SOUVENIR & ABSTRACTS

NATIONAL CONFERENCE ON HORTICULTURE IN NORTH EASTERN REGION

January, 16-18, 2016

Theme

Horticulture for Nutritional Security and Economic Prosperity

Organized by

College of Horticulture and Forestry

Central Agricultural University, Pasighat-791102, Arunachal Pradesh

In Association with

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Department of Biotechnology Govt. of India

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जे.पी.राजखोवा
J. P. Rajkhowa

राज्यपाल
अरुणाचल प्रदेश
राज भवन, ईटानगर-७९१ १११

GOVERNOR
ARUNACHAL PRADESH
RAJ BHAWAN, ITANAGAR-791 111

MESSAGE

I am pleased to learn that the College of Horticulture and Forestry, Central Agriculture University, Pasighat is organizing a National Conference, with a theme 'Horticulture for Nutritional Security and Economic Prosperity' from 16th to 18th January 2016. I hope that the Conference will go a long way in providing better nutrition to people through fruits and vegetables and also additional income and employment avenues to small and marginal farmers through vegetables and quick growing fruits. Arunachal Pradesh has already established a national record as the largest producer of Kiwi fruits in the country.

Arunachal Pradesh with its undulating topography and varied agro-climatic conditions offers vast potential for Horticultural activities such as growing varieties of tropical, subtropical and temperate fruits, vegetable including off season vegetables, spices, aromatic and medicinal plants flowers and mushroom. Since time immemorial, the indigenous communities have been practising organic Agri-Horticultural farming, which are nutritious, wholesome and natural. This aspect should be encouraged and step should be initiated for its certification. I wish that the innovative ideas and latest scientific methods discussed in the Conference percolate down to the indigenous communities and entrepreneurs in this sectors. Such initiative of this College of Horticulture and Forestry will definitely enhance the rural economy; promote entrepreneurship and progressive farmers and open doors for more employment generation.

On this special occasion, on behalf of the people of Arunachal Pradesh and my own behalf, I convey Warm Greetings to the College Fraternity and all the participants and extend our Best Wishes for successful conduct of the National Conference.

(J. P. Rajkhowa)

राधा मोहन सिंह
RADHA MOHAN SINGH

सत्यमेव जयते

कृषि मंत्री
भारत सरकार
MINISTER OF AGRICULTURE
GOVERNMENT OF INDIA
Office: Room No. 120, Krishi Bhawan,
New Delhi-110 001 Tel.: 23383370

MESSAGE

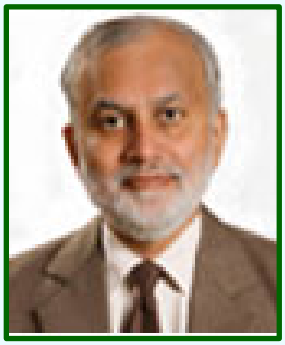
I am pleased to note that the College of Horticulture and Forestry, Central Agricultural University, Pasighat is organizing **National Conference** from 16th to 18th January, 2016 with the very broad thematic area "Horticulture for Nutritional Security and Economic Prosperity"

India's North-Eastern Region, comprising states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, has immense potential to grow an array of cereals, fruits, vegetables, medicinal and aromatic crops round the year. Unfortunately the growth potential of these crops is not realized owing to due to lack of system-specific production technologies, poor infrastructure like transport, markets, processing etc. Further, prevailing shifting cultivation in different parts of the region is also one of the major concerns before planners, policy makers, agriculture scientists as well environmentalists. Despite of these adversities, region has several novelties in terms of its rich genetic wealth, world's highest precipitation, bright sun shine hours and well knitted river and rivulets, which needs to capitalized. Apart from these, whole region has unique system of tribal farming where despite of small holdings every components of agriculture is nicely embedded and is part and parcel of their culture depicting the true picture of crop diversification. I am well sure that this event will provide an appropriate platform to researchers as well as participants to interact with each-others to evolve strategies to achieve significant and desired growth of horticulture in the region.

I extend my greetings to the organizers and wish National Conference a grand success.

(Radha Mohan Singh)

डा. एस अय्यप्पन
Dr. S. AYYAPPAN



सत्यमेव जयते

सचिव एवं महानिदेशक
भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग
एवं
भारतीय कृषि अनुसंधान परिषद्
कृषि एवं किसान कल्याण मंत्रालय,
कृषि भवन, नई दिल्ली ११० ००१

SECRETARY & DIRECTOR GENERAL
GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIA COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE AND FARMERS WELFARE
KRISHI BHAWAN, NEW DELHI-110 001

MESSAGE

I am happy to know that the College of Horticulture and Forestry, Central Agricultural University, Pasighat is organizing a **National Conference** on "Horticulture for Nutritional Security and Economic Prosperity" during 16th to 18th January, 2016.

The north-eastern region, comprising Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, is characterized by diversity of climatic, soil and topographical conditions allowing for cultivation of all kinds of fruits, vegetables, ornamental, medicinal and aromatic plants. In recent past, region has made commendable progress towards production of quality oranges, pineapple, banana and an array of vegetables including underutilized and lesser known vegetables. For enhancing the growth in horticulture sector in the region quality seed and disease free transplants are indispensible. Presently the whole region is as one of the suitable niches for organic production to a number of fruits, vegetable and flowers ready to fetch premium price in national and international markets. In this context, well planned research strategies are needed to standardize the organic protocols for production of high feathered fruits, vegetables and flowers.

Given the fragile environment conditions of the region, I am sure the Conference will discuss the prospectus of horticultural production, from seed to market, providing a strategic framework for value addition and profitability.

I wish the National Conference a grand success.

(S. Ayyappan)

प्रो. आर.बी. सिंह
Prof. R. B. Singh

कुलाधिपति
केन्द्रीय कृषि विश्वविद्यालय
इरोइसेम्बा, इम्फाल-७९५००४, मणिपुर
CHANCELLOR
CENTRAL AGRICULTURAL UNIVERSITY
IROISEMBA, IMPHAL-795004, MANIPUR

MESSAGE

I am pleased to note that the College of Horticulture and Forestry, Pasighat, of the Central Agricultural University, Imphal, is organizing a National Conference on "Horticulture for Nutritional Security and Economic Prosperity" from 16th to 18th January, 2016.

I congratulate the organizers for having chosen a highly topical theme as horticulture-led diversification of agriculture is proving crucial for food, nutrition and income security in the country. India has made quantum jump in production of horticultural crops, multiplying from 97 million tonnes in 1990-91 to an all time high of 278 million tonnes in 2014-15, rendering India the world's second largest producer of horticultural commodities after China. During the same period, area under horticulture increased from 13 to over 23 million ha, whereas average yield of fruits grew from 7.5 to 11.5 tonnes per ha and that of vegetables from 11 to 17 tonnes per ha. Christened as the Golden Revolution, the horticultural transformation is playing an important role in alleviating nutritional insecurity and agrarian poverty in the country.

Given the agro-ecological and socio-economic diversity and productivity gaps, a strategically differentiated approach is called for harnessing the untapped nutritional and economic potential of veritable horticultural commodities. The North Eastern Region of India comprising eight states, namely, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim offers vast scope to grow an array of fruits, vegetables, flowers and medicinal plants. In fact, this "Natural Economic Zone" is one of the richest reservoirs of genetic variability and diversity of different fruit and vegetable crops. The Central and State Governments have been pursuing new programmes to harness the bio-wealth, but there are serious gaps in outcomes. Besides development and adoption of new production technologies, knowledge and innovations, concerted efforts are needed for post-harvest management, packaging, transport, prevention of losses, value addition, processing and quality control. Poor linkage of producers with markets and unsatisfactory pricing mechanisms are the major constraints. I sincerely hope that the Conference will duly discuss these issues and come up with a roadmap for horticulture-led alleviation of under-nutrition and poverty in the country, especially in the North Eastern Region.

I convey my best wishes to the organizers and participants for grand success of the National Conference.

(R.B. Singh)

प्रो. एम. प्रेमजीत सिंह
Prof. M. Premjit Singh

कुलपति
केन्द्रीय कृषि विश्वविद्यालय
इरोइसेम्बा, इम्फाल-७९५००४, मणिपुर
VICE-CHANCELLOR
CENTRAL AGRICULTURAL UNIVERSITY
IROISEMBA, IMPHAL-795004, MANIPUR

MESSAGE

It is a matter of extreme delight to know that our College of Horticulture and Forestry and Krishi Vigyan Kendra, Central Agricultural University, Pasighat is organizing **National Conference** and **Arunachal Agri Expo** w.e.f. 16th to 18th January, 2016 and publishing souvenir to mark the occasion.

