5-6 days after blooming in grapes decrease shot berry formation	
	15 ppm GA at full bloom decrease bunch compactness in grapes	
	2500 ppm ethrel on bunch at colour breaking stage helps in uniform ripening of grape bunches	
	100 ppm GA enhances storage life of pineapple	
	GA 100 ppm on bud decrease seed content and improve quality of guava	

V. Biotechnology in fruit crops

Plant biotechnology is a potential tool for faster development of fruit growing industry through production of novel cultivars by genetic engineering and development of newer crop production technologies.

The main objectives are :

- Production of new strains of plants
- Rapid propagation of plant materials
- More efficient and selective plant protection chemicals and improved fertilizers
- Cloning technology for improvement of resistance to adverse situations.

The various applications of biotechnology in fruit crops include tissue culture, genetic engineering, molecular biology and microbial exploitation.

A. Tissue Culture

The current and future application of tissue culture are the following.

Applied technology

Micro propagation, virus elimination, embryo rescue, haploid production, germ plasma storage and transport, production of secondary metabolities, somatic embryogenesis and ploidy manipulations.

Developing technologies

Modification by soma clonal variation, protoplast fusion for gene transfer and gene introduction by agrobacterium and other means.

Micro propagation

Rapid clonal propagation is now possible in banana, sweet orange, grapes, dates, papaya, pineapple, pear, strawberry, avocado etc.

Virus elimination

Virus and systemic diseases often do not penetrate the extreme shoot tip. Virus free plants can be obtained using these tissues as explants. Works in these lines are in progress in banana, citrus etc.

Embryo rescue

Barriers like embryo abortion in distant crosses can be broken by culturing embryos. In crops like papaya, grapes, mango (crosses of mulgoa and neelum) this is being tried.

Haploid production

Haploid plants can be produced from anthers, immature pollen grains, isolated ovules etc. This is achieved in about 50 species of plants including fruits like papaya, lime, banana, custard apple and cape gooseberry.

Similarly triploids can be developed by endosperm culture (endosperm develops through fusion of one male and two haploid female nucleii) in fruits like citrus, apple and peach.

Germplasm storage and exchange

In vitro storage of germplasm in banana, grapes, papaya at -190°C could be done. Germplasm transportation and exchange is easy and more successful in this way. Short to medium term storage techniques have been developed in grapes and strawberry.

Modification of soma clonal variation

Tissue culture regeneration through callus culture, cell culture, protoplast culture etc. can bring out minor or major changes in plant phenotypes. This is called soma clonal variation. Variations can be induced *in vitro* by using mutagens. These variations can have utility in crop improvement.

Modification by protoplast fusion - To break the crossability barriers, protoplast of one species may be fused with other species. This allows mixing of nuclear and cytoplasmic genetic traits. Disease resistant root stocks of citrus have been developed by this technique.

Gene introduction

Transfer of desirable genes to cells using agrobacterium and other agents helps in transfer of specific trait.

B. Genetic engineering

Genetic diversity can be increased by DNA transfer from one cell to the other. The strategies involved as agrobacterium mediated transfer and direct gene transfer. There are 50 species in which gene transfer was successful. This includes fruits like citrus, strawberry, grapes, papaya, apple, pear, kiwi fruit, cramberry etc. This technology was useful in developing resistance to diseases (potato virus X and Y, *Pseudomonas* sp., *Rhizoctoni* sp.) and pests (Lepidoptera, Coleoptera).

Engineered herbicide resistance helps safe use of herbicides with less harm to the crops.

Research works to impact resistance to heat, cold, salt, heavy metals etc. on tobacco and Brassica are in progress.

Improvement of storage, cooking and nutritional qualities of fruits in another field worth mentioning. Bruise resistant and slow ripening tomato, production of waxins and albumin in potato and banana etc. are some of the achievements.

C. Molecular biology

The available techniques are molecular diagnostics, DNA cloning, *in vitro* translation, gene screening, iso enzyme finger printing etc. Molecular diagnostics is useful in early detection in viral infection and iso enzyme finger printing is systematics (Apple, raspberry).

D. Microbial exploitation

This field has practical utility in production biofertilizers, bio insecticides etc.

Future strategy for forage production in India

Dr. G. Raghavan Pillai

Forages are the mainstay of animal production. India has the largest cattle population in the world of about 15% of world's livestock population with only 2% of the world's geographical area. The main concern in developing dairy industry in India is to feed the high milk yielding animals economically on herbage based ration. As a result of continuing degradation of the forests and grasslands, dry fodder production in the form of grass is expected to decrease further. The opportunity of increasing dry fodder production from agricultural area is also limited. Hence it is important to put enough emphasis on alternative resources for forages from degraded waste lands.

For economic milk production availability of good quality forage in adequate quantity is a must. The availability of forage in sufficient quantity is assured through intensive forage production systems. These production technologies give high yields. Also these measures will maintain the flow of green fodders round the year, enhance the utilization of land resources and ensure efficient recycling of crop - livestock wastes.

Carbohydrates, Protein, fat, minerals and fibre are the important constituents present in feeds and after digestion become available to the animal's body building and production processes. These are called total digestible nutrients. Protein occupies the prime position among them. The average major nutrient contents in feedstuffs can be as shown below:

Feed stuffs	Digestible protein	Digestible nutrients
Fodder grasses	1-2%	13-14%
Fodder legumes	8-10%	50-60%
Concentrate cattle feeds	14-16%	65-70%

Low productivity of livestock in the country is mainly due to poor fodder and feed resources. The animal pressure on limited land resources is tremendous. Nutritious, balanced and adequate feeding of animals is a major limiting factor in realising increased livestock production. Some of the major feed resources are cultivated fodders, grazing from grasslands, and crop residues. The cattle in intensively cultivated areas obtain only 25% of their feed from grazing in woodlands and uncultivated areas. The balance comes from crop residues unsuitable for human consumption. Roughages, hay, stover and silage are unsuitable for human consumption. These non edible materials are converted by animals into high value products of human food and other use.

The livestock population in the country has been projected as 420 million heads. Density of livestock population varies from 0.22 per capita in Kerala to 0.5 in Gujarat and Tamil Nadu, 0.54 in West Bengal, 0.64 in Karnataka, 1.16 in Himachal Pradesh and to 1.44 in Rajasthan. This indicates a relative pressure in different areas. An estimated requirement of fodder till 2000 AD is given in the table below.

Projected Fodder Requirement in India

Year	Estimated Fooder requirement (million tonnes)		Total Fodder on dry basis (million tonnes)
	Dry fodder	Green fodder	
1985	780	932	1013
1990	832	992	1080
1995	890	1064	1155
2000	949	1136	1233

(Source : C.R. Hazra)

This indicates an overall availability of forage of only 60% of the requirement.

It is further reported that the area under cultivated fodder crops in the country is 8.3 m.ha which produces 319 million tonnes of green fodder. Sorghum, berseem, lucerene, Hybrid napier, guinea and para grass are the major cultivated crops. The gap between the demand and supply will increase still further if adequate steps are not taken immediately. Even for meeting the projected green fodder requirement (1136 mt) by the turn of the century, about 10% of the cultivated area (14 m.ha) needs to be diverted for fodder cultivation which itself is a difficult task to achieve. However the productivity of forages could be substantially increased by adopting suitable fodder production technology.

The area and productivity of some of the important fodder crops in the country are given below.

Forage crops grown in India with area and productivity

	Name		Botanical name	Area 000 ha	Green fodder yield T/ha
1.	Berseem	(Egyptian clover)	Trifolium alexandrinum	1900	60-110
2.	Lucerne	(Alfa alfa)	Medicago sativa	1000	60-130
3.	Cowpea	(Lobia)	Vigna unguiculata	300	25-45
4.	Guar	(Cluster bean)	Cyamopsis tetragonaloba	200	15-30
5.	Oats	(Jaie)	Avena sativa	100	35-50
6.	Sorghum	(Chari)	Sorghum bicolor	2600	35-70
7.	Bajra	(Pearl millet)	Pennisetum typhoides	900	20-35
8.	Maize	(Makka)	Zea mays	900	30-55
9.	Napier	(Elephant grass)	Pennisetum purpureum	100	70-100
10.	Guinea grass		Panicum maximum	100	100-190
11.	Para grass	(Angola grass)	Brachiaria mutica	100	100-190
12.	Anjan grass	(Buffel grass)	Cenchrus ciliaris	200	15-40
13.	Sewan grass	Lasiurus hirsutus	100	7-25	
14.	Sudan grass		Sorghum sudanense	100	50-80

(Source : C.R. Hazra)

Appropriate production technologies for intensive fodder production round the year have been developed to suit each locations

Improved crop culture

A large number of fodder crops varieties are available now to suit the different agroecological and farming situations. Choice of the crops and varieties are more important for obtaining high quality forage with high yield.

Food-fodder chain

Technology have been developed for suitable crop re-orientation. This integration depends on soil and climatic conditions and the cropping pattern of the region

eg. 1. Maize + Cowpea — Bajra + Cowpea — Maize

2. Hybrid Napier + Cowpea — Hybrid Napier + Cowpea — Hybrid Napier + Cowpea

Forages from existing cropping systems

Inclusion of forage crops also in the existing cropping system is very relevant especially when land space is not available for forage sole cropping. Forage catch cropping is practiced in rice cropped area with cowpea, stylosanthes humilis, pillipesara, sunhump, moth etc. with residual moisture after rice harvest. Intercropping of maize, sorghum etc. with crops like cowpea and guar is also to be popularised.

Forages from degraded grasslands

India has about 12 m. ha under permanent pastures, 15.45 ha under cultivable wastelands and 22.8 m ha under fallow lands offering varied degrees of grazing resources. It is necessary to rejuvenate these grazing areas especially permanent pastures and forest grazing lands for their enhanced productivity. Application of improved production technology through vegetation of trees, shrubs, grasses and legumes is to be popularised. Through silvipasture practices the productivity of these lands can be improved 4.5 folds and crude protein yield by 9 times.

Non-conventional forage resources

In our country the highest number of crossbred cattle are reported to be maintained in Kerala. But the progress achieved in feed and fodder development is not much appreciable. During scarce period several nutritious non conventional materials are available for cattle feeding.

Forages from agroforestry production system

Agroforestry aims at integration of woody species with agricultural crops, pasture grasses and legumes in the same piece of land. This will conserve and improve the productivity of the site and optimise the combined production. The influence of tree species on grasses are well marked.

Several trees grown in homesteads are also utilized for feeding. The miracle tree, viz, Subabul (*Leucaena leucocephalla*) is recognised as the number one fodder-cum-green manure cum-fuel-cum-timber tree. It contains 15.5% Digestible protein and 54% TDN. The tender stems and leaves of Mulberry are excellent feeds. The energy supplied from this is very efficient. Another nitrogen fixing tree Vaka - which supplies apart from protein, about 2.57% calcium and 0.15% phosphorus. The leaves and other parts of many such plants are excellent cattle feeds.

Forages from forests

The area under forests in the country accounts for about 40% of the total area. The degradation of forests has resulted in the total destruction of vegetation under the forest floor. Or it is composed of shrubs unsuitable for forage purpose. A concerted effort is needed to revegetate such areas. Dinanath grass (*Pennisetum pedicellatum*) and Stylosanthes gracilis in open forests and newly cleared forests are suitable.

Forage production in problem soils

In India the possibility of extension of area under fodder crops is limited. The problem soils accounts for 25 m. ha in the country which can be exploited for fodder production. The productivity of crops depend upon the relative tolerance to soil salinity and alkalinity. Several crops are identified for their suitability in saline and sodic conditions.

Use of biofertilizers

Microbial activities stimulate nutrient mobilization in soil thereby enhancing their absorption by plants. 14 to 50% yield increase has been reported in the case of legumes such as Lucerune, Berseem, Cowpea, Guar etc. due to Rhizobium inoculation. Non, symbiotic nutrient fixers like Azospirillum and Azotobactor have increased yields from 14 to 30% in Maize, Sorghum, Bajra etc.

Forage seed production

One of the factors limiting the popularisation of fodder crops is the availability of quality seeds at the appropriate time. The forage seeds production needs to be thoroughly augmented. Areas suited for forage production may not be ideal for the seed production due to its climatic or other reasons. Hence suitable locations for each crop and variety need to be identified for seed production. Forage seed testing laboratories are to be established and modern scientific techniques are to be followed in seed production.

Research options

a. Application of biotechnology for Resistance breeding in forages

Improvement of prominent conventional forages using modern approaches of plant improvement will be taken up Resistance breeding for abiotic and biotic stresses whereby crops and varieties suitable for specific situations will be evolved and used.

b. Forage genetic resources

Introduction, collection, augmentation, documentation and diversification of forage germ plasm and conservation will be done.

c. Forage crops protection

Integrated disease and pest management will be practiced. Identification and use of bio-pesticides in forage farming to be popularised.

d. Forage production system

A system approach is to be developed. Forage based cropping systems using multicut and dual purpose (food-fodder) forage crops are to be developed. eg. Silvipasture and agroforestry systems.

e. Forage quality

Characterization of forage quality, Establishment of quality indicators, utilization of roughages and residues.

Technology transfer

Technology of forage production adoptable to different locations are available in research stations. Extension of these techniques to needy farmers is very urgent in the ensuing periods. Awareness is to be created on the importance of forage cropping and production. All the available media can be utilized for this. Demonstrations, trainings, visits and seminars need be undertaken for the benefit of extension workers as well as dairy farmers.

Modern crop production techniques for sugarcane

Dr. A. Alexander

Sugar is a universal sweetening agent and sugarcane is a primary age old source of it. It is a very important industrial crop accounting for about sixty per cent of sugar production in the world. In India, it is considered as a safer cash crop under the climate vagaries that form a peculiar feature of Indian Agriculture. Sugarcane cultivated in 38 lakh ha in India and the cane production comes to 2493 lakh tones. Of the total cane produced. 45 per cent cane is used for the manufacture of white sugar while 43 per cent is used for jaggery making. For the use of set as a feed and chewing purpose, 11 per cent of the cane produced is used. The by products of sugarcane ie., bagasse, molasses and press mud are also used for different useful purposes.

In Kerala, Sugarcane cultivation is confined to four districts, ie., Palakkad, Idukki, Pathanamthitta and Alleppey. At present sugarcane occupies above 4500 ha in Kerala. While the cane produced in Palakkad area is used mainly for sugar production, the cane produced in the other districts are exclusively used for jaggery making.

Sugarcane is a hot sunny weather loving crop cultivated in 35 N and S latitude and upto a elevation of 1650 m. It is an excellent solar energy utilizing plant. At peak period of growth, 5 t ha^{-1} day^{-1} of dry matter per ha per day is produced. The potential of the crop is 475 t ha^{-1} millable cane in the tropics. The sugar formed in the leaves are stored in the parenchymatous cells of the stalk. Cooler and drier climate following growth cessation encourage sugar accumulation.

Normally sugarcane grows to a height of 3-3.5 m with an internodal length of 10-20 cm and 25-35 internodes with 2.5 cm diameter are formed. On an average, 2-4 internodes per month. The stalk contains 8-14 per cent fibre and 10-17 per cent sugar. The millable cane, the economical part of sugarcane consists of 55 per cent of ground shoot.

Because of the versatile nature of the crop there is no substitute crop to replace sugarcane where it is now cultivated. Even in waterlogged fields and droughty condition sugarcane survives because of its hardy nature. Scope of using sugarcane in companion cropping, its ratooning ability, possibility of organic recycling, scope as a source of fodder and the profitability make a versatile crop. The wide fluctuation in the price of jaggery and scarcity of labour are the major problems affecting the area under sugarcane.

Though the potential of the crop is 475 t ha^{-1} the average yield of the cane in the state is only 71 t ha^{-1} due to a variety of reasons. The production potential can be significantly improved by adopting modern crop production techniques and improved varieties of sugarcane.

Time of planting

When sugarcane planting is taken up during June and October in Palakkad area, December-January is the best planting time in south. A delay in planting by one month from January 15th in the south cause a reduction of 21 per cent in cane yield. The delay also affects the millable cane count and quality of cane.

Plant density and method of planting

Pit method of planting is practiced in certain areas while ridges and furrows taken at 90 cm apart are practiced in other area. When the ridges and furrow method accommodate 45000 three budded setts/ha, pit method cannot accommodate such a population. As a result millable cane count and the yields are low in areas where pit method of planting is followed. Adoption of ridges and furrow method of planting in the planes and gap filling in the plant and ratoon crop are necessary to have a desired millable cane count of 1.25 lakh/ha.

Organic recycling and integrated use of nutrients

Nearly 12 t ha^{-1} of dry leaves are added, in a sugarcane field apart from the contribution of roots and stubbles. Instead of burning the trashes it should be recycle to enrich the organic matter status of the soil.

Sugarcane crops yielding 120 t ha^{-1} removes 83 kg of N, 37 kg of P_2O_5 and 168 kg of K_2O/ha. In the absence of a soil test data a general recommendation of 165:82.5:82.5 kg, P_2O_5 and K_2O is recommended in the south. In the field balanced application of nutrients is seldom done. The time of application of the nutrients is also important. Use of press mud @ 4t/ha as well as trash mulching @ 5 t/ha can reduce the fertilizer dose by 25 per cent.

Weeding

Weeds are a problem till 45th day after planting. Pre emergent application of Atrazine followed by 2,4-D or pre-emergent application of Goal will effectively check the weeds and reduce the cost of production.

Irrigation

Sugarcane spents 50 per cent of its growth period during the summer month. Due to lack of irrigation, growth and yield is affected. Studies have revealed that irrigation at fortnightly interval during summer month can increase the cane yield by 27 t/ha.

Detrashing and earthing up

Lodging of cane offset vertical growth and stimulate nodal growth. When partial lodging reduce the cane yield by 13.5 per cent complete lodging can bring 32 per cent reduction. Lodging also reduce the sugar yield from 14 to 43 per cent. Timely earthing up and detrashing will prevent such losses.

Timely harvest and speedy processing

A midlate variety comes to maturity by 11th month after planting. When field brix is 18 or more the cane is considered to be mature. Delay in harvest will result in the reduction of sucrose per cent and will increase the pith content.

The cane harvested should be processed with in 24 hours after harvest. Delay in crushing by one day will result in a reduction of 0.6 per cent of sugar and 2 per cent of juice. Purity also is reduced by 3 to 5 per cent for each days delay.

Ratooning in sugarcane

After the harvest of the plant, crop buds on the left over stubbles germinate to give another crop. In India ratoon crop occupies 40 to 70 per cent of the cropped area under sugarcane. Profitability and higher yield / unit area / unit time encourage farmers to raise more number of ratoon crop from the same field. Though farmers raise more than 4 ratoons only 2 ratoons are scientifically recommended.

Ratoon decline

When more number of ratoons are raised reduction in cane yield is a common phenomenon. This is one of the reasons for the low average yield of sugarcane. Nutrient depletion in the root zone, soil acidity, accumulated disease intensity, varietal reaction and degeneration of clumps are the reasons for the yield reduction in ratoon crop. Adoption of gap filling, proper manuring, proper irrigation and timely harvest can improve the cane yield and sugar recovery of ratoon crop.

Modern crop production techniques of rubber

Dr. K. I. Punnoose

Rubber *(Hevea brasiliensis)* is the most important commercial source of natural rubber. Traditionally rubber is cultivated in Kerala and parts of Tamil Nadu and Karnataka. Later, its cultivation was extended to Andaman Nicober Islands, Maharashtra, Orissa, West Bengal and North Eastern States. In India, rubber is cultivated in about 5.33 lakh ha.

Important rubber cultivars

The important cultivars now cultivated in India are RRII 105, RRIM-600, GTI, PB *28/59,* PB217, PB 235 etc. Of these, RRII 105, a clone evolved by the Rubber Research Institute of India enjoys maximum popularity among cultivators due to its outstanding yield potential. Extensive contiguous belts of this clone have come up during the last two decades with a near total predominance of this clone in the rubber plantations in India. In order to avoid the potential risks involved in such monoclone culture, it is now recommended that in place of the single clone RRII 105, as many clones as practicable out of a select list of desirable clones should be planted.

Propagation and planting

Seedling stumps, budded stumps, advanced planting materials like stomped budding. and polybag plants can be used for planting. Seeds collected are germinated in germination beds and are planted in nursery. Nurseries are established for raising seedling stumps, budded stumps, polybag plants, stumped budding and soil core plants. Mother plants or source bushes for the multiplication of budwood are also grown in nurseries. Germinated seeds are planted in the beds prepared in the nursery when the young root is less than 2 cm. long. The conimon spacing adopted for raising seedling stumps is 30 x 30 cm. To produce green budded stumps, the spacing adopted is 23 x 23 cm. and for brown budded stumps, the spacing is 30 x 30 cm or 60 x 23 cm. The spacing adopted for bud wood nuriery is 90 x 60 cm or 120 x 60 cm.

Nursery beds should be kept free of weeds. Weeding can be done either manually or using herbicides. Generally three rounds of weeding are needed. First weeding is done just before application of the first dose of ferilizers and the second weeding before the second dose. Third round of weeding is done just before commencement of budding. Application of pre-emergent herbicide, Diuron @2 a.i kg per ha in 700 l of water-after preparing the nursery beds will control the weeds till the first round of frtilizer application.

Before the beginning of the summer season, ie., after the second round of fertilizer application nursery beds should be mulched with dried plant materials to retain soil moisture and to reduce weed growth. During the summer season, nursery should be irrigated. In large nurseries, sprinkler irrigation is found to be ideal. Manual watering is convenient and cheap for small nurseries.

Generally, the nutrient requirement of a nursery is 500, 250 and 100 kg per ha for N, P_2O_5 and K_2O respectively. Application of Magnesium @ 37.5 kg per ha is necessary when the soil is deficient in Magnesium. Preferably, manuring should be carried out after ascertaining the specific requirements of individual nurseries by soil analysis. Seedlings raised in nurseries are used as stock plants for green budding at 4 to *5* month's stage or brown budding at 8 to 10 month's stage.