The state of Arunachal Pradesh is the richest bio-geographical province of the Himalayan zone and its entire territory forms complex valleys to slant sloppy hill system traversed throughout by a number of rivers and rivulets. Nature has endowed this state with diverse forests and magnificent wildlife. The richness of life forms i.e. the flora & fauna that occur in these forest presents a panorama of biological diversity with over 5000 plants, about 85 terrestrial mammals, over 500 birds and a large number of butterflies, insects and reptiles. Agriculture has been the most primitive occupation of the tribal people, however, it requires sound scientific backup to cope with the increasing population as well as changing climatic conditions. Special emphasis needs to be given on alternative to existing shifting cultivation, ensuring better land management, introducing modern technologies through various systems of farming. Recently, state has paid good attention towards different horticultural crops like kiwi in temperate areas, litchi and oil palm in foot hills and very organized efforts for production of an array of vegetables, flowers and medicinal plants. Further, I am happy to note that the entire developmental programme has been knitted in such a way that eco-sustainability of the state remain unchanged and intact. Central Agriculture University through its College of Horticulture and Forestry is committed to give strong research back up and to solve all production and protection related constraints to achieve newer height in horticulture sector of the state.

I extend my warm wishes for grand success of Conference and Arunachal Agri Expo-2016.

(M. Premjit Singh)

प्रो. एस. एन. पुरी
Prof. S.N.Puri

पूर्व कुलपति
केन्द्रीय कृषि विश्वविद्यालय, इम्फाल
FORMER VICE-CHANCELLOR
CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL
Flat No.-402, Vidyasagar Colony, Salisburry
Park Pune-4110337, Maharastra

MESSAGE

I am extremely happy to note that College of Horticulture and Forestry Central Agricultural University, Pasighat is organizing **National Conference** and **Arunachal Agri Expo** w.e.f. 16th to 18th January, 2016 and publishing souvenir to mark the occasion.

The North Eastern Region comprising States of Assam, Arunachal Pradesh, Manipur, Mizoram, Nagaland, Tripura and Sikkim are endowed with rich natural resources. Agriculture is the main occupation of people and whole region has unique system of tribal farming where despite of small holding every components of agriculture is nicely embedded in the fabric of their culture depicting the true picture of crop diversification. Further, diverse climate in North Eastern Region offers ideal agro climate conditions for cultivation of a wide variety of tropical and temperate fruits in its hills and valleys. The dominant Horticultural crops of the region include different kinds of citrus fruits, pineapple, banana and an array of vegetables ornamental, aromatic and medicinal plants. Among all horticulture produce of the region, Khasi orange occupies an important position in the region; however average production is not satisfactory in comparison to states which are having higher productivity like Karnataka and Punjab. Citrus decline is major problem of the region for low productivity. Many orchards are declining due to virus and other related problems. Use of disease free planting material is indispensible for desired growth and quality produce. I am well sure that conference will provide an appropriate platform to participants to discuss these issues and evolve strategies to achieve significant and vibrant growth of horticulture in the region.

I congratulate organizers and wish National Conference and Arunachal Agri Expo- 2016 a grand success.

(S.N.Puri)

डॉ. अरविंद कुमार
Dr. Arvind Kumar

कुलपति
रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय
ग्वालियर रोड , झांसी -२८४००३ , उत्तर प्रदेश
VICE-CHANCELLOR
RANI LAXMI BAI CENTRAL AGRICULTURAL UNIVERSITY
GWALIOR ROAD, JHANSI-284003, UTTAR PRADESH

MESSAGE

I am pleased to learn that the College of Horticulture and Forestry Central Agricultural University, Pasighat is organizing National Conference from 16th to 18th January, 2016 with the very broad thematic area “Horticulture for Nutritional Security and Economic Prosperity”. Arunachal Pradesh with a massive rural population is the largest state in North-East India; consequently, economy of the state is based on agriculture. Apart from food crops, state grows an array of fruits, vegetables and flowers round the year. The state has got nature's unique gift of hills, valleys and ample sun shine hours for prolific growth of plants. However, in spite of falling under one of the highest rainfall regions of the world, the state faces acute water scarcity during off period of monsoon which adversely affects the production of crops. Efforts are needed to enhance the water use efficiency by adopting modern irrigation techniques like trickle irrigation along with fertigation. I am well confident that during National Conference researchers, planners and policymakers will get ample opportunity to share their experiences and devise several modern technologies to boost production and productivity of Horticultural crops in the region.

I extend warm greetings to all the participants and good wishes for a grand success of National Conference.

(Arvind Kumar)

डॉ . एन.के.कृष्ण कुमार
Dr. N.K.Krishna Kumar

उप महानिदेशक (बाग़. बि.)
भारतीय कृषि अनुसंधान परिषद्
कृषि अनुसंधान भवन -II,
नई दिल्ली ११० ०१२
DEPUTY DIRECTOR (HORTI. SCIENCE)
INDIA COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAWAN-II,
NEW DELHI-110 001

MESSAGE

The North Eastern Hill (NEH) regions of India have rich diversity of horticultural crops. The agro-climatic conditions are suitable for cultivation of a variety of subtropical to temperate horticultural crops. Concerted efforts through establishment of R&D institutes and support by development programmes of the Government in the recent past, the NEH Regions have witnessed significant progress in horticulture. However, several problems like low productivity, post-harvest handling, storage and processing facilities, inadequate infrastructure and market support, non-availability of credit facilities etc. are yet to be properly addressed.

Low share of producers in consumer's price and perishability is a cause of concern. Nevertheless, the NEH Regions have been bestowed with unique agroclimates and relatively cheap human force for development of horticulture sector. Flowers especially orchids, vegetables, pineapple, mandarin, banana, kiwifruit, passion fruits, temperate fruits, oil palm, areca nut, betel vine, cashew, spices especially turmeric, zinger and large cardamom can transform the economy of NEH regions. The need of the hour is to capitalize on the tribal ethnic knowledge for organic production for domestic consumption and export. At this juncture, effective technology and policy support will be determining factors for further significant improvement in this sector.

I am happy to know that the College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh is organizing a National Conference on Horticulture for Nutritional Security and Economic Prosperity from 16 to 18 January, 2016. To mark the occasion, the organizers have planned to bring out a Souvenir. I am sure that the Conference will provide a common platform to researchers and other stakeholders to discuss the issues hampering the development of horticulture sector in NEH region and come out with a detailed Action Plan to enhance productivity of horticultural crops in NEH Regions.

I congratulate the organizers and wish the event a grand success.

(N. K. Krishna Kumar)

डॉ. ए. के. सिंह
Dr. A.K. Singh

उप महानिदेशक (कृषि प्रसार)
भारतीय कृषि अनुसंधान परिषद्
कृषि अनुसंधान भवन -I,
नई दिल्ली ११० ०१२

DEPUTY DIRECTOR (HORTI. SCIENCE)
INDIA COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAWAN-I,
NEW DELHI-110 001

MESSAGE

I am delighted to know that College of Horticulture and Forestry, CAU Imphal is organizing a National Conference during 16th to 18th January, 2016 on Horticulture for Nutritional Security and Economic Prosperity". India has got unique gift of nature with plenty of natural resources, a variety of landscapes, distinct climatic patterns and vast water resources enabling to grow enormous number of fruit and vegetable crops across the country. With the concerted efforts made by the planners, policy makers, researchers and the growers, there has been a steep rise in production and productivity of horticultural crops. However, the rate of growth needs to be further strengthened to commensurate the increasing population and economic well-being of the people.

While extending my heartiest congratulation to the organizers, I hope that National Conference will provide a unique opportunity to discuss various intricate researchable issues of crop production, in general and quality organic production, in particular. As the state is marching ahead towards leading organic producer in the country, there is an urgent need to divert the attention of researchers towards devising organic protocols, good agricultural and eco-sustainable cultivation practices. I am sure that this event will prove boon for the researchers as well as participants to interact with each-others to evolve strategies to make the horticulture sector of the state more competitive, remunerative and progressive.

I congratulate Central Agricultural University for organizing such an important event and wish National Conference a grand success.

(A. K. Singh)

डॉ . नरेन्द्र सिंह राठौड़
Dr. Narendra Singh Rathore

उप महानिदेशक (कृषि शिक्षा)
भारतीय कृषि अनुसंधान परिषद्
कृषि अनुसंधान भवन -II,
नई दिल्ली ११० ०१२

DEPUTY DIRECTOR (AGRIL.EDN.)
INDIA COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAWAN-II,
NEW DELHI-110 001

MESSAGE

It gives me immense pleasure to know that the College of Horticulture and Forestry, Pasighat is organizing National Conference from 16th to 18th January, 2016 with the broad thematic area “Horticulture for Nutritional Security and Economic Prosperity". I am very optimistic that the National Conference will provide a common platform to the students, scholars, scientists, natural resource management experts to interact and come out with concrete recommendation for the benefit of the growers as well as stakeholders engaged in the Agri-Horti sector of the North Eastern Region.