Polybag nursery

Polybagged plants are advanced planting materials which contribute to reduction in immaturity period. They can be transplanted to the main field at 2 to 3 leaf whorl stage or 6 to 7 leaf whorl stage.

Green budded stumps are planted in black polyethylene bags of size 55 x 25 cm or *65* x 35 cm and are allowed to grow to the required size. Powdered rock phosphate @25 g for small bags and 75 g for large bags is mixed with the top layer of soil, at the time of filling the bag. NPK Mg mixture (10:10:4:1.5) is applied at the rate of l0 g during the first month and gradually increased to 30 g in four months. Irrigation, weeding, partial shading and plant protection measures should be adopted in the polybag nurseries.

Planting

The best season for planting in India is June-July. The spacing adopted on slopy land is 6.7 x 3.4 m (445 plants per hectare) and on level lands is 4.9 x 4.9 m

(420 plants per hectare). The pit size recommended for planting rubber is 75 cm^3. Pits should be refilled before the onset of the monsoon season and refilling should be done with fertile top soil as far as possible.

Cover cropping

Covercrops should be established in the interspaces of planting strips along with planting rubber. Leguminous creepers are usually grown as cover crops m rubber plantations. The common cover crop. grown in rubber plantations are *Pueraria phaseoloides, Mucuna bracteata, Calapagonium mucunoides, Centrosema pubescens* and *Mimosa invisa* var. *inermis.*

Soil conservation

On sloping and undulating lands, rubber is planted on terraces which are cut along the contour. These terraces will have a width of 1.25 to 1.50m and an inward drop of 20 to 30cm. Terraces will reduce the length of slope and reduce velocity of rim off and soil erosion. Silt pits are also taken in between planting lines to reduce erosion and conserve water. Trenches of about 120 cm length, 45 cm width and 60 cm depth are taken along the contours at suitable intervals depending on the degree of slope. About 100 to 150 pits are desirable for a hectare of plantation. Construction of stone pitched retaining walls (edakayyala) is another effective method of soil conservation especially when the slope is very steep. Contour terraces and edakayyala should be periodically repaired.

Growing of leguminous covercrops in the interspaces of planting strips will conserve soil and water to a great extent. Covercrops cover the ground completely and reduce the beating action of the falling raindrops. They will reduce the velocity of run off and act as a hindrance to the flow of water. Moreover, they add large quantity of organic matter to soil improving soil structure and thus reducing erosion. Adequate drainage should be provided for proper aeration and root development.

Rubber growing soils

The soils in rubber growing tracts are highly weathered and consists mostly of laterite and lateritic type. Red and alluvial soils are also seen in some areas. The laterite and lateritic soils are found to be very porous, well drained, moderate to highly acidic, deficient in available P and variable with regard to available potassium and magnesium. The average annual rainfall in the rubber growing tracts varies from about 2000 to 4500 mm.

Fertiliser requirement

Response of rubber to nutrition is influenced by the nutrient supplying capacity of the soil, clonal variation, stage of growth, intensity of exploitation and ground cover management Optimum growth and yield of rubber can be achieved through adequate supply of nutrients as well as maintenance of proper balance among the nutrients.

Discriminatory fertilizer usage

Manuring after assessing the nutritional requirements of plant is referred to as discriminatory fertilizer usage. This is accomplished by considering the soil/leaf analysis data and case history of the area represented by the sample.

DRIS

For further improvement of the foliar diagnosis, the Diagnosis and Recommendation Integrated System (DRIS) approach developed by Beaufils (1973) is being attempted. DRIS is a comprehensive system which involves calibration of plant tissue composition, environmental parameters and management practices as a fimction of plant performance yield and quality.

In case, the discriminatory approach is not possible, general recommendation can be followed.

Immature phase

The unproductive period of *Hevea* can be reduced at least by one year through proper manuring. The general fertilizer recommendation schedule upto 4th year is as follows.

Incorporation of 12 kg compost or well rotted cattle manure and 175 g rock phosphate in every pit at the time of filling. In the first year, 225g of 10:10:4:1.5 NPK Mg mixture is applied during September-October. From 2nd year onwards, the fertilizers are applied in two equal splits during April-May and September-October, the quantities being 900g of 10:10:4:1.5 NPKMg mixture during 2nd and 4th year and 1100g during third year.

The fertilizer requirement of rubber during the remaining period of immaturity depends on cultivation practices such as mulching and establishment and maintenance of leguminous ground cover. For plantations where no mulching was carried out during initial years and no legume ground covers were maintained, application of 15-10-6 NPK mixture is at the rate of 400 kg/ha in two splits of 200 kg each during the 5th and succeeding years till the plants become ready for tapping.

For areas where the plant bases were mulched during the initial years and where leguminous cover crops were established, discriminatoy fertilizer usage is preferred. When it is not practicable application of 12-12-12 NPK mixture at the rate of 250 kg/ha in two splitsis

Mature phase

Application of 10-10-10 NPK mixture at the rate of 900g per tree (approximately 300 kg per ha) every year during April-May or in two split doses during April-May and September-October is recommended where discriminatory approach is not possible.

Weed management

Rubber plantations in both immature and mature phases are infested by various weed species. The dominant weed species encountered are *Borreria* sp., *Chromolaena odorata, Mikania micranta, Pennisetum* sp., *Panicum repens, Digitaria* sp. etc.

Maintenance of luxuriant ground cover in the early phase can minimise weed infestation to a great extent Weeds can be controlled by adopting either manual methods alone or by the use of chemicals. However, an integrated approach, combining these two methods in an appropriate manner is more desirable.

The common post-emergent herbicides used in rubber plantations are Gramaxone (2.25 l/ha), Fernoxone (1.25 kg/ha) Glyphosate (2 l/ha). For the control of weeds in seedling nursery application of a pre-emergent herbicide Diuron at 2 kg/ha was found to be effective.

Intercropping

Rubber has got a long immaturity period and requires around six to seven years to reach the productive phase. The farmer therefore has to struggle a long period for subsistance without income from his rubber crop. During the initial years of a rubber plantation, the land area is not fully occupied by the rubber plants and inter spaces are available in the plantation. These interspaces can be utilized for growing intercrops which will help the farmer to generate some subsidiary income.

The topography of the rubber plantations vary from level lands to gentle, moderate and steep slopes. The high rainfall in the rubber growing regions and the undulating topography in many situations make the soil vulnerable to erosion hazards. Growing of intercrops necessitates soil disturbing tillage operations of various kinds. This will predispose the top soil to erosion losses in steep and undulating lands. The growing of intererops has, therefore, to be restricted to level lands and gentle slopes. The general practice of growing leguminous ground covers has to be strictly followed in plantations of moderate and steep slopes.

A variety of annual, short duration and long duration crops are suitable for being grown in rubber plantations.

1. Banana

Though many varieties are available, the non-ratoon type viz. nendran variety is ideally suitable for the initial two years. A net profit of Rs.20,000/- per hectare can be obtained in two years. Ratoon types like Palayankodan, and Poovan are also cultivated.

2. Pineapple

This is grown in contour trenches dug along the inter rows of rubber. Fruits will be available upto four years from planting after which the plants will die out due to want of sunlight. A net profit of Rs.35,000/-per hectare can be obtained.

In addition to Banana and pineapple, ginger, turrneric, tuber crops and a variety of vegetables also can be grown with rubber during the initial years of immaturity.

3. Coffee

This can be grown in both young and mature rubber plantations. It has been observed that the yield of coffee in rubber plantations is considerably low compared to pure plantations. However a small subsidiary income can be realised without affecting the growth and yield of rubber.

4. Medicinal plants

Many shade tolerant medicinal plants also can be grown in both young and mature rubber plantations.

When intercrops are grown in rubber plantations, care should be taken to see that each intercrop is separately and adequately manured and that only the optimum plant population is permitted.

Harvesting

Latex is obtained from the bark of the rubber tree by tapping. Tapping is a process of controlled wounding during which thin shavings of bark are removed. Budded plants are regarded as tappable when they attain a girth of 50cm at a height of 125 cm from bud union. The tapping cut should have a slope of about 300 to the horizontal and should be high left to low right Hevea latex contain 30-40 per cent of rubber. Latex is a hydrosol in which the dispersed particles are protected by a complex film. Besides rubber particles, the latex contains certain other particles also namely lutoids and Frey Wyssling particles. Lutoides are associated with the process of latex vessel plugging, which stops the flow of latex a few hours after tapping.

The best yield is obtained by tapping to a depth of less than 1 mm. close to the cambium. It is necessary to commence tapping early in the morning as late tapping will reduce the exudation of latex. Trees are usually tapped using the "Michie Golledge" knife which is well adapted for a high standard of tapping with minimum bark consumption.

In general, budded trees are to be tapped on half spiral alternate daily (s/2 d/2) system and seedlings on half spiral third daily (s/2 d/3) system. But in clones susceptible to tapping panel dryness, it is recommended to adopt d/3 tapping frequency to ward off the incidence.

There are other tapping methods like high level tapping, controlled Upward Tapping (CUT), Puncture tapping etc. done under different situations.

Bark application of Ethephon (a yield stimulant) thrice in a year is recommended for trees tapped on first renewed bark of the second panel.

Processing

The crop harvested from rubber plantations are highly susceptible to bacterial action due to contamination on keeping. Therefore, it is essential to process it into forms that will allow safe storage and marketing.

The important forms in which the crop can be processed and marketed are (1) Sheet rubber (2) Crepe rubber (3) Preserved field latex or latex concentrates and (4) Block rubber or Crumb rubber.

Preserved field latex

Field latex preserved with a suitable preservative is termed as preserved field latex. Ammonia (1%) is the most popular latex preservative.

Latex concentrates

Latex is processed into latex concentrates either by creaming or by centrifuging.

Sheet rubber

Latex is coagulated in suitable containers into thin slabs of coagulum and sheeted through a set of smooth rollers followed by a grooved set and dried to obtain sheet rubber.

Crepe rubber

When coagulated latex or any form of field coagulum is passed several times through a minimum of 3 mills with heavy rolls, a crinky lace-like rubber will be obtained. This lace-like rubber when air dried is crepe rubber.

Diseases and pests

The most important diseases of rubber are abnormal leaf fall, powdery mildews, pink and *Corynespora* leaf spot. Out of these, most destructive one is abnormal leaf fall caused by *Phytophthora* sp. which occurs during the S.W. Monsoon season. Yield loss to the extent of 38 to 56 per cent is reported when the leaves are left unsprayed for one season. For the control of this disease, prophylatic spraying of the foliage prior to the onset of monsoon with Bordeaux mixture or copper oxychloride is recommended.

Powdery mildews caused by *Odium* is predominantly noticed on newly formed tender flush during the refoliation period of January to March. The disease is controlled by dusting 11 to 14 kg *325* mesh fine sulphur/ha at weekly or fortnightly interval.

Pink is a common stem disease caused by *Corticium salmonicolor.* Infection occurs during the S.W. monsoon season. Prophylatic application of Bordeaux paste in susceptible clones is desirable. In the infected plants, the diseased portion is scraped off and Bordeaux paste is applied.

Corynespora leaf spot incidence occurs during November to May period. It is predominantly noticed in nursery. Recently a severe outbreak of this disease was noticed in Nettana area of Karnataka. Repeated spraying with Bordeaux mixture 1% or Dithane (Indofil) M45 0.2% or Bavistin (0.02%) is recommended for the control of this disease.

Other common diseases are secondary leaf fall, Bird's eye spot, patch canker, Brown root disease etc.

Important pests infesting rubber are scale insect, mealy bug, termites, bark feeding caterpillar etc.

Breeding for new hybrids in hightech flower crops

Dr. S. T. Mercy

The global view in agricultural production is changing. Advances in conventional technology will be inadequate to sustain the demands that will be placed on agriculture in the near future. In the case of Kerala, self sufficiency in food is something we can never hope to attain. It is also not necessary in the background of global economy. The World Trade Organisation directs that each country should utilize its capabilities and resources in those fields where it can most efficiently used. So it may be more profitable if, instead of trying to intensify rice cultivation at exorbitant cost, Kerala exploits its excellent climatic conditions to develop those fields of agriculture which are specially suitable to it such as producing high value agriculture products like vegetables, fruits (banana, pineapple and mango) and cut flowers.

Cultivation of flowering plants for using their flowers as economic product is floriculture. The hot and humid agroclimatic conditions of our state have indicated two high value flower crops as most suited for commercial cultivation in Kerala ie., Anthurium and Orchids. These two crops need a high tech approach to their cultivation ie., micropropagation through mericloning for production of plant materials and green house cultivation for producing flowers.

Anthurium and Orchids are highly heterozygous crops so that to maintain the genetic purity of the cultivated varieties, vegetative multiplication is needed. Natural vegetative multiplication through suckers and keikis are slow processes. So tissue culture of apical or leaf meristem, ie., mericloning is resorted to for the production of planting materials in both crops. This makes a large number of genetically uniform plantlets available to growers. Anthurium needs 75 per cent shade while sympodial orchids need 50 per cent shade. Hence these two crops can be cultivated only under artificial shade in agronet shaded green houses. These operations make their cultivation an expensive process but the high returns can more than compensate the high input.

Anthurium

The genus *Anthurium* with about 500 species is a monocot belonging to family Araceae. *A. andreanum* Linden is the most important commercial species and has recently come into economic prominance in Kerala as a cut flower crop. It is a native of Columbia and the warm tropical climate of our state can easily be adapted for its wide spread cultivation.

The Anthurium varieties cultivated locally in Kerala have mostly been derived from Hawaiian varieties brought to Kalympong, West Bengal, a number of years ago and are now known as Kalympong varieties. These are supplemented by new highly improved commercial varieties imported from Netherlands at prices ranging from Rs. 100/- to 150/- per plant. Among the most serious constraints facing the prospective Anthurium growers today are these high price of plantlets and the lack of their availability in sufficiently large numbers. These can be solved if Kerala could develop a vigorous breeding programme to produce our own suitably adapted, novel and quality hybrids which can compete in the international Anthurium markets.

Hybridization is the proven method of Anthurium breeding which is being practiced continuously by the best known Anthurium growing countries of the world like Netherlands, Mauritius, Hawaii, Philippines, Sri Lanka etc. A long term breeding programme is absolutely essential to establish a wide base of new hybrids from which novel elite hybrids could be continuously selected, multiplied and distributed to growers at reasonable prices.

A commercially viable Anthurium plant type must have certain special attributes. The plant must be compact with short internodes and medium sized leaves which help in accommodating more number of plants within a given area. The inflorescence must be straight, strong and long, holding the spadix above the leaf canopy. The spathe should be heart shaped and medium thick with symmetrical halves, overlapping basal lobes and wrinkled. The angle of candle to spathe must be less than 45° which is better for packing the flowers. These characters should be kept in mind, during selection of new hybrids.

Mature plants of 4-5 years old can be used as mother plants for hybridization. As Anthurium is protozygous, no emasculation is necessary. Hand pollination is done by lifting pollen from selected plant functioning as the male and dusting the pollen on the candle of the mother plant in female phase. The fruit which is a berry takes 5-7 months to mature. They should be hand picked and sown immediately on clean wet cotton or sand. After six months growth in the community pot, seedings at four leaf stage can be transplanted to individual thumb pots. Periodical transplanting should be done to larger pots at six months intervals. The hybrid will start flowering in two and a half to three years and floral characters take another year to stabilize. Elite hybrids can be selected at this point. They need agronomic evaluation, registration and naming. Then they should be meridoned, and plantlets hardened before distribution to growers.

Orchids

Orchids are the royalty among ornamental flowering plants and tropical floriculture itself is primarily concerned with these exotic flowers. They belong to the family orchidaceae comprising over 800 genera and 35,000 species. In addition there are over 100,000 man made hybrid varieties grown in the world today. The range of variation in size, shape and colour that exists among orchids in tremendous and the majority of them are distributed in the tropics and sub-tropics.

Orchids are perennial monocots and may be sympodial or monopodial in growth habit. Monopodials have unlimited growth and popular examples are *Arachnis, Vanda, Renanthera, Aerides, Phalaenopsis* etc. Sympodials are of limited growth and widely cultivated sympodials are *Dendrobium, cattleya* and *Oncidium.* Intervarietal, interspecific and intergeneric hybrids of these genera are now cultivated all over the world. Among the monopodials, hybrids such as *Arachnis* Maggie Oei ('spider'), *Vanda* Miss Joachim, *Aranda* christine, *Aranthere* Annie Black and among sympodials *Dendrobium* hybrids such as Sonia, Emma White, Promote, Renapa Red, Nagoya Pink, Sakura, Pratoom Red etc. are suitable for commercial cultivation in Kerala.

The key factors that control successful orchid cultivation are temperature (18° - 30°C), humidity (75 per cent), light (50-25 per cent shade), aeration and watering. Propagation is by culture of apical or leaf meristem.

Hybrid production

Orchid breeding has certain specific breeding objectives such as improved flower size, improved or correct blending of flower colours, increased numbers of flowers per spike, longer flower spikes, correct mode of flower display, longevity of flowers etc. Cross pollination between orchid genera is reasonably easy and this may be because evolution in Orchidaceae was far too rapid for the effective establishment of successful genetic barriers to hybridization. The production of the multigeneric orchid hybrids with two or more orchid genera as their parentage such as *Mokara* (*Arachnis* x *Ascocentrium* x *Vanda*), *Holtumara* (*Arachnis* x *Renanthera* x *Vanda*), *Kagawaara* (*Ascocentrium* x *Renanthera* x *Vanda*), *Laeliocattleya* (*Laelia* x *Cattleya*), *Brassolaeliocattleya* (*Brassavola* x *Laelia* x *Cattleya*), *Miltonida* (*Miltonia* x *Cochlioda*), etc. has vastly broadened the environmental range of orchids.

Cross pollination mechanisms is simple. Usually the middle flowers in a spike selected as female or pod parent and pollination is done after the flowers have been open for a few days. Pollinated flowers are just tagged with light weight labels and never bagged. The pod or capsule ripens in 3-12 months. In orchids the embryo develops only upto the globular stage in the seed and they are non-endospermous. They cannot germinate in nature unless assisted by the action of mycorrhiza. So embryo culture is the usual method of hybrid seed propagation. Protocorms develop within 45 to 90 days and the master flasks are subcultured again and again for thinning the over crowded plantlets till flasks with 8-10 plantlets each are obtained. When plantlets inside the flasks are well grown and rooted, they are deflasked, hardened and planted out in green houses.

Due to heterozygosity of parent varieties, hybrids derived from the same cross are different from each other. Hence each individual hybrid must be raised to flowering and evaluated for the desired objectives before it is selected and developed into a new variety suitable for commercial cultivation.

Conclusion

There is tremendous scope for the export of the exocit flowers in Anthurium and Orchids. Commercial floriculture of these two crops must be urgently developed as a remunerative self employment programme of the educated and unemployed youth and housewives of Kerala.

Agricultural chemicals and soil health

Dr. Thomas George

Soil, probably the most important resource of a countly represents a complex and dynamic system. The cumulative effect of the activities of host resident microorganism, invertebrates and plants contribute to the dynamic role of soil as a living environment and determine the soil health. With the advent of high yielding varieties, pest problems have become more acute, adversely affecting the crop yields. Pesticides are therefore one of the major inputs in the improved technology for improving crop production through crop protection. The chemical control of insects was revolutionised with the discovery of DDT in 1939. Due to its low cost, broad spectrum contact action, high persistence and ease of formulating it, it has become the most widely used insecticide ever manufactured. A major portion of the pesticides used for crop protection finds its way to the soil or aquatic systems. On reaching the soil, pesticide or its degradation product may disrupt the activity of diverse microorganism in the soil and thereby alter its biological equilibrium and may deteriorate soil health. The impact of these process on soil health and fertility is gaining importance as a variety of agrochemicals are readily available belonging to different groups which are applied with more frequency and at heavy doses. The present discussion focusses on the effect of pesticides on some of the major process in soil, soil enzymes and on its transformations.

a. Ammonification

There are various reports available on the adverse and favourable effect of agrochemicals on ammonification. Herbicides like 2,4,5-T, 2,4-D, MCPA simazine and atrazine do not have adverse effect on ammonification, while Amitrole and Pentachlorophenols had adverse effect. Insecticides like Thimet Disyston and Carbofuran had adverse effect on ammonification. Fungicides like benlate,maneb and mancozeb were found to be inhibitory to the process of ammonification.

b. Nitrification

Nitrate ions produced during nitrification is the major source of assimilable N for crop plants. Out of the herbicides carbamate herbicides are more toxic to nitrification than others. Propanil posses inhibitory action than paraquat and was more when the soil PH was below 7. Nitrification was highly inhibited by HCH and carbofuran. Among the fungicides Benomyl was synergistic to nitrification while Thiram was inhibitory.

c. Denitrification

When the Nitrate ions formed in the oxidised upper layers is leached down to lower levels of soil, in oxygen deficient zones, denitrification occurs. 2,4-D and 2,4,5-T stimulated denitrification process. Atrazine and simazine were also stimulatory to denitrification. Propanil and MCPA decreased the population of denitrifiers. Among the insecticides, HCH and chlorpyrifos inhibited denitrification, while carbaryl, carbofuran and malathion had no effect on denitrification. Among the fungicides, Nabam and maneb were powerful inhibitiors of denitrification. Among dialkyl dithiocarbamates, Ferbam is more toxic than thiram and Ziram, to denitrification.

d. N fixation

Among the N-fixers, blue algae are the most important group affected by agrochemicals. Propanil, HCH and 2,4-D decreased the N-content and dry weight of B.G.A. Bipyridilium herbicides and phenolic compounds caused over 75% reduction of N-fixation and N-reductase enzyme activity in Anabaena. Propanil, butachior and bendiocarb inhibited the N-fixing capctiy of *Azolla* sp. while carbofuran @ 2.5 kg ha^{-1} increased the growth and N-fixing capacity in Azolla-Anabaena association. In flooded alluvial soil, lindane stimulated the N-fixation. Carbofuran and benomyl also synergised N-fixation especially by Azospirillum.