In the last couple of decades, the North East States has witnessed tremendous progress in production of fruits, vegetables and flowers. In fact, horticulture has the potential to transform the rural economy of the region and therefore, it is imperative that further thrust may be given to make it more rewarding. With the introduction of kiwi in the state of Arunachal Pradesh, state has emerged as one of the highest producers of kiwi in India. It is an unmatched beauty of region where both tropical and temperate fruits and vegetables are grown profusely. Further, region has unique opportunity to grow an array of flowers like orchid, anthurium, gerbera which can boost the region’s floriculture industry. This industry has enormous scope to provide job opportunities to thousands of school dropouts and rural youth. Apart from floriculture, the region is blessed with various species of plants with medicinal value. However, considering the divers agro-climatic zones of region, continuous research and development is needed, in order to tap the full potential of horticultural wealth.

I wish National Conference a grand success.

(N. S. Rathore)

GRAFTING IN VEGETABLES FOR AMELIORATING THE BIOTIC AND ABIOTIC STRESSES

A.K.Pandey and S.D.Warade
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Introduction

Vegetable production with grafted seedlings was originated in Japan and Korea to avoid the serious crop loss caused by infection of soil-borne diseases aggravated by successive cropping. This practice is now rapidly spreading and expanding over the world. Vegetable grafting has been safely adapted for the production of organic as well as environmental friendly produce and minimize uptake of undesirable agrochemical residues (Lee *et al*., 2010). Grafting of watermelon onto bottle gourd enhances its tolerance to soil-borne diseases (Heidari *et al*., 2010) and reduces fusarium wilt (Rivard and Louws, 2006). The major vegetable crops being grafted are: tomato, cucumber, eggplant, melon, pepper and watermelon (Nichols, 2007). Grafting is also very much useful for increasing yield for example as much as 106 per cent with the use of certain rootstocks for watermelon production in Australia. Some rootstock varieties have been bred specifically to be used as rootstocks, such as the Maxifort rootstock used in greenhouse tomato production systems. Use of vigorous rootstock varieties can increase water and nutrient uptake in grafted plants. Many growers worldwide are utilizing these rootstocks to increase fruit yields, even where little disease pressure is evident.

Benefits of grafting

Some important benefits of grafting in vegetables are summarized as under:

A. MANAGING BIOTIC STRESSES THROUGH GRAFTING

I. Imparting disease and pest resistance

The main objective of grafting is to avoid soil borne diseases such as Fusarium wilt in cucurbitaceae (cucumber, melon etc.) and bacterial wilt in solanaceae (tomato, eggplant and pepper etc.). Expanding the use of resistant rootstocks in grafting in combination with Integrated Pest Management (IPM) practice, may help to reduce the need for soil fumigation with methyl bromide for many crops. This may prove boon in organic farming of vegetables. Further, continuous cropping is in vogue in greenhouse which results reduced yield and quality of the produce. An estimated loss of 68 per cent in vegetable yield caused by soil born diseases under continuous cropping was reported by Takahashi (1984).

II. Avoiding nematode infestation

Sicyos angulatus and pumpkin are considered to be promising rootstocks for avoiding the nematode infestation in cucumber (Liu *et al.,* 1998; Uffelen, 1983). In tomato, nematex root stock gives complete resistance against nematode infection. While in France, tomato hybrid KNVF is commonly utilized against nematodes (Rezoni and Lamberti, 1974; Ginoux *et al.,* 1978). Intergeneric grafting by utilizing *Solanumnigrum* may also prove useful against nematode attack in tomato (Satpathy and Pradhan, 1996).

B. MANAGING ABIOTIC STRESSES THROUGH GRAFTING

Grafting has been highly effective at producing plants that can overcome abiotic stress—the environmental stresses that can lead to decrease yields. More than one-third of all irrigated land worldwide is affected by high salinity. Grafting with salt-tolerant rootstocks can be instrumental in decreasing yield losses. It has also been used to reduce the negative effects of excess moisture in the soil. Grafted plants also have shown effective tolerance to soil temperature extremes and grafting with certain rootstocks can allow the growing season to be extended in either direction. An extended season can help growers to raise the selling price of their goods as well as add to annual and long-term economic stability.

I. Minimizing the autotoxic effect

Recently autotoxic potential of some cucurbits crops have been pointed out which are serious problem of soil sickness in commercial production of cucurbits. There are differences in autotoxic potential of cucurbits crops. Some species such as watermelon, melon and cucumber exhibits autotoxic potential but others do not. Possibly some phenolic acid of root tissue and root exudates act as autotoxins. These autotoxins affect ion uptake, membrane permeability, photosynthesis and phytohormone balance. It seems possible to overcome autotoxicity in cucurbit crops by grafting on *Cucurbita ficifolia* (Yu and Yu, 2001; Yu *et al.,* 2000).

II. Enhancing cold hardiness

Grafting is also useful to initiate the flowering and fruit set at low temperature. This practice may save the energy of polyhouse to maintain day/night temperature regime. Early yield of cucumber was obtained by grafting on *C. ficifolia* through reducing the temperature regime of polyhouse from 23^0C/20^0C to 20^0C/12^0C and grafted plants survived at very low temperature i.e. 10^0C (Nijs, 1983; Liebig, 1985; Gao*et al.*, 1998; Tsambankis, 1984).Cold tolerance genotypes possess higher level of linolenic acid in several phospholipids than the cold sensitive. Hardening the plants by low temperature treatment results in a higher phospholipid level (especially Phosphatidyl choline), more unsaturated phospholipid and a lower sterol: phospholipid ratio, all of which may contribute to greater membrane fluidity under lower temperature limit. Soil heating slightly reduces the phospholipid level in leaves, but results in higher content of 3-trans-hexadecenoic acid phosphatidyl glycerol. Grafting cucumber on cold resistant *C. ficifolia* enhances the level of transhexadecenoic acid in phosphodialyl glycerol and imparts hardiness (Horvath *et al.,* 1983). Ai *et al*. (1999) observed that concentration of proline, vitamin C (ascorbic acid) and water soluble sugars of grafted seedlings were higher than in ungrafted, while concentration of water soluble proteins was lower in leaves of grafted seedlings than in ungrafted seedlings.Under low temperature stress conditions, photosynthetic rate, chlorophyll content and soluble protein content decreases but all these traits were significantly higher in grafted seedlings (Chen *et al.,* 2000). This indicates that higher photosynthetic rate of grafted seedlings under low temperature stress may be due to higher chlorophyll content, stomatal conductance and initial activity of RubP case.

III. Survival of graft age under excessive moisture condition

Inter-generic grafting imparts the attributes of flood tolerance in cucurbits. Generally flooding reduces photosynthetic rate, stomatal conductance, transpiration,

soluble protein and activity of ribulose-1, 5-biophosphate carboxylase/oxygenase (Rubisco). But these reactions can be minimized by integeneric grafting. Liao *et al*. (2000) concluded that grafting of flood intolerant bitter melon onto flood tolerance *Luffa* rootstock gives flood tolerance.

IV. Enhancing the nutrient mining capacity

Grafting also influences growth and mineral content of the plant tissues (Kim and Lee, 1989). Experimenting on the role of roots and shoots in regulation of Fe efficiency in grafted cucumber and sunflower, Romera *et al.* (1992) concluded that the development of the responses in the root is controlled by Fe content in the root but also by some information transmitted between parts of a root system that differ in their Fe nutritional status. Interveinal chlorosis and marginal greening of cucumber leaves called 'green ring' is due to Mg deficiency induced mainly by excessive accumulation of ammonium. It is more severe in cucumber grafted onto the squash cv. Shintosa than in those grafted onto figleaf gourd (*Cucurbita ficifolia*). It does occur on non grafted cucumber (Kato and Horiuchi, 1981; Arai *et al.*, 1985). Cucumber cultivars which produce fruit with a heavy surface bloom are undesirable for marketing. Bloom originates in trichomes on the fruit epidermis (Yamamoto *et al.*, 1988). Development of bloom can be depressed by grafting the cucumber onto appropriate cultivars of squash, termed 'bloomless rootstocks' (Matsumoto, 1980). The principal component of trichomes is a silica (Oyabu and Aoyagi, 1990). Iwasaki and Matsumura (1999) while using Shintosa rootstock observed that silicon (Si) alleviated the Mn toxicity through a localized accumulation of Mn with Si in a metabolically inactive form around the base of the trichomes on the leaf surface.