Soil enzymes

Soil enzymes, whether intracellular or extracellular have been considered as an index of soil fertility. Of the more than 50 enzymes in soil, attention was given to Nitrogenese and dehydrogenase enzyms which gives an estimate of N-fixation and respiratory activities in soil, respectively

Most of the herbicides stimulated soil enzyme activities while fungicides in general are inhibitory. For eg., 2,4-D, atrazine, Nitrofen, haloxyfop etc. stimulated the urease, dehydrogenase and phosphatase in soil at recommended doses. However Atrazine and metalachlor interfered with acid and alkaline phosphatase.

Fungicides like Fenamiphos and Benomyl inhibited the dehydrogenase, urease and phosphatase enzymes. Insecticides showed a mixed effect to enzymatic activity. O.P. insecticides like fenitrothion, malathion and phorate inhibited soil urease activity and carbofuran a carbamate insecticide has stimulatory effect on soil enzyms while its metabolite 3- Keto carbofuran inhibited dehydrogenase enzymes in flooded soil. HCH, when applied to flooded soil inhibited dehydrogenase activity in soil.

Transformations of agrochemicals in soil

A pesticide applied to crop or soil will undergo various types of transformations generally referred to as metabolism, which is mediated by biotic and abiotic factors. In insects and plants, the degradation is possible by enzymes while, in soil it is effected mainly by microbial activity and physical chemical condition of the soil. The transformation can be either an activation or degradation of the parent compound. In degradation, a less toxic derivative of the parent compound is produced, while the compound get converted to a more potent one in case of activation.

Metabolism of a pesticide can be grouped into two different phases, viz., Phase I and Phase II. In Phase I, free metabolites are produced by biochemical reactions like oxidation, reduction, dehydration etc., which can be extracted by organic solvents. in Phase II Metabolism, the metabolites react with natural components to form either conjugates or bound residues. In the case of conjugates, the free metabolites combine with sugars, amino acids etc. and are more water soluble than the free metabolite. Hence they can be extracted by polar solvents. These residues which cannot be extracted either by organic or polar solvents are bound residues.

Important enzymes in Phase I metabolism are Hydrolases (carboxyesterases, Amidases, Phosphatases) Glutathion. S-Transferases (dealkylation, dehalagenation etc.) and Microsomal oxidase(Oxidation and reduction). As a result of the action of these enzymes, the free metabolite produced is more polar than the parents compound hence more water soluble and less toxic.

In the case of Phase II metabolism, it is a synthetic process in which the OH, COGH, NH_2OH, NH_2, SH groups of the Primary metabolite combine with sulphate group, glucose, glucoronic acid or amino acids to form the corresponding conjugates.Of the amino acids, glycine, Glutamine and cysteine are important for conjugate formation. For the formation of conjugates, Coenzymes and ATP are utilised.

In the case of microbial degradation of pesticides in soil, the important mechanisms by which degradation occur are Beta-oxidation, oxidative dealkylation, thio-ether oxidation, Decarboxylation, Epoxidation, Ring clevage and Nitroreduction. Of the bacterial species the important ones include Azetobactor, Arthrobactor, Achromobactor, Pseudomonas and Bacillus. Among the fungi, Aspergillus, Pencillium, Fusarium and Trichoderma are important.

The Abiotic factors responsble for pesticide degradation includes sunlight, temperature, relative humidity, moisture regime, pH organic matter etc.

Bound residues of pesticides

The residues of pesticides that remain in soil and plants even after exhaustive solvent extraction are termed bound residues. A sizeable portion of pesticide residues remain non-extractable or bound in soil as well as in plants, which cannot be detected by routine analytical procedures, which are chemically unidentifiable and posses no pesticidal action.

In soil, 20-70% of residues of applied pesticides could result in bound residues. Accumulation of bound residues increases with time. Bound residues are regarded as important if the amount estimated after one year is higher than 10% of the original dose. Using radio labelled (^{14}C) materials, the extent of formation of bound residues in soil was estimated. In the case of DDT, applied at 1 kg/ha 13 and 8% of the applied dose was found in the form of bound residues after 28 days. In the case of lindane 8.4 - 13.8% of its applied dose was detected as bound form after one month. Also the extent of bound residues increases with time.

The organic matter and clay fraction of soil play the most important role in the formation of bound residues. The mechanisms include adsorption and chemical reaction. The pesticide get bind with soil colloids by different physical forces and will get linked with the phenolic and benozocarbozylic groups of Humic materials by Hydrogen bonds, of considerable stability. With the passage of time, this will get firmly fixed in the soil matrix and become more resistant to degradation and extraction, known as 'ageing of bound residues'.

The bound residues can be estimated by using ^{14}C labelled materials, either by total combustion method or by High Temperature Distillation (HTD) Process.

In Total combustion, soil and plant samples containing bound ^{14}C residues are combusted in a biological oxidiser to produce $^{14}CO_2$ which is adsorbed and radio assayed. In HTD process 100-200mg of sample containing ^{14}C residues is heated in a quartz tube to 800°C for 15 minutes. Volatile products are trapped in various traps. The materials trapped are analysed by radio assay.

Significance of bound residues

Significance of bound residues in soil is often addressed in terms of its bio-availability, persistence and mobility in soil. These bound residues at a later time be re-mobilised by biochemical or enzymatic process making them available to successive crops and soil fauna. It can thus cause direct food contamination or can contaminate ground water. A strain of psendomonas was identified which can release bound residues of atrazine. The bound residues formed can prolong the persistence of pesticides in soil and were detected even after nine years of application. The slow mineralsiation of bound residues could be the reason that these do not increase indefinitely with time.

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Prospects, problems and new trends in weed management

Dr. C. T. Abraham

Control of weeds is one of the major problems faced by man ever since he started settled farming. Weeds, the unwanted (out of place) plants are ecologically more adapted to a locality than the crop plants. Hence, if proper protection is not given by man to his crop, the weeds will invade the field, compete with crop and finally take over the area. Nature has provided the weeds ability to compete with crops due to some characters known as characters of weediness, uncommon in crop plants. These include prolific seed production, variable dormancy and considerable longevity for the seeds, rapid seedling growth and establishment, tolerance to variation in the environment, adaptations for long and short distance dispersal, good powers for vegetative reproduction a nd strong competitive ability.

Losses caused by weeds

The most important concern to the farmer is the reduction in crop yields due to competition from weeds for nutrients, water, light and space. The yield loss in some of the important crop plants are given in Table 1.

Table 1. Yield loss caused by weeds in some crops

Crop	Yield loss (per cent)
Rice (drilled)	70-80
Rice (transplanted)	30-40
Maize	50-70
Wheat	20-30
Sorghum	50-70
Pulses (Kharif).	40-60
Pulses (Rabi)	20-30
Soybean	40-60
Groundnut	40-50
Cotton	40-50
Sugarcane	20-30
Potato	30-60

Bhan (1992)

Yield loss is higher in cereals, compared to the pulses. It is higher in kharif crops than in the rabi crops. In general, weeds reduce crop yields by 31 per cent [22.7 per cent in winter (rabi) and 36.5 per cent in summer and rainly (rabi) season]. However, as farmers adopt some kind of weeding on their fields, a conservative estimate of 10 per cent loss in crop yields may be taken as more realistic (Bhan and Susilkumar, 1998).

Problem weeds in Indian Agriculture

The surveys conducted under the AICRP on weed control, covering all states in India, had identified the major weeds in different crops and cropping systems. The important weeds are listed in Table 2.

Table 2. Major weeds in Indian Agriculture

Weed	Crop / situation
a. Grasses	
Echinochloa crusgalli	Rice
E. colona	Rice, kharif crops
Cynodon dactylon	All crops
Sorghum halepense	Kharif crops
Digitaria sp.	Kharif crops
Dactyloctenium aegyptium	Kharif crops
Imperata cylinderica	Orachards, Plantation crops
Avena fatua	Rabi crops
Phalaris minor	Wheat
b. Sedges	
Cyperus rotundus	All crops
C. iria	Rice, Vegetables
Fimbristylis miliaeae	Rice
c. Dicots	
Amaranthus sp.	Garden land crops
Phyllanthus niruri	Garden land crops
Celosia argentea	Garden land crops
Euphorbia hirta	Garden land crops
Trianthema portutacastrum	Garden land crops
Leucas aspera	Garden land crops
Lantana camara	Waste lands, orchard
Parthenium hysterophorus	Waste lands, orchard
Chromolaena odorata	Waste lands, orchard
d. Aquatic weeds	
Eichhornia crassipes	Rice and aquatic areas
Salvinia molesta	Rice and aquatic areas

Hydrilla verticillata	Shallow ponds
Typha angustata	Aquatic areas, ponds

e. Parasitic weeds

Striga sp.	Cereal crops
Orobanche cernua	Tobaco
Cuscuta chinensis	Vegetable, Garden plants
Dendropthoe sp.	Mango, teak and other trees

Impact of weed control on agriculture and environment

A. Impact on agriculture

a. Benefits

1. Requirement of human labour

   Before 10000 B.C. weeds were removed from crops by hand. One person could hardly feed himself and starvation was common. By 1000 B.C., man used animals to drag the hoe (as a crude plough) thus reducing human labour. Still one person could produce enough food for two people. After 1731, when growing crops in rows with horse hoeing was introduced, each person could provide food for four persons.

   In 1920, tractors were beginning to be widely used, enabling a farmer to produce food for eight people. In 1947. herbicide use began to be a common practice and at that time one farmer could produce food for 16 people. In the subsequent years many new herbicides were developed and widely used. Many other improvements in agricultural technology also contributed to increased food production. In 1990, one farmer could feed 75 people. This means that the requirement of many people working on the farm could be utilised for other activities..

2. Change in the source of energy for agriculture

   Along with the changes in the method of weed control there was a gradual shift from human energy to animal power, mechanical power (tractors) and chemical energy (herbicides) for weed control. At present an integrated approach involving more than one of these forms is practiced. The animal power, which was the major source of energy during the first half of this century has completely given way to herbicides. Similarly there is increasing dependence on herbicides to replace the scarce and costly human labour.

3. Maintenance of yield potential

   Effective control of weeds by herbicides increased the yield of crops, as the competition from the weeds is excluded.

4. Conservation / minimal tillage made possible

   Tillage is reduced to only those operations essential for sowing the seeds at proper depth. Minimal tillage is followed on one third of the crop area in U.S.A. It helps in conserving soil moisture, preventing soil erosion and maintaining proper soil structure.

   In Kerala also tillage operations are reduced in rice farming by spraying paraquat or glyphosate to dry and kill the existing weeds before land preparation.

5. In areas where tillage is not possible, weeds can be controlled by herbicides. For weed control in factory sites, concrete constructions and walls, railway tracks, play grounds etc., herbicidal weed control is better.

6. For eliminating poisonous and thorny plants, herbicides use is more convenient.

7. Farm income will be more by timely and less labour intensive weed control using herbicides.

b. Problems

1. Shift in weed flora

   Continuous use of same herbicide may result in shifts in the flora to weeds tolerant to that herbicide.

2. Herbicide residues in soil

   Application of herbicides with long residual life in soil may restrict the choice of the crops in the rotation. Only crops tolerant to that herbicide can be included in the rotation.

3. Development of herbicide resistant biotypes of weeds

   Continuous application of some herbicide has lead to development of resistant biotypes of many weeds. Isoproturan resistant biotypes of *Phalaris minor* reported recently from Punjab and Haryana are such cases.

   Although development of herbicide resistant weed biotypes is recent in India, this problem was notices about 30 years back in western countries. More than 100 weed species have been documented with biotypes resistant to herbicides. Of these biotypes, more than half are resistant to triazines (Gressel, 1993, Holt and Le Baron, 1990). This is due to the repeated use of these herbicides with comparatively higher soil persistence, resulting in high selection pressure in the soil.

In India, Isoproturon was being used by farmers for successful control of *Phalaris minor* in wheat fields, from early 1980s. However, recently farmers have reported about the poor efficiency of isoproturon. Studies conducted at the CCS HAU, Hissar revealed that the resistant biotypes from Karnal and Ambala required 4-6 times more isoproturon than the susceptible biotype from Hissar, indicating problem of herbicide resistant biotypes in the wheat belt of India. Further studies have indicated that the resistant biotypes were also cross-resistant to pendimethalin, methabenzthiazuron and oxyluorfen (Malik *et al.*, 1996).

4. Impact on environment

The physical and molecular rate of herbicides in the environment determines its environmenttal impact. The major impact is usually a beneficial biotic response, controlling the target weed species without any detrimental effects. However problems may arise with extensive movement of a herbicide away from the target site. These usually occur due to drift (spray or volatility), leaching or soil erosion by wind or water run off.

Water run off from pesticide treated land is the major source of pesticide contamination of surface waters. Some surface water contamination may occur by lateral movement through shallow ground water. Local contamination can occur from procedures like aquatic weed control, where the herbicide is applied directly to surface water and when water retention procedures are inadequate.

Ground water contamination is lesser since the pesticides are generally bound and / or degraded as they pass through the soil profile with water.

New trends in weed management

1. Biological control of weeds

Because of the increasing concern about the adverse effects of widespread use of herbicides, more importance is now given to the biological methods of weed control, which are more ecofriendly in nature.

a) Classical approach

This involves the traditional biological control of weeds using insects, fishes, disease causing micro organisms etc.

Examples of successful biological control are :

Weed	Insect
1. *Lantana camara*	1. *Crocidosema lantana* 2. *Agromyza lantanae* 3. *Teleonema scrupulosa*
2. *Opuntia* sp.	1. *Cactobdastus cactorum*
3. *Salvinia molesta*	1. *Cyrtobagous salvrniae* 2. *C. Singularis*
4. *Eichhornia crassipes*	1. *Neochetina eichlorniae* 2. *N. bruchi*
5. *Chromolaena odorata*	1. *Pareuchaetus pseudoinsulatus*

Preparations containing microbial plant pathogens can be applied on weeds, the same way as chemical herbicides to cause disease and kill the weed. Fungi are more useful for this and hence the term 'mycoherbicide' is also used to refer bioherbicides. De vine (Abbot Laboratories Illinois) containing a formulation of the soil borne fungus (*Phytophthora palmivora*) is a bioherbicide for controlling strangler vine milk weed (*Morrenia odorata*) in Florida citrus groves. Another bioherbicide 'Collego' containing spores of *Colletotrichum gloeosporoides* (Penz) Sac. and sp. *Aeschynomene* an anthracnose fungus, is used against northern joint vetch (*Aeschynomene virginica*) in rice and soybeans in U.S.A.

2. Naturally occurring herbicides

Many microbial toxins and secondary plant products (allelochemicals) have been found to possess good herbicidal property. They are safer to the environment as they are of natural origin. Bialophos is the first herbicide developed by this method, and is commercially marketed in Japan under the trade name 'Herbiace'. It is isolated from the fermentation broths of *Streptomyces hygroscopicus* and *S. viridochromogenes* and exhibits herbicidal activity against wide spectrum of grasses and broad leaf weeds following foliar application.

Another approach is the biorational synthesis of more stable and selective anologues based on the noval chemistries provided by the allelo chemicals and microbial toxins. Methoxyphenone, marketed in Japan (Nihan, Japan) as a selective herbicide for control of barnyard grass (*Echinochloa crus-galli*) in rice is a synthetic analogue of the microbial toxin anisomycin. The commercial herbicide Basta (Hoechst Scherring Agr Evo) contains ammonium glyfosinate, an analogue of phosphino thricin, which is the active ingredient in the microbial herbicide bialophos discussed above. Other commercial herbicides based on chemistry of natural products are cinmethylin (based on cineole), Benzamin (based on Benzoxazinone) and Quinclorac (based on Quinaloic acid).

3. Genetic engineering of herbicide resistant crops

Advances in biotechnology has made it possible to develop crop varieties having tolerance against broad spectrum herbicides. These crops would provide more effective, less costly and more environmentaly safe weed control. Considering the promise of this approach, a large number of organisations have launched research programmes directed towards developing herbicide tolerant crop varieties of major weed crops and some successes have been obtained (Abraham *et al.*, 1993).

List of the herbicide resistant crop varieties being marketed are given below (Table 3).

Table 3. Genetically modified herbicide resistant crop varieties

Herbicide resistant variety	Herbicide to which resistant
IMI corn	Imidazolinone
Post protected corn	Sethoxydim
Liberty link corn	Glufosinate ammonium
IMI / Liberty hybrid	Imidazolinone and glufosinate
Roundup ready soybean	Glyphosate
Roundup ready corn	Glyphosate
STS soybean (sufanylur tolerant soybean)	Sulfonyl urea

These herbicides tolerant varieties are being grown by farmers from 1996 onwards. In 1997 combined sales of imidazolinone and liberty link corn seeds added to about 5 million acres in the U.S. in addition about 8-10 million acres of Roundup ready soybean and six million acres of STS soybean were expected to be planted. Outside U.S., Argentina emerged as the prime supporter of this technology, planting more than 25,000 acres of roundup ready soybeans during 1996 (Kantz, 1997). Canada, Australia and China also grow considerable areas with genetically modified crop varieties.

4. Soil solarisation

Soil solarisation or solar heating of the soil is based on covering the soil with transparent polyethylene (TPE) films which would trap the heat inside resulting in raising of soil temperature to a level lethal to many soil pathogens including weed seeds. It is based on the principle that light received from the sun is in the form of electromagnetic short waves which would easily pass through the TPE. The re-radiation from the earth is however, as long waves which are not permitted through TPE, resulting in trapping of heat.

The field is irrigated and brought to fine tilth. The PE films are laid close to soil surface and the sides are tricked in the soil to prevent any heat loss. It is best practiced in summer months (April-June) when solar radiation is high, the sky is clear and more importantly the land is vacant. A duration of 2-6 weeks is sufficient.

Soil solarisation is a pre plant treatment and planting or sowing could be undertaken only after removing the PE films. The soil disturbance fallowing solarisation should be kept to the minimum for best results.

Trials conducted at IARI, New Delhi have shown that the effect of weed control lasted for more than two seasons (Yaduraju, 1993). It has proven to be effective against *Orolanche* in tobacco and vegetable crops where other methods have failed. It is ecologically safe and environmentaly friendly. However the application is limited, due to high cost of PE films, to higher value crops, floriculture and nursery beds.

5. Improved application of herbicides

The application technology for herbicides have undergone lot of change from the primitive brooms and wricks (used in 1883 to spray copper sulphate for controlling dicot weeds in cereals). With the introduction of hormonal and systemic herbicides, sprayers were developed for application by farmers. During 1970s significant developments were made by means of special metering and control devices, which will adjust the nozzle output in relation to speed. This system is known as automatic volume regulation (AVR). Many AVR systems are electronic computer systems which will give information regarding the sprayer performance. The output from each nozzle is monitored and recorded, so that faults can be detected and corrected.

a. Controlled droplet application (CDA)

The CDA technology offers huge savings in amount of herbicide used, time and efforts. Compared to the conventional sprayer which used about 500 litres of spray fluid per hectare the CDS sprayer needs only about 10 l/ha. The CDS sprayer, which is also about 10 l/ha. The CDS sprayer, which is also known as ULV (ultra low volume) sprayer, produce droplets in the range of 150 to 250 microns in diameter which are ideal for maximum effect on the target. The droplets are produced by a battery powered rotary atomiser which has a spinning disc with serrated edge, revolving at a speed of 2000 rpm.

CDA sprayers are ideal for application of herbicides in plantation crops, orchards and other crops is large areas and the requirement of spray fluid is considerably reduced.

b. Direct contact application DCA

The herbicide is placed, wiped, rubbed or smeared on to the plant surface. This helps in applying the herbicide only to the target plants (weeds). Examples of CDA applications are:

1. Recirculating sprayer
2. Rope which applicator
3. Herbicide glove and
4. Roller applicator

6. Integrated weed management

Considering the crop, the weed problems, available control measures and their impact on the ecosystem and the environment, integrated approach for weed control, involving the different methods has to be selected. The prime concerns is effective and economical weed management without adversely affecting the sustainability of the system. The methods selected should include preventive methods, cultural methods and biological methods and should restrict the use of herbicides to the minimum.

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Basic principles of Integrated Pest Management and their adoption in rice ecosystem

Dr. T. Nalinakumari

Pests have plagued agriculture ever since people began domesticating plants and animals. Over the centuries, farmers have developed a wide range of methods to combat these pests, but with varying degrees of success. In the 20th century, however, the introduction of commercial pesticides revolutionised pest control. These modern pesticides have helped to control and reduce crop losses to a remarkable degree. The use of these pesticides has, created some of today's major environmental and health problems. It reduced the abundance and diversity of wildlife, resulted in human health hazards, associated with acute or chronic exposure to dangerous products in the workplace and contaminated air, food and water (Conway and Pretty, 1991, Gips 1987 and Pimbert, 1985). Most of the social costs are unevenly distributed within and between countries. About half of all pesticide poisoning of people and 80 per cent of the pesticide related deaths are thought to occur in developing countries, even though, this is where, only 15-20 per cent of pesticides are consumed.

The self-defeating nature of the chemical control strategy that dominates today's crop protection efforts has also become more apparent in recent years. Repeated application of synthetic pesticides have selected pesticide resistant pests world wide and there are now at least 450 species of insects and mites, 100 species of plant pathogens, 48 species of weeds resistant to one or more products. In addition, the death of natural enemies has allowed previously harmless organisms to reach pest status. The impression is that more and more pesticides have to be used to achieve less and less.

For these reasons, crop protection specialists are increasingly being asked to develop pest control methods that are more compatible with the goals of a sustainable, productive, stable and equitable agriculture. To meet these aims, research must seek to integrate a range of complementary pest control methods in a mutually enhancing fashion, namely, Integrated Pest Management (IPM). Geier and Clark first propounded the concept of IPM. Geier (1966) used "pest management" in preference to "pest control".