V. Grafting for minimizing the effect of salinity

Salinity in soil or water is one of the major abiotic stresses that reduce plant growth and crop productivity worldwide (Arzani,). More than 800 million hectares of land throughout the world are salt-affected (including both saline and sodic soils), corresponding to more than 6% of the world's total land area (FAO, 2009). Low rainfall, high evaporation, poor water management and the indiscriminate use of huge quantities of chemical fertilizers have also exacerbated growing concentrations of salts in the rhizosphere (Mahjan and Tuteja, 2005). Most of the vegetable crops are glycophytes and, therefore, highly susceptible to soil salinity even at low electrical conductivity in the saturated soil extract (Shannon and Grieve, 1998). The deleterious effects of salinity on plant growth are associated with (1) low water potential of the root medium which causes a water deficit within theplant; (2) toxic effects of ions mainly Na^{+},Cl^{-}, and SO_4^{2-} ; (3) nutritional imbalance caused by reduced nutrient (e.g., K+,$Ca^{2+,}Mg^{2+)}$uptake and/or transport to the shoot (Munns and Termaat, 1986;Ashraf, 1994; Marschner, 1995; Serrano et al., 1999; Hasegawa *et al*., 2000).

Grafting tomato (*Solanum lycopersicum* L.) plants for increased salinity tolerance is a promising practice to improve the crop performances in saline soil conditions. Santa-Cruz *et al.* (2001) found an increase in growth and fruit yield when a salt-sensitive tomato cultivar 'Moneymaker' was grafted onto a tolerant rootstock 'Pera' and irrigated with water containing 50 mMNaCl as compared to self-grafted plants. Estan *et*

al.(2005) also found that grafting provides an alternative way to improve salt tolerance, determined as fruit yield, in a commercial tomato hybrid ('Jaguar') grafted onto several tomato rootstocks ('Radja', 'Volgogradskij', 'Pera', and 'Vol-gogradskij'×'Pera') with different potentials to exclude saline ions and grown at different NaCl concentrations (0, 25, 50, and 75 mMof NaCl). Estan*et al.* (2005) reported that the positive effect onsalt tolerance caused by the rootstocks was lower at 25 mMNaCl than at 50 and 75 mMNaCl indicating that the tolerance induced by the rootstock in the shoot was related to ionic rather than osmotic stress caused by salinity. In a recent study, Martinez-Rodriguez *et al.* (2008) addressed the question whether shoot genotype withan 'excluder' character ('Moneymaker') is able to increase its salttolerance when grafted onto rootstocks ('Radja' and 'Pera') with excluder character. Grafting onto either 'Radja' or 'Pera' improved tomato fruit yield compared to self-grafted plants of 'Moneymaker'when plants were grown at 50 mMNaCl, whereas there was no effect of either rootstocks or grafting *per se* on fruit yield in the absence of salinity or at 25 mMNaCl. The yield increase in hetero-grafted over self-grafted plants was around 40% whereas in an earlier study (Estan*et al.*, 2005) the increase was 80% for the same salt level, albeit with a different scion. The shoot genotype used in the Martinez-Rodriguez *et al.* (2008) study ('Moneymaker') is a better excluder that that used in the Estan*et al.* (2005)nstudy ('Jaguar'), so the different yield increases may be due to a lower shoot ion concentration induced by the same stress level when a genotype with higher exclusion ability as 'Moneymaker' is used. Taken together, these results support the conclusion that the salt tolerance of the shoot depends on the root system, independently of the genotype used as a scion, although the positive effect of rootstock may show to a different degree depending on the higher or lower exclusionability of the shoot genotype. The salt tolerance mechanisms can occur in wide range of organizational levels from the cellular level (e.g., compartmentation of $Na^{+\ within}$ cells) to the whole plant (e.g., exclusion of Na+ from the shoot (Tester and Devenport,2003, Moller *et al*.,2009). The enhanced salt tolerance of grafted vegetables has often been associated with lower Na+ and/or Cl content in shoots (Table 1).

Table (1) Na^+ and Cl^- exclusion and/or inclusion in grafted vegetables under saline conditions.

Scion species	Rootstocks species	Ion exclusion and/or inclusion in the scion	Ion exclusion and/or inclusion in the rootstock	References
Cucumis sativus L.	*C. moschata* Duch.	Na^+exclusion		Chen and Wang (2008)
Cucumis sativus L.	*C. ficifolia* Bouche	Na^+exclusion		Chen and Wang (2008)
Cucumis sativus L.	*C. moschata* Duch.	Na^+exclusion and Cl^- inclusion	Na^+ and Cl^- inclusion	Zhu *et al*. (2008a)
Cucumis sativus L.	*Lagenaria siceraria* Standl.	Na^+ and Cl^- exclusion	Similar Na^+ and Cl^-	Huang *et al*. (2009a)
Cucumis sativus L.	*L. siceraria* Standl.	Na^+ and Cl^- exclusion		Huang *et al*. (2009b)

Cucumissativus L.	*C. ficifolia* Bouche	Na^+ and Cl^- exclusion		Huang *et al.* (2009b)
Cucumis sativus L.	*C. moschata* Duch.	Na^+ exclusion, similar Cl^-	Na^+ inclusion	Zhu *et al.* (2010)
Citrullus lanatus (Thunb.) Matsum and Nakai	*C. maxima* Duch. X *C. moschata* Duch.	Na^+ exclusion	Na^+ inclusion	Goreta *et al.* (2008)
Citrullus lanatus (Thunb.) Matsum and Nakai	*L. siceraria* Standl.	Na^+ exclusion	Na^+ inclusion	Zhu and Guo (2009)
Citrullus lanatus (Thunb.) Matsum and Nakai	*C. maxima* Duch. X *C. Moschata* Duch.	Na^+exclusion and Cl^- inclusion		Colla *et al.* (2006a)
Citrullus lanatus (Thunb.) Matsum and Nakai	*L. siceraria* Standl.	Na^+exclusion and Cl^- inclusion		Colla *et al.* (2006a)
Citrullus lanatus (Thunb.) Matsum and Nakai	*L. siceraria* landrace	Na^+ exclusion		Yetisir and Uygur (2010)
Citrullus lanatus (Thunb.) Matsum and Nakai	*C. mxima* Duch.	Na^+ exclusion		Yetisir and Uygur (2010)
Cucumismelo L.	*C. maxima* Duch. X *C. Moschata* Duch.	Na^+exclusion and Cl^- inclusion		Colla *et al.* (2006b)
Cucumismelo L.	*C. maxima*Duch. X *C. Moschata* Duch.	Na^+ exclusion, similar Cl^-		Edelstein *et al.* (2005)
Cucumismelo L.	*C. maxima* Duch. X *C. Moschata* Duch.	Na^+ and Cl^- exclusion		Romero *et al.* (1997)
S. melongena L.	*Solanum torvum* Swartz	Na^+ exclusion	Na^+ inclusion	Bai *et al.* (2005)
S. melongena L.	*Solanum torvum*Swartz	Na^+ and Cl^- exclusion	Na^+ and Cl^- inclusion	Wei *et al.* (2007)
S. lycopersicum L.	*Solanum lycopersicum* L.	Similar Na^+ and Cl^-		He *et al.* (2009)
S. lycopersicum L.	*Solanum lycopersicum* L. x *S. cheesmaniae* L. Riley	Similar Na^+		Albacete *et al.* (2009)
S. lycopersicum L.	*Solanum lycopersicum* L.	Na^+ and Cl^- exclusion		Fernández-García *et al.* (2002)
S. lycopersicum L	*Solanum lycopersicum* L.	Na^+ and Cl^- exclusion		Fernández-García *et al.* (2004)
S. lycopersicum L	*Solanum lycopersicum* L.	Na^+ and Cl^- exclusion		Santa-Cruz et al. (2002)
S. lycopersicum L	*Solanum lycopersicum* L.	Na^+ and Cl^- exclusion		Estan *et al.* (2005)

S. lycopersicum L.	*Solanum lyco persicum* L.	Na^+ and Cl^- exclusion	Martinez-Rodriguez *et al.* (2008)

Source: Colla*et al.* (2010)

C. BENEFICIAL INFLUENCE OF GRAFTING ON FLOWERING, FRUITING AND YIELD

I. Altering sex expression for enhancing yield

Due to flow of substances, changes occur in flowering pattern of the grafted scion (Friedlander *et al.,* 1977). *C. hardwickii* scion grafted on monoecious/gynoeciouis cultivars of cucumber expressed increased total flowers and pistillate flower (Nienhuis*et al.,* 1979). Inability of cucumber to express flower when grafted on hybrid squash seedlings (*C. maxima* x *C. moschata*) of without meristem indicates that root may control floral formation by the production of inhibitory factors in some day neutral cucurbitaceous plants (Satoh, 1996). *Sicyos angulata* a qualitatively short day wild species was induced to flower not only by grafting it onto a flower induced plants of the same species but also by intergeneric grafting on day neutral plants of *Cucumis* or onto quantitatively short day plants of *Luffa cylindrica* under non-inductive long day conditions (Takahashi *et al.,* 1982). Further, it was observed that *S. angulata* developed both staminate and pistillate inflorescence with similar sex expression even when one of the cucumber cultivars was andromonoecious.

II. Manipulating the harvesting period

Altering in harvesting period either early or late often prove to be advantageous to the growers and consumers both. Cucumber grafted onto *C. ficifolia* grew faster and expressed 200 per cent early yield. This root stock is also useful for late crops (Nijs, 1981; Ufflen, 1983). The number of harvested fruits in summer cucumber cv. Shogoin – aonanga was increased by grafting on Hokushin or Aodai rootstocks (Asao *et al.,* 1999). In melon, highest early yield of Galia and Haon was obtained on rootstocks of either of the melon cultivar Suiker or 841 (Buitelaar, 1987).

C. IMPROVING QUALITY TRAITS

Obtaining the improved quality with employing the grafting technique has not yet achieved much success. Hoyas *et al.* (2001) observed that grafting did not affect quality in cucumber viz., taste, size and shape. However, collar of the grafted plants was greater. More number of commercially acceptable and shiny fruits of cucumber was obtained by grafting on squash hybrids Ikky (Kanizares and Goto, 1998). In melon, deterioration in taste and texture, poor fruit quality, showing a yellow, green stripes or spots or necrosis of the fruit flesh have been reported (Matsuda and Honda, 1981; Koutsika*et al.,* 2002). However, enhanced sugar content in Galia and Haon melon has been found by grafting on rootstock of either of the melon cultivar Suiker or 841 (Buitelaar, 1987). Increased in number of marketable fruits and decreased number of malformed, under developed and gray mold infected fruits have been obtained in tomato by grafting. Further, grafted fruit had a better colour and higher lycopene content (Chung *et al.,* 1997). The most common complaints about grafted watermelon quality concern low Brix, insipid taste, increased numbers of yellowish bands in the red flesh, and internal flesh breakdown (Davis *et al.* 2008a). The primary sugars in watermelon are sucrose, fructose and glucose, and grafting can affect biochemical pathways that are related to sugar accumulation in the fruit; the low sugar content of grafted

watermelon was correlated with low invertase, high sucrose synthase activity, low sucrose phosphate synthase activity, and low sugar transmembrane transport capability (Liu *et al*. 2006). The increase of sucrose in grafted plants was accompanied by increases in sucrose phosphate synthase and sucrose synthase activities (Xu*et al.* 2006a). In addition, it appears that sugar accumulation in mature fruits varies with rootstocks (Gao and Liao 2006, Xu *et al.* 2006b). In contrast to the reported increases in sugar content in grafted watermelons, the total sugar content of watermelons grafted onto bottle gourd rootstock was reported to be lower than that in self-rooted watermelons by Liu *et al.* (2006), who reported that grafting onto *Cucurbita* sp. rootstock decreased the quality of watermelon fruits, but that fruits from scions grafted onto bottle gourd rootstock differed only slightly from control fruits. Davis *et al.* (2008a, b) demonstrated that grafting watermelon could increase lycopene and total carotenoids by 20%, and increase amino acids, especially citrulline (a nonessential amino acid with vasodilation properties), by up to 35%. Proietti*et al.* (2008) studied grafted and non-grafted control plants of mini-watermelon (*Citrullus lanatus* (Thunb.) Matsum and Nakai), and found that: fruit quality parameters were similar in fruits from grafted and non-grafted plants; the Titratable acidity (TA), juice electrical conductivity, TSS/TA ratio, and K and Mg concentrations were improved in fruits from grafted plants; lycopene, dehydroascorbate and total vitamin C contents were increased in grafted plants relative to controls by 40.5, 13 and 7.3%, whereas spermidine and putrescine concentrations were reduced by 24 and 59%, respectively; mini watermelon fruits from plants grafted onto a *Cucurbita moschata* Poir. × *Cucurbita maxima* Duch. interspecific hybrid rootstock contained higher levels of K, Mg, lycopene and vitamin C than their respective control plants (Proietti *et al*. 2008).

STRATEGIES FOR BREEDING QUALITY ROOT STOCKS

As stated above, grafting through using potential rootstocks may be considered as panacea for a number of production related problems. Further, it has been found that interspecific hybrids often make high quality rootstocks which greatly increase the genetic diversity of the rootstock. While this new set of genes is an advantage for creating more diversity, it also creates unique problems that breeders must learn how to manage. Instead of just having to evaluate new genotypes across different environments (to examine the genetics by environment (GXE) interactions), rootstock breeders must evaluate new genotypes along with various scion genotypes across different environments. This new set of genetics requires examining GXGXE interactions, which can significantly complicate evaluations and delay the release of new rootstock cultivars. Breeding objectives of important rootstocks in different vegetables have been discussed as under:

Tomato

The most common genetic rootstock sources for tomato are tomato hybrids and interspecific tomato hybrids (*S. lycopersicon*× *S. habrochaites* S. Knapp & D.M. Spooner), but eggplant rootstocks are also recommended for specific conditions, such as flooding or waterlogged soil (Black *et al.*, 2003). It appears from currently available commercial sources that most rootstock cultivars originated from screening multiple *S. habrochaites* lines and crossing selections with tomato to create hybrids to use as rootstocks. There are a few open pollinated tomato rootstocks available, which appear to result

from direct selection in the intended environment. While the potential genetic base for rootstocks of tomato would appear to be very large considering the vast array of closely related species that could be used, the actual genetic base appears to be limited. All currently available commercial rootstocks are limited to specific tomato genotypes with resistance to soil-borne disease and to *S. lycopersicon* × *S. habrochaites* hybrids. It would appear that the genetic potential of other *Solanum* spp. has not yet been fully exploited for rootstock development. Even the eggplant rootstocks that are sometimes recommended for a specific purpose are limited to few genotypes.

Brinjal

The primary purpose for grafting eggplant has been for the control of soil-borne diseases, namely Verticillium wilt, bacterial wilt, Fusarium wilt, and root-knot nematodes (Goth *et al.*, 1991; Kalloo, 1993; Yamakawa, 1982). The first rootstocks used for grafting eggplant were selections from *S. integrifolium* (Yamakawa, 1982), which are reported to remain the most popular rootstock in Japan (Iwamoto *et al*., 2007). *S. integrifolium* is highly resistant to Fusarium wilt, is more resistant to bacterial wilt than most eggplant cultivars, and is reported to be highly compatible with eggplant and allows prolonged harvest (Tachibana, 1994). However, the level of bacterial wilt resistance is not enough to protect the scion when conditions favor the disease (Iwamoto *et al*., 2007). Creating interspecific hybrids between *S. integrifolium* selections and eggplant genotypes with some resistance to bacterial wilt has been successfully used to control bacterial wilt (Daunay *et al*., 2001), but the level of resistance is still less than that found in some other *Solanum* spp. (Yamakawa, 1982). More recently, somatic fertile hybrids were created between *S. integrifolium* and *S. sanitwongsei*; both parents have resistance to bacterial wilt, although the disease resistance of the progeny was not reported (Iwamoto *et al*., 2007).

Watermelon

Watermelon can be grafted onto bottle gourd (*Lagenaria siceraria*), *Cucurbita* spp. and *Citrullus* spp. The most common rootstocks for watermelon are bottle gourd, interspecific hybrids between *C. maxima* and *Cucurbita moschata*, and wild watermelon (*C. lanatus* var. citroides) (Davis *et al*., 2008). Compatibility of watermelon with any of these rootstocks is generally high, although there is variability within a species (Marukawa and Yamamuro, 1967). One issue that continually comes up is the loss of flesh quality that is often reported when watermelon is grafted onto *Cucurbita* spp. and especially the interspecific hybrids (Lee and Oda, 2003; Ryu*et al*., 1973). While some of the loss in flesh quality has been attributed to an enhanced nutritional uptake (Kato and Ogiwara, 1978; Shinbori *et al*., 1981), it is now believed by some that the changes in flesh quality are mostly caused by changes in flesh maturity. It is thought that watermelon fruits from grafts to interspecific hybrids acquire color at about the same time as non-grafted plants, but the sugars do not accumulate until later; this results in growers harvesting too soon (about the same time they would harvest non-grafted plants), and the fruits tend to have a lower pH and a "squash" flavor. These interspecific hybrids are also known to increase the firmness of watermelon flesh, which can be an advantage or a disadvantage depending on the scion cultivar (Davis and Perkins-Veazie, 2005).