Integrated Pest Management is the intelligent selection and use of pest-control actions (tactics) that will ensure favourable economic ecological and sociological consequences (Rabb, 1970). The most comprehensive and widely accepted definition of IPM as given by FAO panel of experts is -"the pest management system that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods, in as compatible a manner as possible and maintain the pest populations at levels below those causing economic injury". The overall objectives of IPM is to optimise and not maximise pest control in terms of economical, social and environmental values and to create and to maintain situation in which insects are prevented from causing significant damage to crops.

Specific objectives

Development of a scientific understanding of the significant biological, ecological and economic practices in the growth of crops, the population dynamics of the pest and their natural enemies and other factors affecting them.

Development of alternative tactics, which are ecologically compatible and can be, expected to reduce the use of broad-spectrum pesticides and lessen the adverse effects of their use.

Developments of better methods of collecting and interpreting relevant biological, meteorological and crop production data.

Philosophy or concepts of IPM

The successful integration and use of control options in an integrated pest management programme depends to a very large extent on the understanding and planning of the particular agro-ecosystem.

While considering the economics of pest management, the agriculturist should no longer think solely in terms of costs and benefits but must consider environmental effects as well as the benefit and risks of pest control.

Mere presence of few insects on the host plant does not always cause significant damage. Plants have natural adaptation to tolerate some pest population and sustain the injury to some level without affecting its yield potential adversely.

The ecological balances sought in pest management programmes necessitate the wide spread encouragement of beneficial insects that are effective natural enemies of the pest species. Survival of some pest population helps to breed population of natural enemies uninterrupted, thus maintaining biological control.

A pest in a crop is only a part of complicated ecosystem and those pesticides are always applied to ecosystem and not merely to pests. Therefore, pesticides should be used with great caution and applied "when necessary and where necessary".

Acceptance of pest management systems by farmers and others has been slow for a number of reasons- insufficient funds, lack of understanding, conflict of interests and traditions among others. These factors should be considered while translating IPM into adoption.

Components of IPM

Components of IPM are commonly referred as five "P s". They are pathogens (parasites, predators and microorganisms), policy, people (farmers), plant and pest.

Methods of IPM

IPM focuses on six control areas

- ❑ Mechanical pest control: Collection and destruction of pest species without destruction to the natural enemies.
- ❑ Cultural pest control: The manipulation of sowing and harvest dates to minimise damage, inter cropping, vegetation management to enhance natural process and crop rotations.
- ❑ Host plant resistance: The breeding of crop varieties that are less susceptible to pests.
- ❑ Biological control: The conservation of natural enemies, manipulation/ augmentation of natural enemy population and the introduction of exotic organisms.
- ❑ The wise and judicious use of chemical microbial, botanical pesticides.
- ❑ Legal control: The enforcement of measures and policies that range from quarantine to land and water management practices.

Thus there will be a need to focus on structural change in agro-ecosystems, give great importance to self-sustaining control methods and draw on the local stocks of knowledge useful for pest management.

Limitation of IPM

1. Lack of information about pests and agro-ecosystem.
2. IPM strategy is based on scientific approach, which is often not fully understood by the farmers.
3. Appropriate and feasible technologies will fail to be adopted by farmer because communication gap and social or cultural constraints.
4. Many of IPM programmes are developed in broader perspective and are not adapted to local farmer's meals.
5. The awareness of policy makers of IPM principles is the key for successful IPM implementation.

IPM with special reference to Rice

The earliest concepts of pest control, in rice ecosystems recognised only the "plant" and the "pest". The traditional IPM concept was revolutionary in that it recognized a third tropic level- that of the natural enemy- which was shown to be able to control pests "naturally" in many instances (three tier system)(Fig.1). But the scientists were not fully confident about the three-tier system framework, that in the early season, rice would be at a higher risk because there would be inherent delays caused.

Rice ecosystem is unique in the sense that rice is the only crop, which can grow in standing water. In such a situation natural enemies get a head start, early in the season from the detritivores and filter feeding insects before pest establishment. The basic energy source of these insects is, probably, the break down of organic materials originating from the previous crop cycle, together with materials brought in by irrigation water, phyto-plankton and algae. These organic residues feed bacteria, which in turn feed zooplankton. Population of zooplankton, in turn feed filter feeders such as midges and mosquito larvae. In another direction, organic

Fig. 1. Prior concepts of trophic (feeding or energy flow) relationship in rice ecosystems

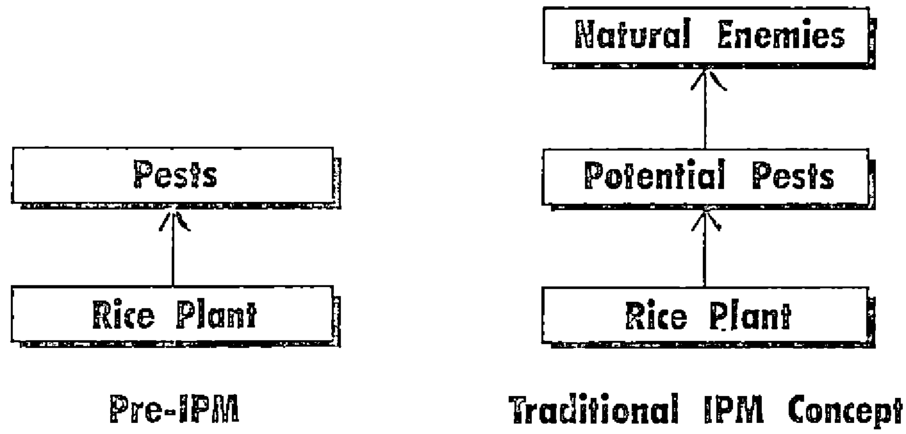


Fig. 2. Rice has three separate pathways for energy supporting natural enemies

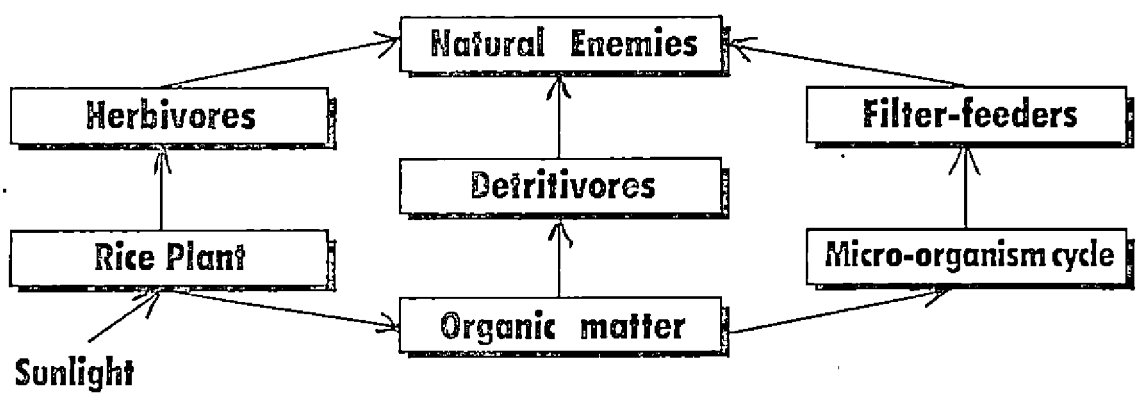
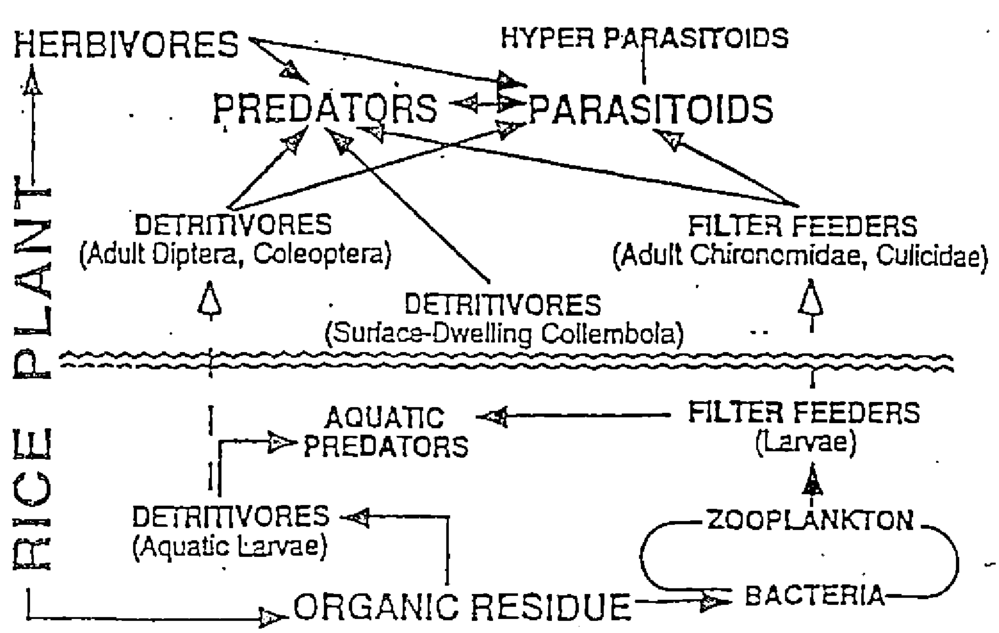


Fig. 3. Functional group relationship among the major elements in the rice community



material goes to directly feed insect decomposers. These two avenues for energy flow provide a consistent and abundant source of food for large and diverse population of natural enemies, upto half way through the season. That is, there exists three independent avenues for energy flows to natural enemy populations exist in the early season rice fields (Fig. 2 & 3).

Studies conducted at the Kerala Agricultural University revealed that natural enemies were present in different rice ecosystems of the State (Reghunath *et al* 1990; Nalinakumari, 1996; Nandakumar and Pramod, 1998 and Ambikadevi, 1998). The natural enemies are present through out the season but the proportion of pest and natural enemies are less in the early stages of the crop (Nalinakumari *et al* 1997). Studies have also revealed that there was no increase in grain yield due to insecticide application in the rice ecosystem where tolerant variety was planted but insecticide application reduced the pest and natural enemy population for a short period and thereafter the population of pests and natural enemies increased. Thus the best mix for integrated pest management in rice is considered as cultivation of tolerant varieties and conservation of the existing population of natural enemies in rice ecosystem (KAU 1997, 1998,1999).

The concepts of IPM in rice has been known for over 30 years in India and it has come to be well recognised but it is still more of an aspiration than a reality for average farmers in many crops. But with the efforts of FAO launched programmes on "Farmer Field School" and "Hands on" training to farmers through the State Department of Agriculture, rice farmers of the State are now adopting IPM strategies to their farms and thus reduced the use of pesticides in rice ecosystems with KAU released tolerant varieties.

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Integrated Pest Management in Vegetables

Dr. K. Sudharma

1. Introduction

The world today is witnessing an over exploitation of technologies as well as resources for feeding the billions of people. Significant improvements in pesticide research could result in spectacular gains in crop production during the last two decades. But the over reliance on chemicals for pest control without regard to the agricultural ecosystem resulted in serious backlashes like secondary pest out break, development of resistant pest populations, destruction of other non target organisms and resurgence of pests, besides pesticide residues on food materials.

It is well understood that pesticides alone cannot ensure long lasting pest control and it is now widely accepted that integration of the various prophylactic and curative measures suited to specific situations are required for suppressing pest population.

Integrated Pest Management (IPM) is defind as "a pest management system that in the context of the associated environment and population dynamics of pest species utilises ail suitable techniques and methods in as compatable a manner as possible and maintain the population below those cause causing economic injury". IPM is considered to be the best for managing pests in a manner compatible with environment and with production economics.

2. Need for IPM in Vegetables

The monitoring of insecticide residues in vegetables carried out under the All India Co/ordinated Research Projects in Kerala and other parts of India clearly revealed that vegetables were highly contaminated with insecticides [ICAR,1999]. In some cases the residues were even 4 - 6 times more than maximum residue levels prescribed by FAO. This is mainly due to the repeated application of insecticides given at 2-3 days intervals to tackle the pests in the fruiting stage of the crops. The attitude of the public in getting blemish free vegetables is one of the factors that prompt the farmers to use pesticides till the harvest of the crop. In order to reduce the toxic hazards and to get reasonably good returns it is high time we adopted IPM in vegetables.

3. Tactics involved in IPM

IPM necessitates the weaving together of all pest management tactics whether cultural, biological ,behavioural or chemical with the existing components of the environment so as to be mutually augmentative and bring about the most effective and least disruptive pest management possible. The tactics that can be employed are diverse. An intelligent selection of the different tactics to suit the different situation is of utmost importance.

3.1 Cultural control

Cultural control aims at manipulation of the cropping techniques for alleviating a pest problem.

3.1.1 Sanitation

Sanitation is one of the cultural practices that can reduce the favourablity of agroecosystem for a pest species. When fruit flies viz. *Bactrocera cucurbitae* attack fruits of plants like snakegourd and bittergourd, the fruits rot and drop to the ground. These fruits which harbour the maggots, if not collected and destroyed acts as a source of infestation and promotes further attack on these crops.

3.1.2 Tillage

Tillage is another cultural practice that affect the population build up of certain insects. Insects like fruit flies spend part of their life cycle ie. the pupal stage in soil. Tilling the soil exposes the pupae to the hot sun and also to avian predation. A sound knowledge on the biology of insect pest and the soil community is required while adopting tillage operation to suppress insect pests. Besides it is to be ensured that the tillage practiced is within the limits of good agronomic practice.

3.1.3 Disrupting the continuity of food supply

Manipulation of the presence of favourable crop species in the environment disrupts the continuity of insect's food requisites and this in turn affects the build up of the pest population as in the case of the Amaranthus weevil, *Hypolixus truncatulus*. This weevil pest attacks both wild and cultivated varieties of amaranthus.

Destruction of wild amaranthus significantly reduces the population of the weevil.

3.1.4 Crop rotation

Crop rotation is one of the most imporatant methods for avoiding contnuity in a pest's requisides. Crop rotation works, well in the case of soil inhabiting pests like the root knot nematode, *Meloidogyne incognita*. Tomato is a preferred host of *M. incognita*. Following a tomato crop peanuts can be grown without risk of damage. While peanuts are grown the nematodes cannot reproduce and the larvae in the soil die or become non infective.

3.1.5 Trap crop

Planting a favourable crop/plant species near the main crop reduces the intensity of attack of a pest species. Interculture of marigold with bhindi and Tomato reduces root knot attack on these vegetables. Growing mustard as trap crop @ 2 rows per 25 cabbage rows reduces the attack of diamond back moth on cabbage.

3.1.6 Modification of sowing dates

One of the methods to cause asynchrony between crops and pests is by modifying the planting dates. An example for this type of approach is changing the sowing dates in endemic areas for cucurbitaceous vegetables as fruit fly population is low in hot dry conditions and its peak during rainy seasons.

3.2 Plant resistance

Planting resistant cultivars when available is one of the most effective and environmentally safe tactics. Growing resistant cultivate Karnataka hybrid reduces root knot nematode attack in tomato.

3.3 Biological control

Biological control is recognized as one of the promising and ecologically acceptable methods for suppression of pests. The role of entomophages in regulating pest population is well appreciated. One of the goals of IPM is to restore the regulatory role of the natural biological agents.

3.2.1 Parasitoids and Predators

An array of natural enemies occur in vegetable ecosystem which include parasites as well as predators. The lady bird beeltes viz. *Micraspis crocea*, *Menochilus sexmaculatus* and *Scymnus sps*; the syphid, *Xanthogramma scutellare*; the chrysopid, *Chrysoperla carnea* and spiders viz. *Lycosa pseudoannulata*, *Oxyopes*, and *Tetragnatha maxillosa* are a few of the predators that occur in the vegetable ecosystem.

The parasitoids that are often encountered indude *Chrysocharis johnsonii*, *Cotesia* sp., *Trichospilus* spp., *Trichogramma* spp., *Chelonus opp.* etc. Inundative release of *Trichospilus chilonis and T. brasiliensis* in Tomato fields were found effective in checking the population build up of the tomato fruit borer, *Helicoverpa armigera*.

Spider mites are important pests of vegetables but often their population is kept under check by the enemies which include both insect and acarine predators. Of the acarine predators, phytoseiid mites exert a significant role in the suppression of spider mite populations. Conservation of these natural enemies by restricting the use of insecticides itself will pave way for the full expression of these bioagents and consequent pest suppression.

3.2.2 Pathogens

Pathogens form an important tool in biological control. Viruses, Bacteria and fungi help to regulate pests without any cost to the society. As these insect pathogenic microorganism leave to toxic residues and as they have apparent *specificty* for target pests they can be well fitted in IPM programmes. Application of NPV of *Helicoverpa armigera* at weekly intervals from flower initiation results in appreciable reduction of the fruit borer *H. armigera* in tomato.

The entomopathogenic fungi, *Fusarium pallidoroseum* has been identified as a potent pathogen of cowpea aphids on Kerala. There is ample scope for utilising this pathogen for the management of cowpea aphids on vegetables in places like Kerala where the climate is highly humid (Hareendranath, 1987)

3.4 Pesticides

IPM does not imply complete avoidance of chemical pesticides. Insecticides are highly potent and they will continue to be an important component in IPM. An analysis of the agroecosystem to assess the status of the pests and its defenders is highly essential before resorting to insecticide application. Selection of the appropriate chemical and proper timing of pesticide application needs special attention.

3.5 Botanical pesticides

Utilisation of plant products for pest control was in vogue long before the use of synthetic chemical pesticides. The insecticidal, attractant and repellent properties possessed by many of the plants/plant products have been now elucidated. The plants that have potential in pest control include *Azadirachta indica, Annona squamose Clerodendron information, Vitex negundo, Hyptis saveolens, Andrographis paniculata* etc. (Saradamma, 1989, Lilly 1995).

The management of the American Serpentine leaf miner *Liriomyza trifolii* which is an introduced pest in India is difficult with conventional insecticides but sucess has been achieved by adopting integrated strategy comprising removal of badly infested leaves in cowpea and by spraying the neem seed oil emulsion at 10% strength. *Aphis craccivora* infesting pulses can be effectively checked by emulsified leaf extract of *Hyptis saveolens* at 10% strength or neem seed oil emulsion at 10%. (Reghunath and Gokulapalan 1996).

3.6 Behaviour modification

3.6.1 Use of traditional traps

Baits or food lures offer considerable scope for attracting and killing pests of vegetables. Hanging coconut shells containing palayamkodan banana poisoned with carbofuran granules in pandals of bittergourd and snakegourd substantially reduces fruit fly infestation. (Pillai *et.al.* 1991)

3.6.2 Pheromones

The use of sex phenomones for the survey of insect pests and management is a new approach in pest management. Sex lives for melon fly *B. cucurbitae* and *H. armigera* can be very well integrated in pest management programmes in vegetables.

Implementation of IPM

IPM is not simply the super imposition of control techniques but integration of all suitable management techniques with the natural regulating and limiting elements of the environment. A thorough understanding of the pest and the associated environment is essential for which agroecosystem is analysis required. The extension personnel need to be properly trained for the successful transfer of the concept of IPM to farmers.

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Modern trends in plant disease management

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Indian farmers and agricultural technologist have made tremendous effects during the last three and a half decades. This is largely due to introduction of high yielding crop varieties, fertilizers, assured irrigation and improved agronomic practices. However, to exploit the potential of the improved varieties and to ward of pests and diseases farmers started using very high doses of pesticides. In recent years concern has grown regarding the increasing use of potentially hazardous chemicals. Pesticides that accumulate in the soil and ground water may interfere with the biotic activity and food chain. Moreover, intensive use of pesticides has through natural selection, led to the increase in pathogens' resistance to those chemicals. These problems, and others, has instigated the research for new approaches to plant disease control.

Biopesticides

Bioagents are an integral part of integrated pest management. Biopesticides as a component of IPM are cheaper than pesticides by 50 per cent. They are ecofriendly, have a high cost benefit ratio and do not pose risk of the pathogen developing resistance. During the recent years several biopesticides have been marketed in several parts of India against certain selected plant pathogens. Talc based formulation of the fungus *Trichoderma viride* for seed treatment came as a boon to rainfed crop farmers cultivating oil seeds and pulses for managing root rot. Biopesticides against foot rot of pepper, soft rot of ginger and turmeric and preemergent damping off of chillies, vegetables and ornamentals are now available in the market under different trade names (Antogen TV, Ecofit, etc.)

Integrating biological and chemical control seems a very promising way of controlling pathogens with minimal interference with biological equilibrium. Several biopesticides resistant to common fungicides have been developed and are about to be commercialised. Application of *T. harzianum* preparation combined with the fungicide prothiocarb has shown synergistic effect in controlling *Pythium apanidermatum* infection of several crop plants.

Use of VAM fungi for the control of fungal root diseases

The potential of vesicular arbuscular mycorrhizal fungi in managing root diseases of several crop plants have been reported. The severity of diseases caused by *Phytophthora, Fusarium* and *Thielaviopsis* can be reduced with AM inoculation. The mechanisms of disease control varies with specific combination of host, pathogen and AM.

The possible AM effects on disease can be categorized as either chemical or morphological. In the chemical category increase of aminoacids, phenolic compounds and enzymatic activity in the roots of mycorrhizal plants has been suggested as the possible reasons. Morphological phenomena noted in mycorrhizal plants that have been suggested as factors influencing disease include (1) a greater morphogenic response in cell walls to the pathogens presence on mycorrhizal roots (2) increase in wound barrier and an (3) increase in lignification of cell walls.

Soil solarization

Solarization for the control of soil borne plant pathogens including weeds refers to a new approach for soil disinfestation by use of solar energy. The basis process involved in soil solarization is the heating of soil to relatively mild levels, usually 35-50°C in the upper 30 cm by tarping wet soil by transparent polythene sheets and there by inhibiting or killing most of the plant pathogens. This is very effective in reducing fungal pathogens like *Fusarium, Phytophthora, Phythium, Selerotium-verticillium*, nematodes like *Heterodera, Meliodogyne, Praty lenchus* and several weeds. Apart from inhibiting the pests, solarization have also found to be effective in increasing the yield of several crop plants.