Melon

Melons can be grafted onto *Cucurbita* spp., bottle gourd, and *C. melo* rootstocks. There are even a few reports of grafting melon onto luffa (*Luffa cylindrical* (L.) M. Roem.) and wax gourd (*Benincasa hispida* (thumb.) Cogn.). Each rootstock has its beneficial characters and disadvantages (Cohen *et al.*, 2002; Edelstein *et al*., 2004). The most common *Cucurbita* spp. rootstock used is an interspecific *C. moschata*×*C. maxima* hybrid and provides non-specific but efficient protection from a wide range of soil-borne diseases and against some abiotic stresses. However, the compatibility between the two can be problematic. Melons grafted onto melons are expected to have less horticultural problems related to scion – rootstock compatibility and environmental stresses. However, the major obstacle for using melon as a rootstock is the insufficient availability of disease-resistant germplasm sources. Interspecific hybridization between different *Cucumis* spp. is extremely difficult or impossible. List of the promising root stocks are given in table (2).

Table (2). Rootstocks for grafting of vegetables

Scion	Rootstocks
Cucumber	*Cucurbita moschata*
	Cucurbita ficifolia
	Cucurbita maxima
	Sicyos angulatus
Melons (for open filed)	*Cucurbita sp.*
	C. Moschata x C maxima
	Cucumis melo
Melons (for greenhouse)	*Cucumis melo*
	Cucurbita spp.
	C. Moschata x C maxima
Watermelon	*Citrulus lanatus*
	Cucurbita maxima
	C moshcata
	C. moschata x C maxima
Bitter gourd	*Cucurbita moschata*
	Lagenaria siceraria
	Luffa aegyptica
Tomato	*Lycoperston pimpinellifolium*
	L. esculentum
Eggplant	*Solanum nigrum*
	Solanum torvum
	Solanum integrfolium
	Solanum melongena
	Solanum nigrum

Source: Pandey and Pandita, 2002

RAISING THE SEEDLINGS FOR GRAFTING

When planting the scion and rootstock seeds, use good sanitation practices and a sterile, lightweight potting mix. The grafting process and the subsequent healing time require that seeds be sown two weeks before typical, non-grafted transplant production begins. This allows the newly grafted

seedlings to spend up to one week in the chamber followed by one week in the greenhouse to re-acclimate to normal light conditions before they are put into the field. To achieve a successful graft, make sure that the rootstock and the scion stems are the same diameter. Because different varieties require different germination periods, seeding times may need to be altered to grow different cultivars to the same size. Stagger plantings to offset the effects of variable germination periods between rootstock and scion varieties. In many cases, rootstock varieties take two to five days longer to germinate than heirlooms. However, hybrid rootstock varieties may germinate faster than heirlooms. Plant a few test seeds of each variety (both rootstock and scion) early in the year to determine how long the germination period is for each in your greenhouse or propagation facility. If seedlings have already emerged and either the rootstock or scion is much larger than its corresponding variety, decreasing the environmental temperature can help to slow the growth of the variety that may be ahead of schedule.

VARYING METHODS OF GRAFTING

As Hartmann *et al*. (2002) described the sequence events of the grafted herbaceous plants. First, new parenchymatous cells proliferate from both stock and scion produces the callus tissues that fill up the spaces between the two components connecting the scion and the stock. Following, the new cambial cells differentiate from the newly formed callus, forming a continuous cambial connection between the stock and scion. Furthermore, prior to the binding of vascular cambium across the callus bridge, initial xylem and phloem may be differentiated. The wound repair xylem is generally the first differentiated tissue to bridge the graft union, followed by wound-repair phloem. Finally, the newly formed cambial layer in the callus bridge begins typical cambial activity forming new vascular tissues. Production of new xylem and phloem thus permits the vascular connection between the scion and rootstock. Grafting methods include such techniques as cleft grafting, tube grafting, whip and tongue grafting, splice grafting, flat grafting, saddle grafting, bud grafting, hole insertion grafting, tongue approach grafting etc. These methods of grafting are briefly described as under:

Cleft grafting

Tomato plants are mainly grafted by this method of grafting. For practicing this method of grafting, seeds of the rootstocks are sown 5-7 days earlier than those of the scion. The stem of the scion (at the four leaf stage) and the rootstock (at the 4-5 leaf stage) are cut at right angles, each with 2-3 leaves remaining on the stem. The stem of the scion is cut in a wedge and the tapered end fitted into a cleft cut in the end of the rootstock. The graft is held firm with a plastic clip.

Tube grafting

This method of grafting was developed by Itagi *et al*. (1990). It makes possible to graft small plant grown in plug trays two or three times faster than the conventional method and is quite popular among Japanese seedling producers. The optimum growth stage for grafting varies according to the kind of plug used. Plants in small cells must be grafted at earlier growth stage and requires tubes with a smaller inside diameter. First the rootstock is cut at a slant. The scion is cut in the same way. Elastic tubes with side slit are placed onto the cut end of the rootstock. The cut ends of the scions are inserted into the tube, splicing the cut surfaces of the scions and root stocks together. While practicing the tube grafting in eggplant the seeds of *S. torvum* must be sown

a few days earlier than those of the other rootstock species.

Tongue approach grafting

Melons and other cucurbitaceous plants are generally grafted by this method. It gives higher survival ratio because the root of the scion remains until the formation of the graft union. In this method, seeds of cucumber are sown 10-13 days before grafting and Pumpkin seeds 7-10 days before grafting, to ensure uniformity in the diameter of the hypocotyl of the scion and rootstock. The shoot apex of the rootstock is removed so that the shoot cannot grow. The hypocotyl of the scion and rootstock are cut in such a way that they tongue into each other, and the graft is secured with a plastic clip. The hypocotyl of the scion is left to heal for 3-4 days and then crushed between the fingers. The hypocotyl is cut off with razor blade three or four days after being crushed.

Slant cut grafting

Recently this method of grafting has got popularity. It has been developed for robotic grafting. In this method, it is essential to remove the first leaf and lateral buds when a cotyledon of rootstock is cut on a slant.

Mechanized grafting

Grafting is arduous task and efforts are being made to reduce the labour required. Attempts have been made to mechanize grafting since 1987. There are several basic factors which govern the success of grafting by machine or robot such as seedling shape, location of cut, seedling gripping, cutting method, fixing materials and tools etc. (Suzuki *el al*., 1995 a&b). Grafting robots for plug have been developed by combining the adhesive and grafting plates (Kurata, 1994; Oda, 1995). This robot makes it possible for eight plugs of tomato, eggplant or pepper to be grafted simultaneously. Recently a fully automatic grafting system for cucurbitaceous vegetables has been designed (Nagata *et al*., 1999) in which seedling quality estimation is done by using fuzzy logic and neural network. Further, healing chamber with controlled atmospheric conditions has also been designed to enhance the survival of graftage.

Conclusion

In recent past, Grafting technology in vegetables has emerged one of the most potential mechanisms to manage the several, biotic, abiotic and yield and quality related issues. It will also promote production of quality vegetables and its availability for longer time. Practicing the eco-friendly production practices for raising the vegetables in context of compelling demand of reducing the load of chemicals is need of hour. Grafting technology besides imparting the resistance, reduce the need of soil disinfectants like methyl bromide and provide opportunity to produce vegetables eco-friendly environment. Further, efforts made to develop mechanized grafting has opened new vista towards meeting the huge requirements of transplant in time scale and cost of labour. A well planned research strategy is needed for breeding quality rootstocks possessing potential to impart beneficial influence under adverse environment with enhanced yield and quality traits.

QUALITY TRANSPLANT PRODUCTION OF CITRUS IN NEH REGION

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Introduction

Citrus trees can be propagated by seed and vegetative means. Seedling trees have a protracted juvenile period. Juvenility is undesirable in most citrus species because trees are non-productive and excessively vigorous, resulting in upright growth. Most seedlings trees are also susceptible to several soil related problems, in particular *Phytophthoraparasitica* and citrus nematodes. However seeds of most of the citrus species and cultivars are polyembryonic and the nucellar seedlings obtained through seed propagation are true to the type. On the other hand, vegetative propagation is always preferred because of true to type plants, uniformity, and regular and early bearing etc. Among vegetative means budding is a recommended method for most of the citrus and it is one of the recommended practice for production of quality transplants of khasi mandarin which is a commercial citrus species in North East India. For budding in Khasi mandarin, selection of desired rootstocks is of prime importance. The rootstock also induce long-lived productive trees with good quality fruits.