Plant immunization

Immunization as a method of disease prevention is popular in human and animal medicine. Recently this method is being tried in the management of several plant diseases. Reports indicate that cucumbers, watermelons and musk melons can be systemically immunized against diseases caused by viruses, bacteria or fungi by restricted infection with viruses, bacteria or fungi. Immunization involves sensitization of plants to respond rapidly to infection by several different ways. Immunization is now being practiced in a limited way to prevent diseases of fruit and plantation crops. Two aspects of immunization are cross protection and induced resistance.

Third generation fungicides

Certain chemical compounds which are inactive as antimicrobial agents *in vitro* are found to be effective as elicitors of resistance in susceptible plant hosts. One of the main advantage of this technique is that it is highly sensitive and non toxic to human being and beneficial micro organisms. These chemicals have been found to increase the production of phytoalexins and related compounds by the plants which in turn inhibit the growth of pathogenic microorganisms. Fungicides based on the principle are (eg: Aluminium phosphorate) becoming popular among the farmers.

Management of abiotic disorders through biotic means

Management of abiotic disorders using micro organisms is gaining popularity during the recent times. The most widely practiced technique is the use of ice nucleation bacteria for the control of frost injury. Ice nucelation deficient strains by *Pseudomonas syringae* have been produced by genetic engineering. The biological control of frost damage has several implications. Firstly it is one of the few biological procedures which have been patented. Secondly it is cheaper than chemical or other means. Thirdly it has become a test case for use of genetically engineered organisms in agricultural plant protection.

Siderophores

These are iron binding proteins excreted by certain specific strains of bacteria like *Pseudomonas fluorescense*. Siderophores can bind iron molecules and thereby make it unavailable to other soil microorganisms. This principles have been successively adopted in the biological control of certain iron dependent soil borne pathogens like *Fusarium oxysporum.*

Bacteriocins

A bacteriocin is an antibiotic like substance produced by certain strains of bacteria which are active against other strains of the same or closely related strains of bacterium. A classical example of bacteriocin used in plant disease control is Agrocin 84 produced by certain specific strains of *Agrobacterium radiobacter* which selectively inhibit the growth and proliferation of *Agrobacterium tumaciens* causing crown gall disease in many dicots.

Transgenic plants

Introduction of certain plant pathogen inhibiting genes to crop plants through vector mediated transfer is a modern trend in plant disease management. Tobacco mosaic virus disease in tomatoes have been effectively controlled through this method.

Botanicals

Use of plant based fungicides for the control of plant diseases is becoming increasingly popular. Botanicals are found to be effective against several fungal, bacterial and viral diseases of crop plants. Botanical based fungicides are being marketed by several companies in India (eg: Wanis, Neemglod etc.)

Planning of Agricultural Projects within the Overall Plan Frame Work

N. Lekshminarayanan Nair

The goal of planning is to provide a desired array of quality of life elements through physical and social design of the human environment. This is sought to be achieved through optimal utilization of the biophysical resources within the command of the community for augmenting the income and employment opportunities of the dependent population. Five Year Plans are considered to be the purveyors of development and are formulated against a long term perspective for 10 to 15 years. In formulating the five year plant the Planning Commission co-ordinates the development programmes of the Central Ministeries and State Governments and integrate them in a national plan covering both the public and private sectors. The first step in the process of formulating a five year plan is the preparation of an approach paper highlighting the major goals set under the plan along with the approaches and strategies proposed for attaining the same. Growth equity and self reliance are the major goals which invariably received high priority in almost all the Five Year Plan. Growth is measured in terms of the annual average increase in the gross domestic product and the Planning Commission suggests the rate of growth which is attainable in every Five Year Plan largely guided by the past trend. The investment required for attaining the projected growth rate is also estimated sectorwise on the basis of the incremental capital output ratio attained in the past by the different sectors. The approach paper of the National Development Council will be circulated to the State Government enabling them to start the Planning process. Concurrently the Financial Resources Division of the Planning Commission also requests the State Governments to furnish detailed estimates of resources for the plan including the projects for additional resources mobilization indicating the sources.

The State Governments (the State Planning Board in the case of Kerala) in their turn come out with approach papers reviewing the past performance projected growth, future perspectives including thrust areas for development under the plan. The State Governments also constitutes Steering Committees for major sectors supported by task forces for the subsectors nearly one year ahead of the launching of a new five year plan. These advisory bodies comprising of subject matter experts, policy makers and economists after detailed deliberations submit their reports to the State Governments/State Planning Boards incorporating the policies and programmes for the Five Year Plan. The recommendations of the Steering Committees will be primarily on the basis of the past performance and future needs and the potential for attaining the same, since they do not have a clear idea of the availability of resources for financing the plan at that time. The State Planning Board communicate these reports to the Administrative Departments in Government and calls for plan proposals. The Administrative Department generally go by the recommendations of the committees and with the approval of the Ministries concerned submit the plan proposals to the State Planing Board along with the programme-wise outlays and physical targets. Concurrently the Planning Commission will be finalising the size of the State plan in consulation with the Chief Ministers concerned after a critical assessment of the resource position. The size of the plan is determined by aggregating the net revenue surplus likely to be available with the State Government at the beginning of the plan, the additional resources that the State Governments would be able to mobilise and the share of assistance for the State from the Central divisible pool worked out on the basis of the Modified Gadgil Formula. The modified Gadgil formula gives 60 per cent weightage on population 25 per cent on percapita income, 7.5 per cent for special problems and 7.5 per cent for special fiscal efforts. The State Planning Board through detailed discussions with the Secretaries to Government and heads of Departments concerned tentatively arrive at the sectoral outlays and formulate the Five Year Plan. The plan proposals thus formulated is submitted to the State Government and will be finalised with appropriate modifications by the Cabinet. The final plan document is submitted to the Planning Commission and the Planning Commission after detailed deliberations with the representatives of the State Government approve the plan.

The Five Year Plan gets operationalised through the mechanism of Annual Plans. The formulation of the Annual Plan provides the Planning Commission with an opportunity to assess the past performance in the various sectors and suggest mid course corrections including reorientation of strategies. The procedure for the formulation of the Annual Plan is broadly the same as that adopted for the Five Year Plan. The annual plan is prepared within the overall frame work of the Five Year Plan and the size of the Annual Plans are decided based on the assessment of the resources every year. The sectoral outlays and the plan programmes are finalised by the working groups constituted by the Planning Commission with representatives of the Commission, Central Ministries and State Governments.

Agricultural Plans

Agricultural planning forms a part of the overall plan for the economy. Agricultural planning aims at raising the productivity of agriculture rapidly which can often be done with relatively modest investment and thus enable it to provide greater surplus for investment in industry and generate the foreign exchange needed for the import of development goods. Agricultural Planning is particularly difficult not only because the factors determining the demand are largely exogenous but also on account of the fact that supply is conditioned by the biological and seasonal nature of agriculture and farmers are widely scattered usually in small units and often without much commercial outlook.

The perspective for agricultural development has also undergone fundamental changes over the years with vast changes taking place in the national and international trade. Planning for agricultural development in the present day context aims at optimal utilization of the local resources for providing the livelihood security for the dependent population through augmenting the income base and expansion of employment opportunities. The efficient use of agricultural resources largely depends on an accurate inventory of them and a careful assessment of their potential uses. The various steps in the agricultural planning process includes inventory of resources, their current level of productivity and uses, demand projections with reference to population growth, charges in end use patterns, improvement in living standards, changes in the pattern and direction of internal and external trade, growth of the industrial sector etc. targetting of agricultural production with reference past trends, level of technology, efficiency of level of technology, efficiency of input delivery systems and capability for plan implementation, increases in the supply of material inputs like land, water etc. and provision of economic incentives and institutional reforms.

Agricultural plans are operationalised through policy reforms as well as implementation of schemes and projects. Schemes are development activities contemplated on a short term basis with objective of attaining limited goals. While projects are prepared with a long term perspective with the objective of creation of assets capable of generating income over a long period.

Project

In economic literature a project has been defined in different ways. One definition is that it is "the smallest unit of investment activity to be considered in the case of programming". Another definition is that it is a proposal for a capital investment to develop facilities to provide goods or services. In agricultural projects we think of an investment activity where capital resources are expanded to create a producing asset from which we can expect to realise benefits over an extended period of its economic life. It is a well defined activity with a specific starting point and a specific ending point and targetted against a definite clientele in a specific location to accomplish a specific objective. It is measurable in terms of costs and benefits. The construction of a dam is an investment under a project capable of yielding returns over several years of its economic life.

Steps in the planning and implementation of project

(1) Project identification
(ii) Project formulation
(iii) Project appraisal
(iv) Project implementation
(v) Project evaluation

Choice of projects

Choice of projects have to be made with meticulous core giving due consideration for the priority it deserves in the context of national economic objectives, the alternatives available for attaining the objectives, financial viability of the investment proposed and its social, economical, ecological implications.

Relationship between plans, programmes and projects

Projects are often linked in one form or another not only to the development of the sector concerned but also to the overall development of the economy. A programme or plan provides useful background data and information for project planning and selection. They validity of the basic policies and assumptions embodied in the plant or programmes can be tested and firmed up during the project preparation stage. In fact projects are the basic elements for achieving the objectives of the programmes and plan and at the same time they provide useful information for steering the economy and the development plan in the right direction.

Project analysis

Project analysis comprising of identification, formulation and appraisal of investment projects is an integral part of economic planning. Agricultural projects with their specific characteristics like seasonal fluctuations in production and large number of participants necessitate an adopted set of criteria for analysing the technical feasibility and economic viability. Project analysis makes it possible to identify promising opportunities for development and facilitates rational choices among alternatives. The emerging agricultural scenario demands a participatory process for planning of agricultural projects from the very beginning of the conceptualisation process.

According to Mr. Price Gittinger (Economic Analysis of Agricultural Projects, EDI, World Bank) the various steps involved in the project analysis could be summarised into the following six broad categories.

(i) Technical
(ii) Social
(iii) Commercial
(iv) Institutional
(v) Financial and
(vi) Economical

Project Formulation and Analysis

The first step in project formulation and analysis is to undertake a feasibility study. Once the project is found to be feasible detailed planning and analysis of the project may begin. By this time the less promising alternatives would have been eliminated and even at this stage the selected project will continue to be redefined and shaped as more and more becomes known. This is the stage at which detailed studies such as soil surveys, demand and supply, detailed hydrological analysis, farmer response surveys etc. would commence. As already mentioned, project preparation and analysis would cover six important aspects as detailed below.

(a) Technical aspects

This is concerned with input output relationship. It would include the study of the soil, rainfall pattern, groundwater resources, livestock species available in the locality, potential land use pattern, identification of appropriate species, choice of the technology, input output ratio in respect of the selected species etc.

(b) Institutional - Organisational - managerial aspects

The basic issue to be considered here is whether the institutional setting of the project is appropriate. What will be the institutional arrangement for the implementation and management of the project ? Whether new institutions are necessary? Whether the existing manpower do have the required skill for managing the project? In this context it would be appropriate to examine the scope of entrusting the responsibility for organisation and management with non-governmental organisations.

(c) Social aspects

Project should be socially acceptable and can be successful only with the whole hearted co-operation of the people. While finalising the land use plan and allocation of land area for the various types of plant species feasible in the area social considerations for meeting the growing demand for timber, fire wood, fodder should receive particular attention. Only through careful examination of the demand of the society and proportionate allocation of land space for various needs it would be possible to reduce the pressure for over exploitation of the forest wealth by the society. Employment potential of the project should also receive attention.

(d) Commercial aspects

It would include the arrangements for marketing of the output and the supply of inputs.

(e) Financial aspects

Through financial analysis the viability and bankability of the project are established. It also facilitate the nature of incentives and financial support necessary for the project including its sequencing and timing. This is the most important aspect in project analysis and is done through cash flow projections. The incoming and outgoing cash flows will be presented yearwise from the inception covering the entire economic life period of the project and the incremental net benefit will be worked out. The net benefit likely to be available without the project situation will be deducted from the year-wise not benefit flow in order to get the incremental net benefit. In financial analysis the present value of the cost and benefit streams are compared and the rate of return provided by the benefit stream over and above the cost stream, both at their present values, is worked out using the discounted cash flow technique. Only those projects which provides for a rate of return of more than the opportunity cost of capital (@ 12%) is considered to be financially viable. Cash flow analysis will have to be done for each species, representative farm models as well as for the project as a whole. The project overheads are accounted only in the project model.

(f) Economic aspects

Economic analysis is for determining the net benefit a project would contribute to the total economy considering the global situation.

Decentralised Planning

With the introduction of decentralised planning under the Panchayat Raj System planning process has undergone tremendous changes in Kerala. The State Government has taken a policy decision as part of the strategy for IX Five Year Plan to earmark 35-40 per cent of the State Plan outlay for implementation of total programmes drawn up by the Local Self Government Institutions based on the needs that emerged from the grass root level. The system operationalised by Kerala is unique in the sense that there is transparency in the allocation of resources to the various tiers of local bodies based on a well thought of criteria. The allocation for each local body is placed before the State Legislature as part of the State Plan Budget. The people's campaign launched by the Kerala Government for the implementation of the local plan is also novel in the sense that it is organised through a participatory approach involving elected representatives of the local bodies, local resource persons and beneficiaires concerned. A massive awareness-cum-training programme has also be launched associating nearly one lakh volunteer workers.

The criteria for devolution of plan funds to the various tiers of the local bodies and the flow of resources under the annual plan 1997-98 are given in Tables 1 & 2.

Table 1. Criteria for devolution of plan funds to local bodies

Parameters	Weightage (%)
GRAMA PANCHAYAT	
1. Population (Non SC/ST)	65
2. Agricultural labourers, people engaged in livestock, fishing, forestry etc., and marginal workers	15
3. Area (geographical)	5
4. Area under paddy	5
5. Panchayat's own income	10
Total	100
BLOCK PANCHAYAT	
1. Population (Non SC/ST)	65
2. Agricultural labourers, people engaged in livestock, fishing, forestry etc., and marginal workers	25
3. Area	10
Total	100
DISTRICT PANCHAYAT	
1. Population (Non SC/ST and excluding municipal/corporation areas)	55
2. Agricultural labourers, livestock, fisheries etc. marginal workers	20
3. Area (excluding forest, municipal/corporation areas)	15
4. Huts, houses without electricity, houses without latrines	10
Total	100
MUNICIPALITY / CORPORATIONS	
1. Population (Non SC/ST)	75
2. Area	5
3. Houses without latrines and houses without electricity	20
Total	100

Table 2. Annual Plan (1997-98) Local plans under decentralised planning financial flows from different sources

(Rs. in crores)

Local Bodies	No.of local bodies	No.of projects	State assistance	Internal funds	State sponsored	Centrally sponsored	Loan from Co-p.inst	Loan from fin.inst	Voluntary contribution	Beneficiary contribution	Others	Total Outlay
1	2	3	4	5	6	7	8	9	10	11	12	13
Grama Panchayat	990	20526	424.70	63.27	32.18	23.82	19.81	88.21	43.31	272.44	26.77	994.50
			42.71	6.36	3.24	2.39	1.99	8.87	4.35	27.39	2.69	100.00
Block panchayat	152	8798	108.17	0.70	15.31	84.67	3.01	43.49	6.07	29.28	4.27	295.00
			36.67	0.24	5.19	28.70	1.02	14.74	2.06	9.93	4.45	100.00
District Panchayat	14	3360	125.00	0.34	12.14	3.34	1.66	6.27	4.73	14.60	14.01	152.12
			68.64	0.19	6.67	1.84	0.91	3.44	2.60	8.02	7.69	100.00
Municipality	55	4214	63.84	27.04	5.42	5.47	1.67	24.24	8.92	25.31	4.55	166.57
			38.33	16.29	3.26	3.26	1.00	14.55	5.33	13.19	2.73	100.00
Corporation	3	889	33.79	9.93	6.14	0.99	1.12	21.33	4.09	15.60	3.49	97.00
			34.80	10.23	6.32	1.03	1.13	21.98	1.83	16.07	3.39	100.00
TOTAL	1214	67787	775.50	101.28	71.19	118.29	27.27	183.54	67.72	357.23	53.09	1735.28
			43.54	5.84	4.10	6.82	1.57	10.58	3.90	20.59	3.06	100.00

Transfer of Technology for Agricultural Development

Dr. C. Bhaskaran

I. INTRODUCTION

Slow pace in the transfer of technology is a major hurdle in the agricultural development process. There is concern in our country that the time between a research discovery and its first application averages 13 years. Implicit in these observations is the urgent need for planned intervention for the speedy and effective transfer of agricultural technology through appropriate communication strategies. An attempt is made herein to outline the principles to be considered while formulating and executing communication approaches for transfer of agricultural technology among the farmers.

II. TRANSFER OF TECHNOLOGY PROCESS

A comprehensive understanding of the Transfer of Technology (TOT) process is indispensable to be effective in our communication attempts. The steps in the TOT process are :

1. Dissemination

The technology generated through the research process, including the Participatory Technology Development (PTD), must be assessed and refined before being disseminated to the farmers. The technology must have the following characteristics.

i) Relative advantage
ii) Simplicity
iii) Visibility of results
iv) Divisibility
v) Compatibility
vi) Utility
vii) Possibility for group action

2. Assimilation

Once the technology is disseminated to farmers using various communication approaches, the assimilation process commences. It is the level of understandability and popularity of an idea in a social system. Social approval of an idea is a major break-through in its adoption. The spread of assimilation depends upon the manner and intensity of the communication campaign.

3. Acceptance

Acceptance is the decision of an individual to make full use of an innovation as the best course of action available. Demonstrations of the usefulness of an innovation spread its popularity. Formation of favourable attitude towards an innovation helps in its acceptance. Since adoption of an innovation by the farmers is the ultimate aim of all the promoting agencies, it is also important to know the causes of non-adoption such as ignorance, low motivation, inability, inappropriate technology, economic constraints etc.

III. EFFECTIVE COMMUNIATION

Effective communiation is sine quo non for transfer of technology. Communication is effective if it results in the achievement of the objective. Development agencies are equally interested in communication efficiency wherein the emphasis is placed not only an achievement of the objective but on the cost of communication also. Therefore, effective communication in the present context refers to the process by which extension workers exchange knowledge, attributes and skills with farmers individually or in groups or through mass media such that each gains comprehension, understanding and use of the messages exchanged.

IV. COMMUNICATION STRATEGY

Technology transfer is seldom a spontaneous process. Rather, it involves meticulous planning to introduce a technology among the farmers so that they use the technology and benefit from the same. The steps in planning a communication strategy are illustrated in Figure 1.

V. COMMUNICATION CHANNELS

To facilitate the extension worker in the technology transfer process, a variety of communication channels as in figure 2 are available.

VI. GUIDELINES FOR PLANNING COMMUNICATION STRATEGY

1. Principle of Felt needs

Selection of the messages and channel need to be based on the felt-needs and interests of the people. This implies that factors like land, crops, economic trends, social structure, economic status of the people, their habits, traditions and culture, in fact, every thing about the area in which the job is to be done and its people may be considered. Message cannot get the desired results when not in harmony with the culture of the people. At the same time, it must be in line with the state and national needs and policies. The needs of most urgent concern and widespread interest should be given first priority.

2. Principle of Joint Participation

Planning should be considered as a joint responsibility of the officials and the public. Strategy should be developed jointly by the extension staff and the local leaders. It should be planned with the people and not for the people. in addition to becoming a people's programme, it will also serve as an educational process for identifying problems, planning and executing the strategy to solve these problems. Moreover, people become interested and give better support to the strategy when they are involved in the planning process.

3. Principle of Multi-Media Approach

The widespread dissemination of messages by different channels of communication aims to achieve a cumulative impact among those who see and hear them. It is to arouse awareness and to prompt parents and others to seek confirmation through the local health worker, school teacher or other authority with whom audience can discuss and measure themselves about adopting a new practice.

4. Principle of simplicity

A good planning is one that will provide possible direction for a large number of people to move some distance. It will only be possible if message can be accomplished through a practice of selective adaptation and by applying a principle of common sense and value. Simplicity of the message will also help the change agent to handle the message and channel properly.

5. Principle of Co-ordination

Working alone, an extension worker may not be able to accomplish much. He must obtain the support of local groups and other organizations. He co-ordinates the efforts of all interested leaders, groups and agencies and considers the use of resources. Systematic planning must allow for planning to be co-ordinated horizontally, vertically, across time span and by types. Co-ordination with other supporting institutions and communication channels (both formal and informal) will make the execution easy and complete.

6. Principle of Satisfaction

A strategy is good if it provides satisfaction to the people who participate in the planning process. Such programmes promote the growth of the development programme as well as that of communication. Level of satisfaction of the people indicates the extent of the adoption of the message. It also relates to motivation for action. People must see how they or their communities are going to benefit from the proposed solutions.

7. Principles of practicability

Messages should be such which are attainable with the economic, social and mental capacities of the people through their own efforts and with a minimum of outside help. The planning process must not be complicated so that it can handle even complex situations in a workable manner. To get the right resources, in the right quality and quantity, at the right time and place and at the right cost should be the main purpose of planning.

8. Principle of comprehensibility

Efforts should be made to have a balanced programme, taking care of all sections of the society. The message must be comprehensive enough to embrace all age groups, creeds and races at all levels and community, block, state and national problems. It must also be highly significant economically, socially, aesthetically or morally to a relatively large number of people in each place. Unless information contributes to he welfare of all the groups, especially weaker section of the society, it cannot be fully effective in raising the level of living of the community.

9. Principle of Achievability

It is always better to focus attention on problems that are most important. A common weakness of the development strategy is that is includes attempts to solve too many problems at once without making a significant contribution to any of them. A few successful projects create much better impression than making too many half-hearted attempts. Message should always be selected according to the available resources and the priorities of people's needs.

10. Principle of Evaluation

Each and every strategy must have provision for evaluation. It is, therefore, important to state the objectives clearly and in terms that can be measured or evaluated while planning communication strategy. Continual evaluation is the map chart by which we direct ourselves. Evaluation helps to measure the progress of message, its weaknesses and achievements. Results are the basis for improvement in the future.

VII. FACTORS AFFECTING CHOICE OF COMMUNICATION CHANNELS

The following are some of the factors that may influence the effectiveness and hence choice of communication methods :

1) The behavioural changes expected in people, ie., changes in their attitude, knowledge or skills : We all know that most mass media methods are good for effecting changes in attitude and knowledge of the people, while most individual and group methods are useful for bringing about changes in knowledge and skills.

2) The number of persons to be covered : Individual and group contact methods are slow and cannot cover a large population in a relatively short period. Hence if the population to be covered is large and the time available is relatively short, mass contact methods may be more efficient.

3) The socio economic and educational level of people: Educated people with a relatively better socio-economic level can be reached through mass media and mass contact methods while reaching poor and illiterate farmers will require repeated exposure, individual and group contacts.

4) Availability of mass media to clientele : If farmers own radios, television sets, and subscribe to farm and home journals, newspapers and by extension publications, they can be effectively reached through such media. However, if the availability of any or all such sources of information is limited in any area, it will be difficult to communicate with them, unless the information sources available to them are utilised.

5) Skill on the part of extension workers for the use of different communication methods : All extension workers are not equally efficient in the use of all the communication methods. Hence they will tend to use relatively more of those methods with which they are familiar.

6) Cost involved : some methods are relatively more costly to use than others. Hence the initial investment required and the availability of related equipment and facilities may encourage or discourage the use of some methods.

7) Basic facilities needed : Some methods need electricity, dark room, projection screens, projectors and so forth. Hence such methods can only be used if such facilities are available at a place and time when needed.

8) Nature of communication methods : Each communication method is unique in itself as well as possesses some characteristics in common with several other methods. Hence an adequate understanding about the nature of each method is necessary for its effective use.

Methods that may be used to attract attention and create interest could include photographs, demonstrations, new stories, hoardings, posters, radio talks, television programmes, cartoons, exhibits, circular letters, real objects, conducted tours, media forums, extension publications etc.

Methods used to teach skills may include demonstrations, farm and home visits, training meetings, compaigns, specially prepared movies and tele-programmes etc. Methods that inspire action on the part of farmers may include farm and home visits, farmer's calls, conducted from tours, peripatetic team visits, media forms.

VIII. EFFECTIVE ORAL COMMUNIATION

Extension workers need to improve their oral communication skills particularly to be effective in interpersonal and group communication situations. The following are some suggestions to improve the oral communication skills :

1. Depend on the outline
2. Have an emphatic introduction
3. Avoid excuses
4. Have appropriate non-verbal signs
5. Avoid 'antics'
6. Avoid 'Speechtics'
7. Avoid unnecessary data

8. Use audio-visual aids in sequence
9. Have eye contact
10. Use acceptable speaking rates
11. Manage time appropriately
12. Use homour judiciously
13. Have motive appeal
14. Have modulations in speech
15. Listen and answer to questions carefully
16. Use pleasing conclusions

"Tell what you are going to tell"

"Tell"

"Tell what you have told"

Effective speaking is rather an 'acquirement' than 'innate'

A score card for judging speech is furnished herein for careful scrutiny.

IX. BARRIERS TO EFFECTIVE COMMUNICATION

Extension workers must be aware of the following barriers to effective communiation :

1. PRACTICAL BARRIERS

i) People jump to conclusion
ii) Fell off or loss of information
iii) Vertical Vs horizontal communication
iv) Selective processes
v) Meanings in heads and not in words
vi) Levels of interdependence
vii) Types of public Administration
viii) Vested interest
ix) Economic constraints

2. CULTURAL BARRIERS

i) Tradition
ii) Fatalism
iii) Ethnocentrism
iv) Norms
v) Relative values
vi) Trait compatibility
vii) Consequence of communication
viii) Habits and patterns

3. SOCIAL BARRIERS

i) Mutal obligation
ii) Small group dynamics
iii) Public opinion
iv) Conflict and Factions
v) Authority
vi) Caste and Class
vii) Basic configuration of society

4. PSYCHOLOGICAL BARRIERS

i) Perception
ii) Language compatibility
iii) Individual difference
iv) Problems of learning

These barriers must be kept in mind and ways and means must be designed to overcome them and to ensure speedy, efficient and sustainable transfer of technology process.

Strengthening Extension in India-Farrington *et al.* (1998)

1. Try out new approaches to Extension relying on less of face-to-face contact between extension agents and farmers and more on innovative vehicles (such as mass media) and on support of farmer-to-farmer information exchange.
2. Increase flexibility so that extension workers can focus more on identifying farmer's requirements and responding to them.
3. Set up Joing Committees at state and district levels and representations from SAUs, KVKs and Department of Agriculture to streamline and strengthen extension staff training procedures.
4. Introduce more widely innovations in Research-Extension linkages, including multi-agency approaches to extension and the wider way of para-extension workers

Government policy for the future

To enhance the enabling environment for non-governmental provision of extension services (Diana Carney, 1998).

SCORE CARD FOR JUDGING A SPEECH

I. PERSONAL (25)		
a.	Appearance	5
b.	Friendly conversational approach	5
c.	Poise, confidence, enthusiasm	5
d.	Gestures, mannerisms, eye contact and homour	5
e.	Voice, style, fluency and pronunciation	5
II. PRESENTATION (35)		
a.	Introduction and objectives	5
b.	Treatment, highlights, key points and examples	5
c.	Visuals carefully selected and arranged	10
d.	Summary and Conclusion	5
e.	Question and answers	5
f.	Maintaining interest	5
III. SUBJECT MATTER (40)		
a.	Relevance to field/current situation	5
b.	Adequacy	10
c.	Systematic breakup	7
d.	Balanced coverage	6
e.	Problems well brought out and covered	7
f.	Latest information	5
		100

INDEX

Excellent	85-100
Good	70-84
Fair	50-69
Needs improvement	40 and below

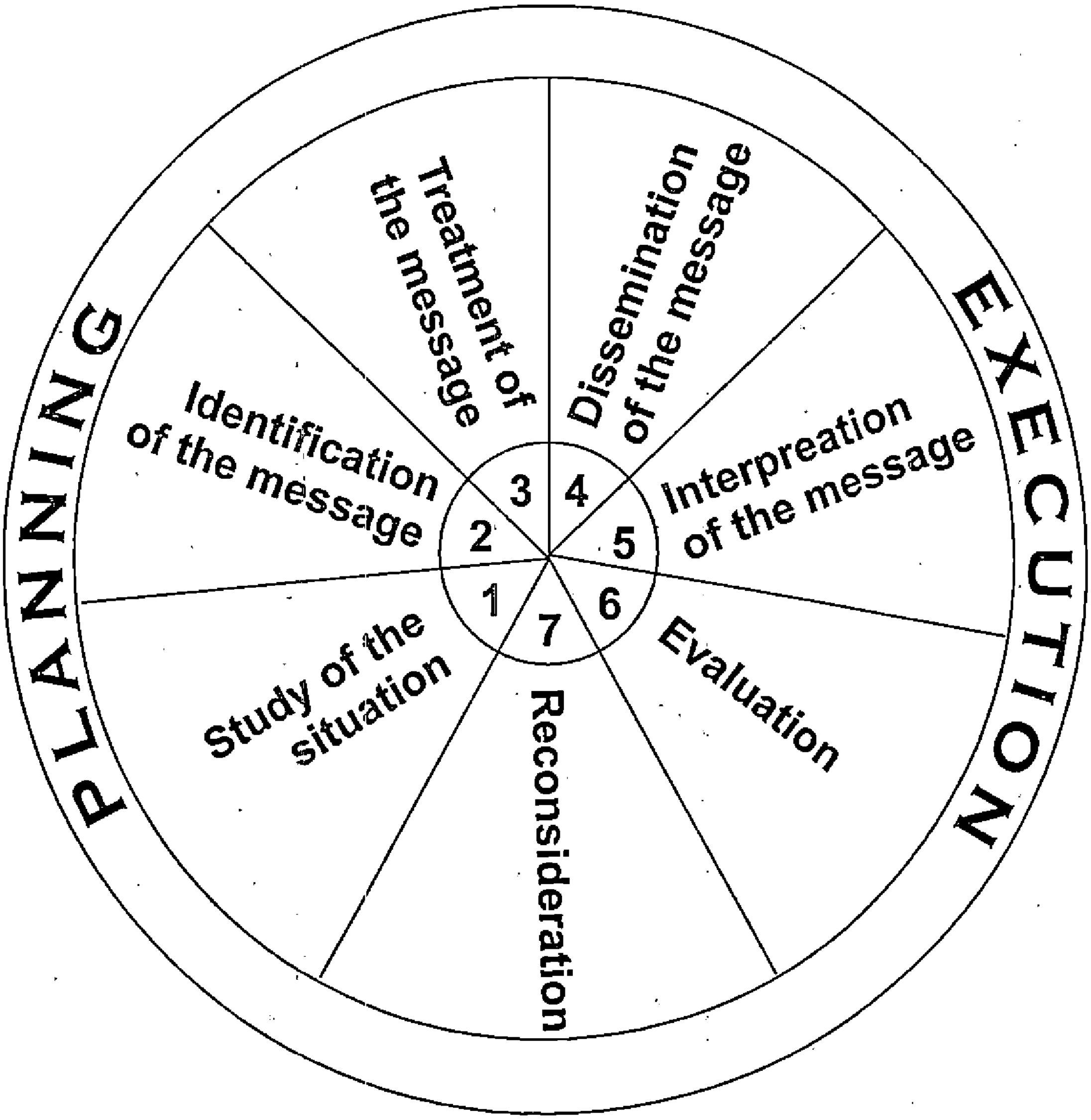
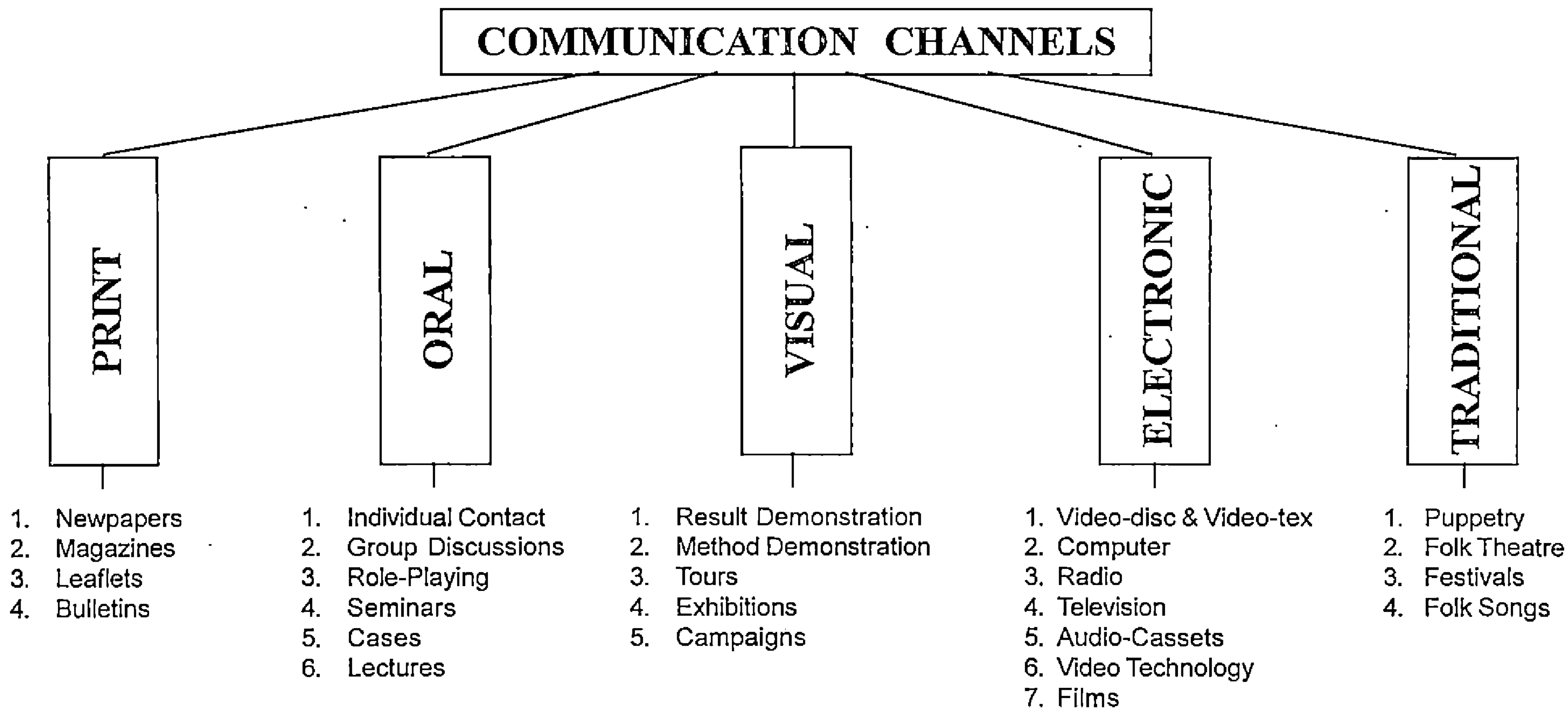


Fig. 1. Steps in Planning a Communication Strategy

1. Available physical resources
2. Situational factors
3. Socio-political factors
4. Values and culture of the social system
5. Human resources
6. Infrastructural support
7. Needs and interests of the people
8. Existing communication channels

Figure 2


COMMUNICATION CHANNELS
PRINT
ORAL
VISUAL
ELECTRONIC
TRADITIONAL
1. Newpapers
2. Magazines
3. Leaflets
4. Bulletins
1. Individual Contact
2. Group Discussions
3. Role-Playing
4. Seminars
5. Cases
6. Lectures
1. Result Demonstration
2. Method Demonstration
3. Tours
4. Exhibitions
5. Campaigns
1. Video-disc & Video-tex
2. Computer
3. Radio
4. Television
5. Audio-Cassets
6. Video Technology
7. Films
1. Puppetry
2. Folk Theatre
3. Festivals
4. Folk Songs

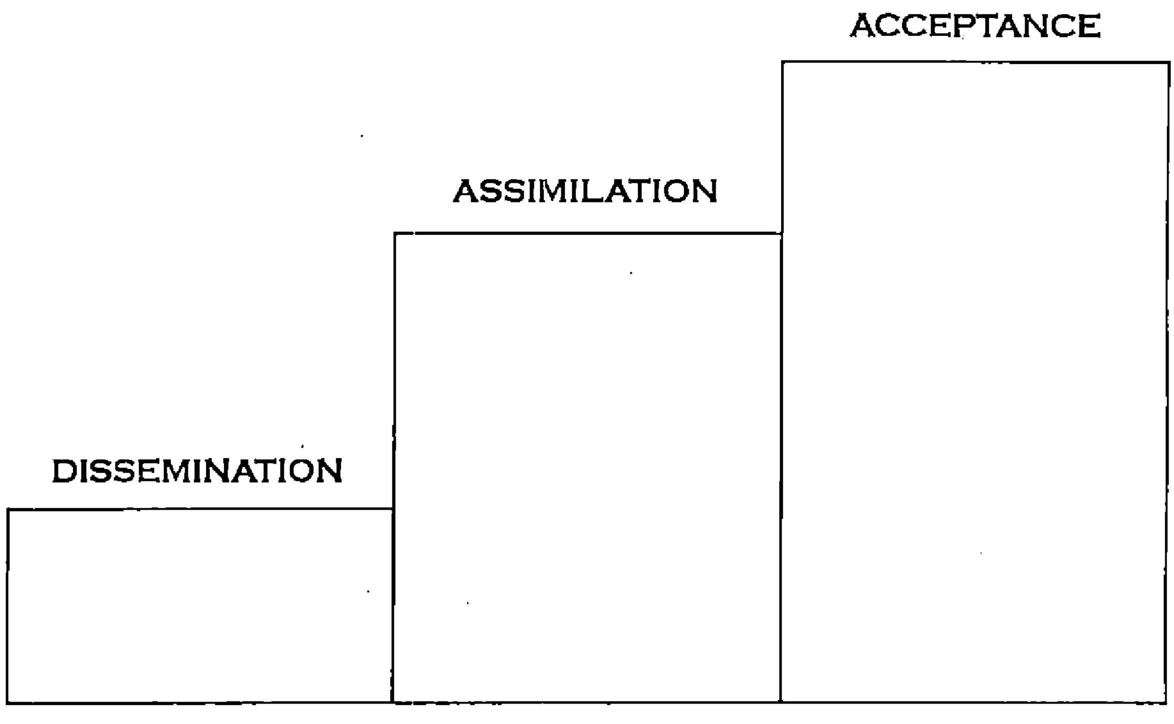
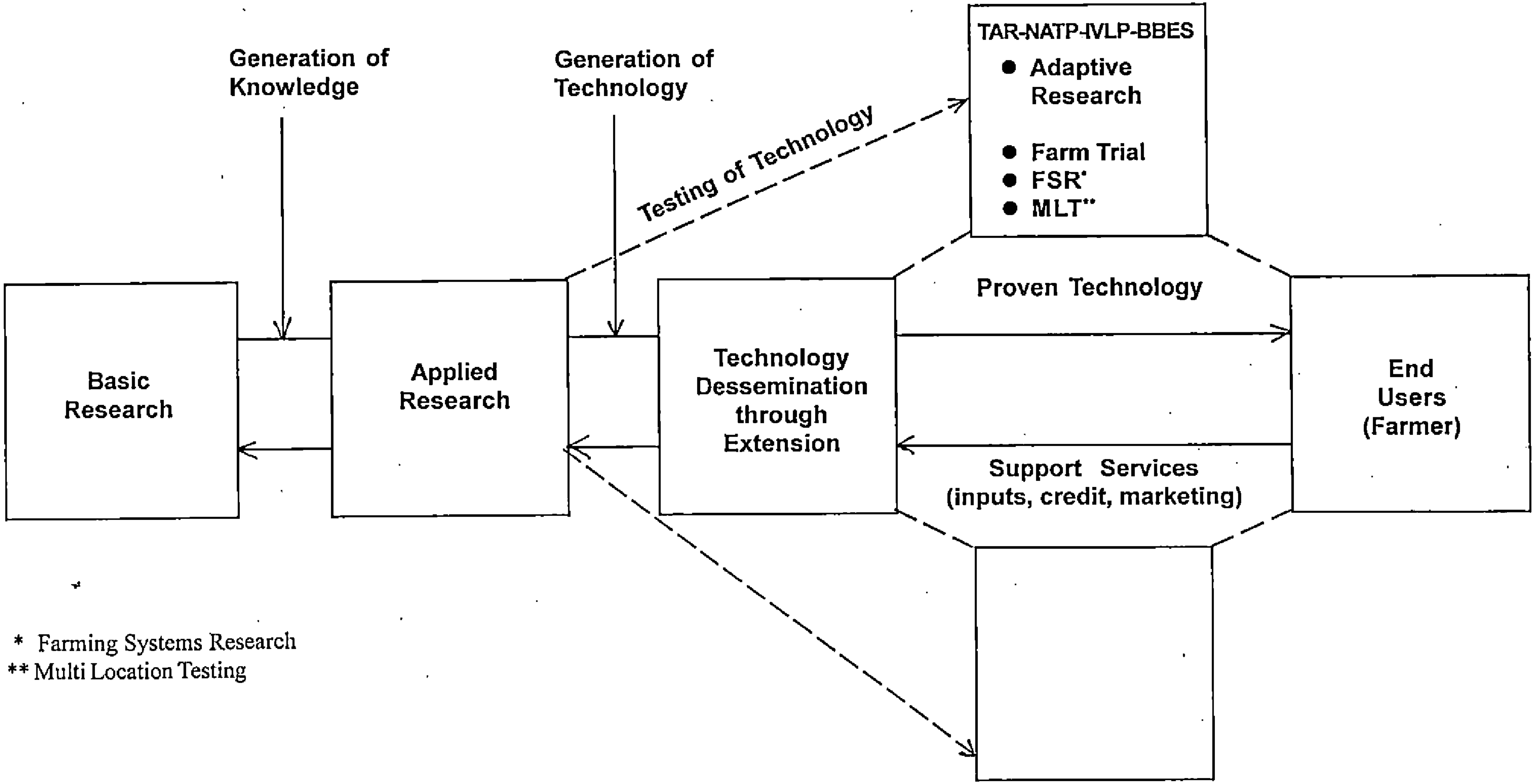


Fig. 3. Technology Transfer Process

1. Dissemination
2. Assimilation
3. Acceptance



* Farming Systems Research
** Multi Location Testing

Fig. 4. Extension: An Essential Component in the Agricultural Development Process

NES - Jack of all., Master of <u>none</u>
BBES - Jack of all., Master of <u>one</u>

Management aspects of problem soils of Kuttanad rice ecosystem

P. H. Latif

Kuttanad region, the rice bowl of Kerala, has a very unique and highly complex ecology. The region is spread over the low land of the Alleppey, Kottayam and Pathanamthitta districts and is separated from the sea by a narrow strip of land. The paddy fields in the region lies 1-2 metres below mean sea level (MSL). Four major rivers, viz. Pampa, Achencoil, Manimala and Meenachil course through the region, periodically replenishing the fields on either banks will rich deposits of silt. They discharge their flow into the Vembanad lake, the life line of Kuttanad, which lies parallel to the sea coast and is connected to the sea at its northern end.