Criteria of a good rootstock

A good rootstock is a very vital component for a grafted plant and rootstocks should have
following criteria.

1. The rootstock should have compatibility with the scion
2. It should be well adaptable to the agro-climatic conditions
3. It should be resistant to diseases
4. It should also have desirable qualities like salt tolerance, drought resistance, frost endurance etc.
5. It is also essential that the stock should possess good germination, vigour, and straight stem.

It is indeed difficult to find an ideal rootstock that possess all the desirable qualities and be equally successful under widely varying conditions and situations, with different scions. Each of the rootstocks now in use, has its own merits and demerits. Among suitable rootstocks following rootstocks are widely used for khasi mandarin.

Rough lemon: *Citrus jambheri* Lush Rough lemon (Jambheri) is the most widely used rootstock in the world. The stock is sensitive to cold. It has good adaptability to light sandy

soils. It is not suitable for wet soils as well as for poorly drained soils. It is more tolerant to salts than sweet orange.

Washington Navel oranges are more prolific on Rough lemon stock. In Australia orange trees on Rough lemon stock are precocious as well as prolific. In Queensland, the fruits on Rough lemon stock are low in soluble solids and flavor than fruits on trifoliate orange stocks. In some cases the juice from the fruits on this stock becomes quite bitter after processing and storage. Fruits on Rough lemon stock tend to granulate. Mandarins on Rough lemon are puffier, probably due to the invigoration effect.

Seeds of Rough lemon, which germinate liberally with 90-100 per cent nucellarembryony. The seedlings are upright growing with single, unbranched trunks, easy to graft. Rough lemon is well suited for lemons and limes, kumquats, tangelos, Dancytangerins etc. This is mostly used as rootstock in India. However one rough lemon strain known as Kachai lemon is grown commercially in the region.

Rangpur lime: *Citrus limonia* Tanaka

It is the principal rootstock for sweet oranges, mandarins and grapefruit. It is highly resistant to tristeza and does well in heavy soils. It is more tolerant to salts than others. It is susceptible to exocortis. Some strains of Rangpur lime seem to be susceptible to *Phytophthora*incidence. Trees on this stock are vigorous, precocious and prolific with quality produce. It makes a good union with a number of *Citrus* species like sweet orange, mandarins.

Characteristics of important rootstocks of citrus

Character Root stock	*Phytophthora tolerance*	Flood tolerance	Drought lolerance	Freeze tolerance	Blight tolaerance	Tristeza tolerance	Exocrislolerance	Xyloporosis tolerance	Burrowing nematode tolerance	Citrus nematode olerance	Yield / tree	Brix	Fruit size	Tree vigour	High calcium tolerance	Salinity tolerance
Rough lemon	S	G	G	P	P	T	T	T	S	S	H	L	LG	H	H	I
Rangpur lime	S	?	G	P	P	T	S	S	S	S	H	L	LG	H	H	G
Sour orange	T	I	I	G	G	S	T	T	S	S	I	H	I	I	H	I
Cleopatra mandarin	T	P	I	G	G	T	T	T	S	S	LI	H	SM	H	I	G
Sweet orange	S	P	P	I	G	T	T	T	S	S	I	I	I	I	L	I
Trifoliate orange	R	I	P	G	P	R	S	T	S	R	LI	H	SM	L	L	P

Troyer citrange	R	G	I	G	I	T	T	T	S	R	I	H	I	I	I?	I
Grapefruit	S	?	P	I	?	T	T	T	S	S	H	L	SM	H	L	I

Source ; Castle (1987)

Key to Symbols: G=good; H=high; I=intermediate; L=low; LG=large; P=poor;R=resistant;S=susceptible;SM=small;T=tolerant;?=inadequate information

Propagation Environment

The plant propagation period is generally a very narrow segment of a plant's life, ranging from several weeks for fast-growing herbaceous plants to one to two years for woody perennials. To enhance the propagation of plants, commercial producers manipulate the environment of propagules by managing microclimatic conditions, biotic as well as abiotic factors. The environment conditions that are optimum for plant propagation are frequently conducive for pests. It is necessary to manage the environment not only during propagation, but also manipulate the environment of stock plantsprior to selecting propagules. Generally citrus nursery has mainly the component of primary nursery and secondary nursery.The primary nursery may be field or containerized nurseries. As it is very difficult to eradicate some soil borne disease in field nursery,containerized nursery system is followed now a days for which infrastructure required like shaded net houses, sterilized plastic trays etc. are required. For budwood, mother plants should be selected from authentic sources with known pedigree with respect to health, vigor, regular bearing and high yield with good quality fruit. Selected plants should be indexed against diseases (virus and greening) and only disease free plants should be marked. The bud should be selected from fairly well mature non- bearing current years shoots having round twigs longitudinal white streak on the bark and swollen buds ready to grow. Bud wood should be kept in moist sphagnum moss and gunny bags to avoid exposure desiccation. Budding should be done when seedlings attain the girth of 3 to 3.5 cm at not less than 9 inches height from the ground level. The budded plants should be given frequent light irrigation and side shoots below the bud union should be removed from time to time.

Growing of rootstock

These rootstocks are grown upto a stem size of pencil thickness. For growing of seedlings, extracted seeds were washed in

running tap water several times to remove the

mucilage, dried and treated with Captan fungicide @ 1g/kg of seed or thiram + bavistin @ 2g/kg of seed for about 1 hour to protect against fungal attack and kept drying in the shade condition for seed sowing to protect damping–off disease during the rainy season. It is desirable to raise citrus nursery bed in light and well-drained fertile soils which is free from soil borne pathogens. Soils should be free from gravel and stones. Seedlings may be raised in polythene bag filled with soil: FYM: sand in 2:1:1 ratio. A seedling after 3-4 months germination, when attains pencil thickness are used for budding.

Selection of Scion

Bud wood should be collected from vigorous, productive, true to type mother

plants,which are giving consistent yield of high quality fruits and viral disease free. Selected mother plants for the scion are indexed against diseases particularly tristiza virus which cause quick citrus decline through ELISA test using Double Sandwitch ELISA method. Well matured twigs of pencil thickness size of current season's growth are selected from the mother plants for the collection of the buds. The leaves of the bud stick are trimmed, leaving only a short piece of the leaf stalk or petiole attached to the bud and kept in moist gunny bag, The bud sticks which are to be sent to distant places are kept in wet paper or with the moist sphagnum moss grass and kept in cool and shady place.

Budding operation

When seedling of the rootstock attains a height of 20-25 cm from the ground level and its flaps are lifted easily with the help of budding knife are selected for budding. The active sap flow is noticed in Jan-April. After 'I' shape dormant bud scion are inserted inside the cut in the rootstock portion about 10-13 cm above the ground are wrapped with plastic polythene binding from bottom portion and move upward with 200 gauge polythene strips of 1.2 to 1.8 cm width.

After the scion is wrapped it tightly kept under the partial shade net house condition for 21 days. After 21 days of wrapping period, it was open in which those scions which are green are kept under the shade house for the sprouting of the dormant bud of the scion. If successfully sprouted about 5 cm above the budded portion are cut and allowed the scion for growth. After the successful budding sprouting of the new flush of leaves from the scion take about 3-4 weeks. On successful budding the parenchymatous cells of the callus from a cambial bridge within 12- 15 days after budding. The success on the budding is depending on the temperature and relative humidity of the location where the budding is carried out.

Success of budding needs sense of art and science. While doing the budding operation the budder should understand the art of inserting the scion to the stock and also the science of graft compatibility. Though citrus fruits are commercially propagated through 'T' budding, yet 'I' budding is found more successful in khasi mandarin instead of 'T' budding as this method caused less injury to the plant system as compared to 'T' system and hence gives better success. Selection of bud stick in the selected mother plants is done. In general mother plants should be grown under protected condition and they are generally pruned before time to promote shoot for scion. Shoots of pencil thickness size of current season's growth are selected from the mother plants for the collection of the buds. Before collection of scion, the leaves of the bud stick are trimmed leaving only a short piece of the leaf stalk or petiole attached to the bud. The shoots are collected and kept in moist condition. The condition of active sap flow is important consideration for success of budding in khasi mandarin.