The Kuttanad region consists of the deltaic formations of the four rivers that flow through it, together with the low lying adjoining areas in and around the Vembanad lake. The ecology of Kuttanad is intricately interrelated to the dynamic flux of flood water carried through the rivers, the water level in the Vembanad lake and its quality and the sea water that enters the lake by tidal action when the water level in the rivers fall. Over the years an ecological balance has been struck with the plants and animals both on land and water, providing favourable environment for each in a phased manner. The rivers flow full throughout the monsoon period from May to December. By mid December the river flow dwindles paving the way for entry of sea water through the Vembanad lake and progressively spread throughout the Kuttanad region. The Thanneermukkom salt water barrier constructed in the Vembanad lake, since its commissioning in 1974, has become an integral part of the Kuttanad, playing a decisive role in the Kuttanad ecosystem. The barrier is scheduled to be closed by mid December at the time of high tide, retaining maximum fresh water in the region, to prevent salt water intrusion and opened by March 15th every year.

The Kuttanad region occupies an area of 1157 sq.km. It comprises of 66048 hectares of wet land, 31086 hectares of garden dry land and 18623 hectares of water spread like lake, and back water. Among the wet land 53639 ha are identified as Punja land and are distributed among 1086 padasekharams where rice is cultivated.

Based on the incidence of flood submergence, saline water intrusion and soil acidity, the whole of Kuttanad can be dlineated into seven agro-ecological zones viz. 1. North Kuttanad 2. Upper Kuttanad 3. Lower/Mid Kuttanad 4. Kayal land 5. Coastal Kuttanad 6. Vaikom kari 7. Purakkad kari.

The core of the Kuttanad region consists of two separate deltaic formations; one at the confluence of the three river system, namely Achencoil, Pampa and Manimala and the other formed by Meenachil river located to the North of the former.

The deltaic formation of the three river system, in the basin gradually slopes down to the Vembanad lake and merges with it. Hence the flood incidence and submergence affects the various parts of the delta formation differently. Maximum impact of the flood is felt in the region close the upland, identified as the 'Upper Kuttanad', since there is only limited land area to contain the flood waters. The flood hazards will be minimum in the area adjoining the lake and back waters because of the vast land area available to spread out the flood water. This area is delineated as the Kayal lands. The reverse of this is true with the salinity hazards, Upper Kuttanad being farthest from the lake and back water system experience the least salinity hazards, where as the kayal lands will be severely affected. The area in between the upper Kuttanad and kayal lands is subjected to moderate impact of both flood and salinity and is termed the lower Kuttanad or mid Kuttanad. The upper Kuttanad, Lower Kuttanad and North Kuttanad together forms the Karappadam.

The deltaic formation of the Meenachil river is located to the north of former delta, separated by the kayal lands. This region is subjected to both salinity hazards and flood submergence and is known as the North Kuttanad.

The area lying to the west of these two deltaic formations is formed of undecomposed organic matter and has intense black colour and high acidity. Since these area lie closer to the sea, it is subjected to saline water intrusion. These soils are called Kariland. Karilands are located to the North and South of the Tahnneermukkom barrage. The Vaikom-Vadayar kari is located to the North and Purakkad kari to the South.

The sand dune formation overlaid on clay and silt, that separates the deltaic formation and back water system from the sea is known as the coastal Kuttanad.

Rice cultivation

The main crop in Kuttanad is known as Punja, and is raised from September-October to January-February. The second crop that is taken during the Virippu season from May-June to August-September is known as additional crop and is normally limited to less than 30% of the Punja area because of the risks involved.

Punja lands are devided into identifiable homogenous physical entities called 'Padasekharam' or polder. The punja lands of Kuttanad are classified in to three categories viz. Kayal land, Karappadam and Kariland with reference to elevation, geographical formation and soil characteristics. Karappadams are situated along with the waterways and constitute the lower and eastern reaches of Kuttanad, occupying about 33800 ha. The kayal lands are recently reclaimed lands from the Vembanad lake and lies 1.5 m to 2.5 m below mean sea level and is spread over 8100 hectares.

The *kari* lands are peaty and marshy in nature and has an area of 9400 ha.

The land preparation starts soon after the harvest of the previous crop. The fields are ploughed twice and water is let into the field. During the South West monsoon period, the padasekharams will be flooded to a depth of 2 m or more, often submerging even the outerbunds. Then the whole area looks like a sheet of water. At the commencement of the cropping season in September-October, water from the field is bailed out using a special pumping device called 'Petti and Para'. It is an axial flow pump with low head and high discharge. The field bunds and channels are also repaired.

Women labourers are employed for the removal of undecomposed organic residues and the water weed named 'Payal' from the soil surface and the soil prepared to a fine puddle and levelled by hand. Germinated seeds are sown on the prepared land either on a drained surface or into a shallow depth of water, which is drained the next day. The field is maintained as such till small cracks develop on the soil surface. Then water is let in and the soil is flushed.

Nutrients (N and K) are applied in 3 equal splits, viz: 1st at the time of letting in water 2nd at active tillering and 3rd at pamide initiation stage. P is applied in two equal splits in water soluble form and completed before the active tillering stage.

The fertilizer recommendation is 90-45-45 kg/ha of N, P and K.

The weedicide 2,4-D is regularly used at 15-18 days after sowing (DAS) to control sedges and broad leaved weeds. It is followed by thinning and gap filling around 20-25 days after sowing.

Fields are drained one day before application of fertilizers and weedicides and reflooded 12 hrs after fertilizer application and 48 hrs after weedicide application.

CONSTRAINTS

1. Soil acidity

The soil acidity is inherently high in Karappadam and Karilands. Liming is to be practiced where soil pH is below 5.5. Lime @ 600 kg/ha is applied in two splits, one at basal and the other one month after the 1st application. Occasional flushing with fresh water, without affecting the fertilizer use efficiency is the cheapest and easiest way to control soil acidity.

2. Salinity

The Thanneermukham barrier protects the area south of it by cutting the sea water, from entering into the kayal. Salinity hazards are to be avoided by timing the cropping period well within the safe period.

3. Weed problem

Sedges and most of the dicot weeds are effectively controlled by 2,4-D. But the grassy weeds, especially the Echinochloa and wild rice can not be effectively controlled by the available herbicides. Hence the cultural method of weed control called 'Stale seed bed preparation' is practiced. In this method the weeds on the soil surface are allowed to germinate and grow. Later these weeds are killed by prolonged deep submergence, for 3-4 weeks. Then the soil is drained organic residues removed with minimum soil disturbance. Germinated seeds are sown on the seed bed to get a weed free crop.

4. Lodging

The direct sown crop usually have poor anchorage and hence are liable to lodge. Proper draining of water during active tillering stage of the crop provide deeper roots and more number of tillers.

5. Grain loss due to field germination of crop

Usually the harvest period of additional crop encounters rainy days. Lodging occurring at this period will induce germination of paddy especially when varieties with no-dormant seeds are used. Moncompu varieties Aruna, Makom, Uma and Revathy have seed dormancy and hence are best suited for additional crop season.

Management of Problem Soils of Onattukara tract

Sri. N. R. Nair

The Onattukara region falls in Quilon (Karunagappally Taluk) and Alleppy (Mavelikkara and Karthikappally Taluks) districtsaf the State. The total geographical area of this situation is 722km^2. It is bounded on the Southern side by "Neendakara Azhi" and Ashtamudi lake, on the northern side by Thottappally Pozhi and Kuttanad region, on the eastern side by midland laterite belt and on the Western side by Arabian sea. This situation had a plain level topography.

In olden days this region was considered as Onam - oottukara (meaning ushering plenty). But now it has become an area of low productivity with many constraints limiting production.

Onattukara enjoys warm humid climate. The mean annual rainfall is 2032mm. About 40 percent of the rain is received during the south-west monsoon period. The average maximum and minimum temperature in the situation are 30°C and 25°C respectively.

Onattukara region is mainly located on the coastal belt and it consists of recent sediments of sand and sandy loam. The soil is classified as Onattukara alluvium. The water table is 4.5 metres below the ground level in uplands, and 1 to 2 metres below the ground level in the lowlands during summer period.

A typical soi1 profile characteristics of the situation is given below:

Typifying pedon cultivated Pallipad Sandy Loam

Horizon	Depth(cm.)	Description
1	0-20	Dark brown lOYR 3/3 sandy loam. Weak-medium- opanular loose non stickly and non plastic fine roots plenty, moderately rapid permeability, clear smooth boundary.
2	20-55	Very pale brown (l0 YR 7/3) sandy clay loam, weak medium, sub-angular blocky, very friable, slightly sticky, non-plastic, moderate permeability, gradual wavy boundary.
3	35-70	Soft laterite mixed with soil.

4. Range in Characteristics

The depth of the soil ranges from 40-80cm. The surface texture varies from sandy loam to sandy clay and colour varies from dark brown in hue to YR, with values l to 3 and chroma 3. The structure of the layer varies from weak, medium, granular to sub angular, blocky.

The texture of the sub surface layers are genera-lly sandy loam. The colour varies from very pale brown to yellowish brown in hue 10YR with values 6 to 7 and chroma 5 to 6. Structure of the layer weak to moderate, medium, sub angular, blocky. Soils have moderate permeability.

5. Land use pattern

The total extent of low land in the situation is 28340 ha which forms 11.3% of the net area sown in Quilon and Alleppey district. Rice is raised in the lowlands during 'Virippu' and 'Mundakan' seasons. Sesamum is cultivated in the paddy fields during summer season utilis ng the residual soil moisture. In the uplands two framing situations can be identified. Coconut based farming system is in vogue in the garden lands. There is a special type of land called 'Tharas', which are situated in between the lowland and upland in which mixed cropping of the annual crops is done.

6. Irrigation

The cultivation in the situation depends upon rainfall during the South West & North East monsoon. The spread of the monsoons is erratic causing scarcity of water during the summer period. Pampa and Kallada projects in Quilon Districts, on commissioning was envisaged to irrigate 20,000ha. in this situation.

7. Land holding pattern, population and Socio-economic

Characteristics

The population in the situation is 10.9 lakhs which is distributed in the different taluks (1981 census).

Taluk	Population	Growth rate
Karunagappally	377181	17.44
Karthikappally	364357	10.24
Mavelikkara	352894	9.18

Seventy seven per cent of the population depend upon agriculture. The per capita land availability is 0.13. The cultivators possessing land in the range of 0.5 to 1 ha comes to 131470 and only 9960 cultivators own more than I ha of land. The density of population in the situation is 1493/km^2 which is more than double the state average. The literacy is 74.4% which is much higher than the state average (69.1%).

8. Major crops and cropping patterns / systems

The situation faces shortage of water in the early autumn (virippu season), floods during the latter period of the virippu and early winter seasons (Mundakan) and again waterstress during the summer months. A sesamum crop is therefore taken after autumn and winter rices utilizing the residual moisture in the fields.

9. Cropping systems

1. Low lands (wet lands) - Autumn Rice (Virippu) Winter rice (Mundakan) - sesamum in summer
2. Uplands (Garden land) - Coconut as the main crop Arecanut, Fruit crops as mixed crop. Banana, Cocoa, Vegetables and Yams as intercrop.
3. Upland (Thara lands) - Banana, Tapioca, Pulses, from September-June.

Autumn rice is taken in about 26480 ha during April to August. The average yield for modern rice varieties is 2752 kg./ha and for local varieties 1735kg/ha. The coverage of modern varieties during the season is 75%. The popular varieties are Ptb-23, Pavizham, Onam, Bhagya, Jyothi, Red Triveni etc.

Winter rice (Mundakan) is taken in about 28340ha. The average production during the season, 2149 kg/ha. The modern varieties are grown in about *5%* of the area during this season. The varieties used for the season are ptb.20, Lakshmi, Dhanya, Sagara, Oorumunndakan etc. During the summer months a sesamum crop is taken in about 7427 ha. Kayamkulam-1, Thilothama, Tilak, Thilathara etc. are the popular varities.

10. Adoption pattern and production constraint

The main constraints that limit rice production in the situation are intermittent floods during the monsoon and severe drought during the summer months. Frequent floods and impeded drainage make difficult the application of inorganic fertilizers to virippu crop. There is lack of drainage due to the conversion of paddy lands and blocking of canals by roads. This can be tackled only by creating awareness among the farmers on the need for providing drainage system for each field. Flooding during the later stages of the first crop and early stages of the second crop creates many problems that reduce the yield drastically. Harvesting of the first crop is mostly done in standing water and lodging varieties poses many a problem. Hence farmers are advised to go in for short varieties of rice for the first crop. So also the second crop being transplanted the seedlings should be sufficiently tall enough to overcome the flood during the early stages. The farmers are advised to cultivate tall varieties of rice during this season. So also the lack of rain during the early stages of the first crop and later stages of the second crop is another production constraint.

The low productivity of the Onattukara agro-climatic zone can be attributed to the low organic matter content of the porous sandy soil, resulting in low Water holding capacity. The soil is low in nitrogen and potash status and medium in Phosphorous content. The organic carbon content of the soil is also low. Application of organic manures to these soils is indispensable to improve the soil structure and nutrient status. The non availability of organic manures and their productive cost prevent full adoption of the technology. The clay fraction of this soil ranges from 4 to 10% which shows that the nutrient retention and water holding capacity of these soils are low.

In Onattukara, since the cropping intensity is 300% with two rice crops and one sesamum, there is no time gap for growing a separate green manure crop insitu and incorporating it in the field. Alley cropp-ing of these green manure crops can be practised during Kharif and Rabi. An alternative is to grow green manure crops elsewhere in the garden lands which is mostly coconut garden and incorporate it into the standing crop before transplanting. Vermicompost and coir-pith compost can also be successfully used as an alternative to FYM.

Micro nutrient deficiencies and Fe toxicity is seen in some pockets of Onattukara. Varities tolerant to iron toxicity has to be screened out. Management practices to reduce the ill effects may also be adopted. Suitable technologies like use of slow release fertilizers, deep placement of fertilizers, foliar nutrition, use of nitrification inhibitors etc. have to be developed for manuring the crop during adverse situations. The inorganic fertilizers should be applied in as many splits as possible taking into account the high leaching loss of the sandy loam soil.

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Enriched compost preparation

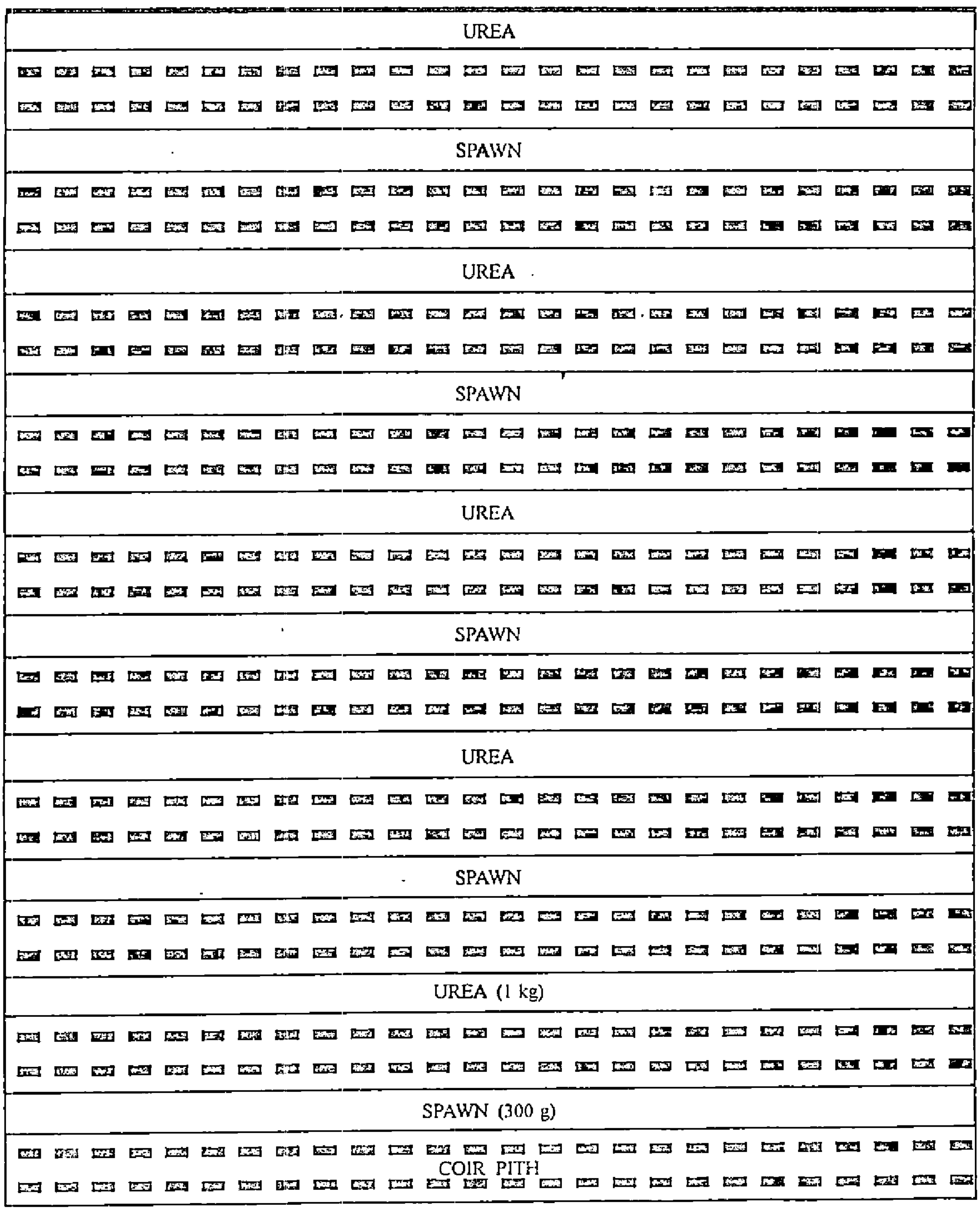
Dr. M. Suharban

Compost is the end product of aerobic decomposition process known as composting in which organic matter are decomposed by micro-organisms.

Coir pith

After the removal of coconuts, husks are used for manufacturing coir. During the process of coir manufacturing fibre dusts along with baby fibres of varied dimensions are rejected out. On an average from 10,000 coconut husks, one tonne coir and one tonne coir wastes are obtained. This coirpith is heaped in and around coir industry and along road side in huge mounds which results in solid pollution of the environment.

Coirpith contain an appreciable amount of Lignin, Pentosan and Hexasan compounds which are resistant to degradation. Besides this it also contain macro and



COIR PITH (100 kg each)

micro nutrients. A technology to compost this waste material and convert the same into manure is described here under.

Materials required

Coir pith	One tonne
Urea	5 kg
Oystermushroom spawn	5 bottles @ 250 gm each

Select a shaded place having 5 x 3 m dimension. First spread 100 kg coirpith uniformly in this place. Then spread one bottle of *Pleurotus sajar caju* spawn on this and cover this with second layer of 100 kg coirpith. On the surface of the 2nd layer spread one kg urea uniformly.

Repeat this sandwiching process of one layer of coirpith with mushroom followed by another layer of coirpith with urea upto one metre height. Sprinkle water now and then to keep the moisture level approximately to 200 per cent. Allow the heap to decompose for 1½ months.

Due to composting the coirpith is being converted into a good manure. The lignin content is drastically reduced from 30 per cent to 4.8 per cent. The next important change that occur is the lowering down in C:N ratio from 112:1 to 24:1.

Due to these changes and content of macro secondary and micro nutrients this composted material act as a good source of organic manure and improves crop growth.

Coirpith has got the unique property of absorbing and retaining moisture to about 500-600 per cent. Further it improves the water infiltration rate. It increases the moisture retention capacity of the soil which approximately accounts to 12 per cent. It also prevents the crack formation in heavy textured soils. Results of experiments conducted in chillies, brinjal. and tomato showed increased yields.

Layout and working of micro irrigation systems

M. S. Hajilal

I. Micro irrigation

Micro irrigation or Drip irrigation, as it is popularly known, is the most efficient irrigation method in areas with water scarcity and salt problems. It is a method of watering plants frequently and with a volume of water approaching the comsumptive use of the plants, thereby minimizing such conventional losses such as deep percolation. runoff and soil water evaporation. This is a method of irrigation which is characterised by the following features:

1. Water is applied at a low flow rate
2. Water is applied over a long period of time
3. Water is applied at frequent intervals
4. Water is applied directly into the plants root zone
5. Water is applied via a low pressure delivery system.

In this method, irrigation is accomplished by using small diameter plastic lateral lines with devices called emitters or drippers at selected spacings to deliver water to the soil surface near the base of the plants. The system applies water slowly to keep the soil moisture within the desired range for plant growth.

Crops like coconut, banana, sugarcane, papaya, guava, vegatab1es and most other types of fruit trees have been found to respond well to drip irrigation.

II. Components of drip irrigation system

A drip irrigation system consists essentially of a main line, submains. laterals and emitters. The main line delivers water to the submains and the submains into the laterals. The emitters, which are attached to the laterals distribute water for irrigation. The mains and submains are usually made of PVC materials and laterals, microtubes and emitters are made of LDPE. PVC/LDPE material is preferred for drip system as it can withstand saline irrigation water and is also not affected by chemical fertilizers.

The total irrigation system has the following components:

- a water source
- a pumping unit
- a fertilizer unit
- a filter unit
- main lines, submains and laterals
- microtubes, drippers/emitters.

III. Design and layout considerations

The following general information are required for the design and layout of a drip irrigation system,

1. Water source

The source of water is usually a well, a tank or an overhead tank.

2. Types of crops

Different crops require different plant spacings and irrigation requirements. The general layout of the system and especially the emitters will depend on the type of crop.

3. Topographic condition

It is necessary to know the general land slope to determine the size and location of the mains and submains. Pressure compensating type of drippers are recommended for sloppy lands.

4. Soils

The soil infiltration rate, water holding capacity, texture, structure and bulk density must be known for selecting emitter type, determining spacing and setting up irrigation schedule.

5. Climatic records

The climatic records will show when and how often an irrigation is needed in various seasons of the year.

Based on the above mentioned information, an economic system is developed to provide:

- Main line design
- Submain desin
- Lateral design
- Dripper details
- Filtration requirement

Consideration for PVC main and submain

The length and dimensions of main and submain depends mainly on the location of available water source. area to be irrigated and the water requirements. Basic flow equations in hydraulics are to be considered for working out proper dimensions of the mains and submains.

Consideration for lateral design

Because the drip lateral is such a significant component in regard to pressure variation, proper evaluation of frictional head loss in the lateral is essential to achieve optimum uniformity for emitter characteristics. Considerations for design are:

1. Evaluation consideration
2. Multiple outlets
3. Frictional losses in lateral
4. Emitter discharge versus pressure performance

Consideration for Dripper Selection

There are numerous varieties of drippers available. An ideal or perfect emitter would meet the four following objectives:

i) Should be compact, serviceable and inexpensive
ii) Should have relatively low discharge
iii) Should not vary significantly with pressure
iv) Should have a large cross sectional area to avoid clogging

Considerations for Filtration Requirements

Clogging of drippers or emitters has been a ma.jor problem in drip system performance. This can be due to:

i) presence of salts in water.
ii) suspended inorganic clay, silts, etc.
iii) presence organic matters (algae, weeds, bacteria etc.)

There are two types of filter system commonly available, they are:

1) Screen Mesh Filters

A sceen mesh filter is useful primarily for removing inorganic particles in water containing significant amount of organic matter. Accumulated particles in screen filters require frequent flushing.

2) Sand filters

Sand media filters are most effective in the removal of suspended inorganic and organic particles from water. These filters are capable of extracting and retaining large volumes of suspended soilds while continuing to deliver the rated flow of filtered water.

IV. Maintenance of the drip system

Periodic preventive maintenance is the key for the successful working of microirrigation systems.

1) General Maintenance

a) Check emitter functioning, wetting pattern and zone, leakage of pipes, valves, fittings etc.

b) Check the placement of drippers. If the placement is disturbed, put the drippers in the proper location.

c) Check leakage through filter gaskets in the lids. flushing valves., fittings etc.

2) Filter cleaning

Filter failure will lead to the clogging of the entire system. For sand filter, back-wash it daily for five minutes to remove the silt and other dirt accumulated during the previous day's irrigation. For the screen filter, open the flushing valve on the filter lid so that the dirt and silt will be washed out. Open the filter and take out the filter element. Remove the rubber seals and clean the filter element from both sides.

3) Submain and Lateral Flushing

To remove the silts and accumulated particles in submains. frequent flushings by opening the flush valves fitted in submains are to be carried out. The lateral lines are flushed by removing the end stops.

4) Chemical Treatment

Chemical treatment commonly used in micro irrigation systems include addition of chloride and\or acid to the water supply. The frequency and the rate of the chemical treatment is to be finalised after conducting detailed water analysis.

Acid Treatment

Hydrochloric acid (HCl) is injected into drip systems at the rate suggested in the water analysis report. The acid treatment is performed till a pH of 4 is observed at the end of lateral lines. After achieving a pH of 4 the system is shut for 24 hours. Next day the system is flushed by opening the flush valve and lateral ends.

Chlorine Treatment

Chlorine treatment, in the form of bleaching powder is performed to inhibit the growth of microorganisms like algae and bacteria. The bleaching powder is dissolved in water and this solution is injected into the system for about 30 minutes. Then the system is shut of for 24 hours. After 24 hours the lateral ends and flush valves are opened to flush out the water with impurities. Bleaching powder treatment is also useful for clearing salts/slimes created due to bacterial action on iron and sulpher. Copper sulphate is also good for inhibiting bacterial/algae growth but water with copper sulphate is very toxic and should not be consumed by humans and animals.

V. Advantages of drip irrigation

a) water saving (30% - 70%)
b) high water application efficieny, upto 90%
c) higher yield
d) less weed growth
e) operates on low pressure
f) less labour requirement for operation
g) application of fertilizer along with water
h) reduces salt concentration in root zone
i) best suited for widely spaced crops
j) reduces soil erosion

VI. Disadvantages

a) high initial investment
b) requirement of clean water
c) clogging of the emitter tubes
d) requires proper maintenance
d) poor water distribution efficiency on steep slopes.

VII. Cost analysis

The cost analysis for one hectare coconut garden is given below. This is only a guideline to work out the expenditure incurred for the installation of a drip system. The actual cost may vary with the water source available, the nature and shape of the field and the type of crop.

It is assumed that

(i) the shape of the field is rectangular (200m x 50m),

(ii) water source is 150 m away from the field,

(iii) submain line is given for 50 m length,

(iv) 200 coconut palms are there in the field and

(v) 4 drippers are provided for each palm.

Filter unit	:	Rs.	1500/-
Main line, 40 mm PVC (150 m) @ Rs. 40 per m	:	Rs.	6000/-
Submain, 25 mm PVC (50 m) @ Rs. 30 per m	:	Rs.	1500/-
Control valves, 4 nos. @ Rs. 350/-	:	Rs.	1400/-
16mm LDPE lateral (1500 m) @ Rs. 6 per m	:	Rs.	9000/-
3mm microtubes (1200 m) @ Rs. 2 per m	:	Rs.	2400/-
3mm pin connector (1200 nos.) @ Rs.1	:	Rs.	1200/-
Drippers, (800 nos.) @ Rs. 2.5	:	Rs.	2000/-
Other pipe fitting accessories (bend, coupling, end caps, flush valves,lateral connectors etc.)	:	Rs.	3000/-
Installation charges (labour & supervision)	:	Rs.	2000/-
TOTAL	:	Rs.	30,000/-

Internet surfing

P. Sanjeev

Introduction

Internet is popular among scientists and is probably the most important scientific instrument of the late twentieth century. The powerful sophisticated access that it provides to specialized data and personal communication has sped up the pace of scientific research enormously. It has become a forum for human communication in wide variety of disciplines ranging from computers, medicine, bioscience, social science etc.

1. Internet

1.1. History

In a remarkably short time, the Internet has evolved from an academic curiosity to a mass medium. It has been heralded as the basis of economic salvation for developing countries, as a new scholarly communications system and even as an entertainment alternative to television.

The earliest experiments in what later became the Internet began in 1966 with the United States Department of Defence Advanced Research Projects Agency (DARPA). The first nodes in the resultant ARPANET were created in 1969. In 1977, the TCP/IP (Transmission Control Protocol / Internet Protocol) protocols that underlay the Internet were demonstrated for the first time. In 1986, the National Science Foundation (NSF) created the first NSFNET backbone and allowed regional networks, mostly supporting universities, to feed into the backbone. By 1990, the Internet was supporting commercial activities. Even after all this growth and development, some basic TCP/IP protocols remain in use and still serve to unify the Internet. In March 1989, the first World Wide Web (WWW) proposal was elaborated and circulated at the European Laboratory for Particle Physics (CERN) in Geneva, Switzerland, and in November, 1990 the first proto-type web browser was created.

2. Uses

Internet is a world-wide collection of computers. Each computer is a treasury of information compiled by a number o

1. Exchange E-mail with any of the tens of millions of people with E-mail addresses. There are estimates that about 40 million people are on the Internet.
2. Search for, retrieve, and read literally millions of files stored on computers throughout the world.
3. Search for and bring to your computer, shareware, freeware and commercial software.
4. Search databases of governments, individuals and organizations for files on tens of thousands of topics.
5. Join specific topic-oriented discussion groups (known as news groups, about 15,000 to 20,000 of them are there).
6. Send and receive program data files such as desktop publishing files, spreadsheets, CAD files or word processor files, which you or the receiver can immediately start to work on.
7. Send or receive sound, animation and picture files from very distant places
8. Set up temporary or permanent discussion of work-oriented groups.
9. Browse through resources of private or public information services that are on the Internet.
10. Communicate in real time, with others connected to the Internet.
11. Browse and search 'Catalogues' of goods and services, and purchase items on-line.
12. Conduct test marketing
13. Distribute / read electronic publications
14. Sell products and services

Enumerated above are some of the uses of the Internet, which are commonly known at this time. These are like

3. Surfing

The important thing to realize is that the Internet permits almost anything. There is in fact goldmine of information available but problem is knowing what is where and how to get at it. To a novice, it seems wildly exciting at first to have a huge array of 'hits' to be scanned. The world is at one's feet with a few keystrokes. When he goes through the 'hits', he may feel that eventhough it is interesting, it is not exactly what he is looking for. There are usually two result of most searches performed.

- One finds something worthwhile
- One doesnot

The latter happens because people do not know how to search or people are not able to clearly state what they want.

Searching the net is like searching a library. We can either browse the library or search for a specific book by its author or title or by subject. The subject search is very useful in libraries because of the subject wise order followed in libraries. But most areas in the web have not been in an organized manner. Internet is thus a huge unindexed uncatalogued library.

Internet is not a controlled institution. No 'publisher' checks for the authenticity of contents. So there is no guarantee that everything found through the net search is of value or authentic. Everything on net is not free. There are some areas which requires payment. URL's move or change so also the contents. So one finds today may be difficult to find tomorrow if the site manager has decided to change the page. Remember, internet is a great reference source, if searched properly and with a recognition and awareness of its limitations.

In the web, a search is usually done by putting in a key word in a search box and getting hits. When the computer retrieves documents on the search terms, the hits contain documents which contain the terms. The documents may or may not be about the exact search term because the search engine pulls out and 'ranks' the retrieved documents by the number of times the word has appeared.

Surfing the net is not easy, there is a lot of junk out there, and it can be frustrating to sift through it all. There are many variables in a web database, and different types of searches demand different types of web databases. We can't use the same database for all of your searching just like we can't use the same reference book for all of your questions. You need to select the proper tool for your searches.

4. Search engines

Web databases, commonly known as search engines or web directories are currently the most useful way to search the internet. A web database is an organised listing of web pages. Its like the card catalogue that we might find in the library. The database holds a surrogate (like title, holdings etc.) for each page. The creation of this surrogate is called indexing and each web database does it in a different way. Web data bases hold surrogates for anywhere from 1 to 30 million web pages. The program also has a search interface, which is the box we type words into or the lists of directories we pick from. Thus each web database has a different indexing method and a different search interface.

The internet provides a link to many valuable information sources with no centralised database for organisation and searching. Many individual web databases and their attached search engines accessible through the World Wide Web compete to provide subject and keyword access to information available through the internet. These databases are created by both humans and automatic computer programs called 'spiders' or 'robots'. As there is no standard (like AACR followed in libraries) for descriptions of web pages, each engine provides access in a unique way to a different database.

The major search engines used in finding out Internet resources are the following.

4.1. Yahoo (http://www.yahoo.com)

A few years ago, Yahoo took on a hip status as the first place to go to look for something on the web and the two graduate students who created it have become big time Internet entrepreneurs. Yahoo has been enhanced, expanded, enameld and was the first to establish itself as an Internet Home Companion. Yahoo now offers Yahooligans for kids and even publishes a magazine in paper. Yahoo features extensive categories and sub-categories and under sub-categories. The search engine finds a simple, easy and straight forward way to locate web pages others find it a bit tendious especially since Yahoo suffers from being lethargically slow to up-to-date its links. The slowness comes in part from the size of Yahoo's database and the way it was created Yahoo relies mainly on user submissions both to add links.

And remember that the description of the sites were created by the people who maintain the site, not from and independent reviewer at Yahoo.

4.2. Alta vista (http://www.altavista.com)

It is one of the largest and most popular search engines of today. It indexes every word on every page of the records in its database. The searches are exhaustive and may produce too much rather than too little. So it is better to use Advanced Search Page for finding exact matches. Ask Alta Vista is another option. It borrows technology from 'Ask Jeeves' that asks for a question in our own words. Alta Vista's help screen describes many other search tips. One search technique is searching by the link label.

4.3. Excite Netsearch (http://www.excite.com)

Excite's web searching database is huge, if not quite as enormous as same of its competitors, and its main page offers as many extra services as any of the Internet Home Companions. If we search AOL Net Find or Netscape Search, we are really using the Excite search engine.

4.4. Hotbot (http://www/hotbot.com)

Hotbot is a comprehensive search engine with an enormous database and has a unique menu driven search system for adding precision to the searches. Its expert modes permit us to modify our search even further with such limits as media types, type of page, or location. Its direct hit feature analyzes millions of previous searchers and presents results based on what sites people have selected most often after doing similar searches. Hotbot is powered by 'Inktomi' which began as a research prototype database at the University of California at Berkeley.

4.5. Lycos (http://www.lycos.com)

One of the oldest and still one of the most precise web indexing tools. It doesn't index the full text of documents, which may help with precision, but that also means we will usually get fewer results than similar searches using Altavista and Hot Bot. The Lycos site has been revamped several times since it went from a Carnegie Mellon site to a commercial venture. With its latest major revision, Lycos was greatly improved with the additional of Lycos Pro. With options to narrow a search intelligently as well as allowing you to search for sounds, pictures, or its choice of 'Top 5 %' sites.

4.6. Infoseek (http://www.infoseek.com)

This resource both basic and advanced search modes, plus a directory of channels which serves as a some what yahoo subject index. Its basic search mode gives us more hand-holding. Once we produce a list we can narrow our search by doing a follow-up search within the first one. One nice feature of Infoseek is a separate page for some special searches : images, sites, links URLS. In addition to its simple search mode, it offers, 'Ultraseek' which is supposed to be bigger, faster and more advanced than its competitors. A special feature of Ultraseek is the ability to enter a query in plain English.

5. Using a search engine

The four main steps in using a search engine :

1) translation from our search request into search terms that we type
2) methods of combining the search terms to give the computer more information about our search request
3) examining the results presented
4) re-searching if needed.

This cycle can be repeated as necessary until we have found that which we are looking for or we decide that we have exhausted the selection from this search engine and we move onto another tool.

5.1. Translation of the search request into search terms

A simple way to conduct a search request to search term is as follows.

eg:- 'I want to get production statistics of tuber crops' and turn it into a search request. The burden falls to the user to make their search request as simple and specific as possible. Here are the steps to do that.

5.1.1. Think through the search request we have, and vocalize exactly what we are looking for (Instead of 'I want to get production statistics of tuber crops', expand your request to say 'I want to get country wise production statistics of tuber crops especially cassava'. Come up with as much detail as we can about our search. To be successful, we must be specific. Computers cannot read anything from our tone of voice and will not add in anything that's not there.

5.1.2. Break down our search request into its individual facets. In this example facets would be 'production' 'statistics' and 'tuber crops / cassava'. If two of our facets are similar, combine them. This will simplify our search to focus on the important ideas.

Once we have done this two steps we have the basics of searching - a handful of very specific facets, which if combined, make up the whole of our search request. However these are still something to consider, when selecting our search terms. Never use articles, pronouns, conjunctions, prepositions, action terms and modifiers in your querries.

5.1.3. Synonyms

It will always help if we will come up with synonyms for each facet in our search request. The more synonyms we can come up with for each facet, the better chance the computer will have of matching our search request. CAB Thesaurers is an effective tool in finding out synonyms, homonyms in the subject of Agriculture and allied sciences.

5.1.4. Homonyms

We must be cautions of choosing words that have more than one meaning (like China / china or Polish / polish). The computer doesn't know the difference and can't tell the context of the terms. Just avoid these terms if at all possible.

5.1.5. English dialects

If our word is spelled differently in our English and other dialects of English (American, Britain, Canadian etc.) we need to include all variations for an inclusive search. Words like cobr/colour or catalog/catalogue will allow us to select pages from one country or the other. If we want pages from both countries, we will need to include both spellings in our search. Similarly being aware of different teras used will help us with successful searching. If this is a concern, look at Britspeak, a UK-US and US-UK dictionary for some help.

5.1.6. Truncation

Trunction involves trying to look at multiple forms of a word (like woman and women) we can indicate this with a symbol (for eg: wom*n). Search engines have different symbols for truncation. Some engines, like Lycos only allow 'right truncation' (for eg: child$ for children, child, childlike, childhood). Try to use the simplest form of each word in our search facet and use truncation symbols.

5.2. Combining search terms

By indicating a relationship between our search terms, we can help the computer rank the pages in an order that is more relevant to us. We can do this through phrase searching Boolean logic, pseudo-Boolean logic and term weighting.

5.2.1. Phrase searching

This is the most powerful of the combination techniques, and we should always use it if possible. When we are creating our search terms, if there are words that usually go together in a phrase, we can indicate that by placing them in quotes.

5.2.2. Boolean logic

This is placing the words 'AND', 'OR' and 'NOT' to indicate a relationship between the search terms for the web database.

'AND' – By putting the word 'AND' between two terms, we are tellng the database "I want to find pages that have both of these terms. The page is not useful to me if its only got one or the other".

'OR' – The term 'OR' is used to indicate a broader search. In the example given above 'tapioca' or 'cassava' we will get all records covering both the terms. Between synonyms of the same facet we place 'or' and to combine both facets in the same record we use 'AND' grouping by using parenthesis is also helpful in conducting searches because it groups a facet. Most search engines automatically put (and / or) between each search term we enter, if we do not specify a connector. This helps al of the entries first that contain all of the search terms, and then listing those that contain some of the search terms. A disadvantage to this is that we might not know when entries stop matching all of the search terms.

'NOT' – NOT can be used in specific circumstances, such as given us a way to use a homonym. If we want to look up things that are Polish (ie. from Poland) and we do not want anything on 'Shoe Polish' we can use (Polish NOT Shoe). Notice that we should always use NOT in parenthesis.

In short, 'AND' is used for the combination of facets for narrowing search and 'OR' is used in synonyms terms to broaden searches.

5.2.2.1. Pseudo-Boolean Logic

Many of the search engines allow 'natural language' searching, which involves two symbols, + and - for pseudo-boolean operations.

If we include a + before a search term of a phrase, it means that the term must be in all sites that are retrieved. It is very similar to a Boolean AND. If we want pages about an individual, such + 'Micheal Johson'. We would gather all of the pages with the phrase 'Micheal Johnson' on them, and then move the pages with the other terms to the top of the list.

if we include '—' before a search term or phrase, it means that the term should not be in all sites that are retrieved. It is similar to the Boolean NOT.

5.2.3. Term weighting

By 'Weighting' we are telling the search engine that some terms are more important to us than other terms. Different search engines have different techniques for weighting.

If we have a higher number of synonyms for one search facet, that facet will carry more 'weight' in the relevance ranking. Thus if there is a facet of the search that we feel needs to be brought out, enter more synonyms for that term.

5.2.4. Advances operators

There are some additional Boolean operators that provide more control than AND and OR. These operators are less frequently used and are not all supported by search services with baric Boolean capabilities.

1) NEAR operator
2) BEFORE operator
3) AFTER operator

5.2.4.1. NEAR operator

Most search engines that support the NEAR operator have a set value of a ten word maximum distance.

The NEAR operator is to ensure that your search terms occur within the same sentence or same paragraph.

5.2.4.2. BEFORE and AFTER operators

This operators work in the exact manner as the NEAR operator but we can specify which terms or phases need to come first or second. In the case of BEFORE operator, the first term or phrase MUST occur before the second term or phrase within the specified word distance. In the case of AFTER operator, the first term or phrase MUST occur after the second term or phrase within the specified word distance.

Examples for searching the web

Request : I want to find pages on punishment of deaf children in elementary school.

Facets - Punishment, Deaf, Children, Elementary School
Synomyms for Punishment : - Punish, Spank, Discipline
Synomyms for Deaf : Deaf, hearing impaired, mute
Synomyms for children : Child, children, youth, students
Synomyms for elementary school : Primary school

Here the possibilities of truncation arise ie.,

Punish*, Spank*, discipline*
Child*, youth, student*

Boolean construct

eg: (punish* OR spank* OR discipline*) AND
(deaf OR "hearing impaired" OR mute) AND
(child* OR youth OR student) AND
("elementary school" OR "primary school")

Simpler Boolean Construct

eg: punish* AND deaf AND child* AND school (this is similar and is easier to type)

Pseudo Boolean

eg: + punish*-+ deaf child* school

(This says we definitely want punish and deaf in there, and then want stuff about children and school near a the top of the list)

5.3. Examining the results

When we get our results, look at 50 listing - and if there is nothing at all about our topic, try a different search or a different search engine. The more time we spend on terms selection and combination, the less time we should have to spend on result analysis. When looking at our results, glance at the www addresses - pages with similar addresses are probably from the same site, and can be skipped over once we have seen the site. The best type of page to look for is one that has other links on the same topic. Another good term to look for is FAQ

(Frequently Asked Questions) for an introduction to a topic. If we don't find what we are looking for, then we must either change our search or more to a different database.

5.4. Researching if we need

If we want to change the search, the best way to do so is examine pages that are like what we are wanting. If we can find one page that's similar to what we are looking for, read over that pages for phrases, synonyms, or search facets we could add into our search. Many times, other pages will jog our memory for another term to add.

If the page selection we get is too broad, we need to add more terms with 'AND'. If the selection we get is too narrow, we need to remove search facets or change some AND's or OR's. If there are lots of articles on a facet that ignore the other facets, remove some synonyms from that facet. However the fewer search terms we have, the more pages we will have to go through to find what we want.

Some search engines such as Excite, Infoseek have a button we can push to 'find more pages like this one'. By using this feature we can narrow down to a group of relevant documents quickly. This is a good feature when we are having a lot of trouble coming up with synonyms - if we can find one page we like, we can easily find others.

6. Conclusions

Search engines are the most common way to access the data in a web database. The basic steps to using one are

1) Specify and simplify the search request
2) Break the request up into search facets
3) Develop synonym for each facet
4) Create phrases when possible
5) Link the synonyms for each facet together with OR, and link the facets together with AND.
6) Go through a least 50 results before starting again.
7) Use pages that are similar to the one we want for new synonyms and facets to add.

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRONOMY

COLLEGE OF AGRICULTURE, VELLAYANI

SHORT COURSE ON

"CROP RESOURCE MANAGEMENT IN HUMID TROPICS"

3-8-1999 to 12-8-1999

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