ORGANIC HORTICULTURE IN NEH REGION

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Introduction

Organic production is a holistic system designed to optimize the productivity and fitness of diverse communities within the agro-ecosystem, including soil organisms, plants, livestock and people. The principal goal of organic production is to develop enterprises that are sustainable and harmonious with the environment. "Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity." It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. It is also the process of producing food naturally. According to Fantilanan (1990), "organic farming is a matter of giving back to nature what we take from it. "Organic farming is not mere non-chemicalism in agriculture, it is a system of farming based on integral relationship. There was an increase in production and productivity in chemical or conventional farming and our country was able to satisfy partly the food security. After 30- 40 years, production and productivity reduced drastically with abnormal input costs and the farming sector turned to be unfavorable occupation to all concerned. Soil degradation, more diseases, uncontrollable weeds, high water consumption, unfavorable price and with several natural and manmade issues, conventional farming turned to be unworthy for farmers.

North East India is a place of God gifted having world hot spot of biodiversity. Among the crops, Horticultural crops provide quick and good remuneration along with nutritional security of human being. Middle hill and foothill is the very suitable land for Horticultural crops. Much land is still virgin in nature where farmer grows crop in their natural ways. Therefore, NE India is the hot spot for organic farming which favoured by the nature.

Advantages of organic farming

1. It maintains the optimal condition of soil for high yield and good quality.
2. It supply the entire nutrient required by the plant.
3. It improves the plant growth and physiology activity.
4. It improves the soil physical, biological and chemical properties.
5. It reduces the need of purchased input.
6. Organic manures are considered as complete plant foods.
7. Organically grown crops are believed to provide more health and nutritionally superior food.
8. Organically grown plants are more resistant to pest and diseases and hence only a few other protective treatments are required.
9. Due to free of toxic chemical, organically produce have more consumer demand.
10. It helps to prevent environmental degradation.
11. Since the basic aim is diversification of crops, much more secure income can be obtained than to rely on only one crop enterprises.

So, organic farming method is found to be superior than conventional farming method on account of increased human labour employment, lower cost of cultivation, high profits, better input use efficiency and reduced risk leading to increased income, enhanced self-reliance and livelihood security of the farmers along with reduction of pollution and conserving the biodiversity.

Table 1.Organic production in India

Data for Organic products (2010-11)	
Total production	3.88 million M.T.
Total quantity exported	69837 M.T.
Total area under certification (including wild Harvest)	4.43 million Hectares
Total area under certified organic cultivation	0.24 million Hectares
Shares of exports to total production	4% approx.
Increases in export value over previous year	33%

Table 2.The ten countries with the most organic agricultural land, 2010

Countries	**Area in million ha**
Australia	12.0
Argentinia	4.18
US	1.95
Brazil	1.71
Spain	1.48
China	1.39
Italy	1.11
Germany	0.99
Uruguay	0.93
France	0.85

Important organic manures

Manures may be defined as material which is organic in origin, bulky and concentrated in nature and capable of supplying plant nutrients and improving soil physical environment having no definite chemical composition with low analytical value produced from animal, plant and other organic wastes and by product. Manure is the organic material that is used to fertilize land, usually consisting of the faeces and urine of domestic livestock, with or without accompanying litter such as straw, hay, or bedding. Farm animals void most of the nitrogen, phosphorus, and potassium that is present in the food they eat, and this constitutes an enormous fertility resource. In some countries, human excrement is also used. Livestock manure is less rich in nitrogen, phosphorus, and potash than synthetic fertilizers and hence must be applied in much greater quantities than the latter. A ton of manure from cattle, dogs, or horses usually contains only 5.0 kg of nitrogen, 2.5 kg of phosphorus pentoxide, and 5.0 kg of potash.

Advantages of manuring

(i) Manures supply plant nutrient including micronutrients.
(ii) It improves soil physical properties like structure, water holding capacity.
(iii) Increase nutrient availability.
(iv) Provide food for soil microorganism.
(v) Provide buffering action in soil reaction.
(vi) Prevent loss of nutrients by leaching or erosion.

Types of Manure

Based on concentration of nutrients, manures can be grouped into two:

Bulky organic manures

The organic manures contain small percentage of nutrients and they applied in

large quantities. eg., farm yard manures, compost, green manures, etc.

Concentrate organic manures

This organic manure contain large amount of nutrient compound to bulky organic manures. eg. oil seed cakes, blood meal, bone meals etc.

Table 3. Nutrient content of Manures

Organic manures	N(%)	P_2O_5(%)	K_2O(%)
Farm yard manures	0.5	0.25	0.60
Compost	0.80	0.51	3.06
Night soil	1.0	0.8	0.40
Ground nut cake	7.29	1.50	1.3
Linseed cake	5.5	1.4	1.2
Neem cake	5.2	1.08	1.4
Caster cake	4.37	1.85	1.39
Blood meal	10 – 12	1.2	1.0
Meat meal	10.5	2.5	0.5
Fish meal	4 -10	3 – 9	0.3 – 1.5

Source: Palaniappan&Annaduria (2003**).** Organic farming: Theory & Practice, Jodpur

Green undecomposed plant materials used as manure is called green manure. Incorporation green plants into soil with a view to increase soil organic matter and humus content is an old practice which was later modified to incorporation of legume plants and the practice was technically called as green manuring.

Characteristics of green manure

1. It should have rapid growth and shorter duration so that can be fitted in a crop rotation.
2. It should yield abundant biomass and should be succulent to have rapid decomposition.
3. It should have the ability to grow on poor soils.
4. Provably they should be in leguminous in nature.

Green manuring in situ

This method refers to incorporation of growing plants, preferably legumes in the same field where they are being grown. Dhaincha, Urd, Mung, Khesari, Berseem, Cowpea, Black gram, etc are the best crops for this type of green manuring.

Green leaf manuring

It is the application of green leaves and twigs of trees, shrubs, and herbs collected from elsewhere especially from wasteland, bund and jungle or forest. eg. Neem, Mahua, Glyricidia, Karanji, Sesbania, Subabul, Indigo etc.

Green manuring

Table (4). Green manuring crops and their growing season

Sl. No	Green manure crop	Growing season	Nitrogen added per hectare
1	Sunnhemp(*Crotalaria juncea*)	Summer	85
2	Dhaincha(*Sesbania aculeate*)	Kharif& summer	80
3	Urd(*Phaseolusmung*)	Kharif& summer	45
4	Berseen (*Trifoliumalexandrinum*)	Kharif& summer	55

Farm yard manure (FYM).

The FYM refers to the refuse from farm animals, mainly sheep, cattle and poultry. This is one of the oldest manure known and is highly valued for its many of the beneficial properties that are said to be produced when this manure is added to the soil. It not only adds the constituents to the soil but also adds organic matter to the soil.

Organic wastes.

Organic wastes are the wastes of biological/animal/agro-industry origin and can be converted to valuable manure by composting. The various organic wastes can be classified as follows:

Table 5:Various kinds of organic waste

Agriculture	Animal Husbandry	Agro-industries	Municipal Activities
Crop residues (paddy straw, sugarcane trash etc.), weeds	Dairy, goat /sheep, poultry, piggery	Sugar industry (pressmud), coir industry (ciorpith), fruits / vegetables processing industries, sago industry	Household / municipal solid waste, market waste (vegetable/ fruit / flower market)

Composting

Composting is a process of allowing organic materials to decompose more or less controlled conditions to produce stabilized product that can be used as a manure or soil amendment. Composting is basically a microbial process, which change the property of the organic material or mixtures. Compost is the material resulting from the decomposition of plant residues under the action of bacteria and fungi. Composting is simply an acceleration of natural process or organic matter mineralization. The final product is dark brown in colour and resembles to FYM in its properties and appearance.

Methods of compost preparation

Following is the method which can be used to preparation of compost in low cost:

NADEP method

NADEP method of composting developed by Shri N.D. PandhariPande from Maharashtra is one such processes facilitating aerobic decomposition of organic matter. NADEP method consists in construction of a tank above the ground level and collection of agro-wastes in the tank for production of compost by following a technique, which is discussed in detail.

1. The ingredients for making compost are agro-wastes, animal dung and soil in the ratio of 45:5:50 by weight.
2. About 22-50 1itres of water is to be sprinkled twice a week after the tank is loaded.
3. The material loaded has to be left in the tank for about 100 to 120 days for complete decomposition. With production of 3 tons to 3.5 tons of compost produced per cycle about 9 to 10 tons of compost can be made annually from one tank of standard size 3m × 1.8 m × 0.9m or 3.6 m × 1.5m ×0.9msition of the material.

Vermicompost

Organic matter when subjected to decomposition with help of earthworms is called vermicompost and the process is called vermicomposing. Earthworms play a key role in soil biology as versatile natural bioreactors. They effectively harness the beneficial soil micro flora, destroy soil pathogens and convert

organic wastes into valuable products of biofertilizers, vitamins, enzymes, antibiotics, growth hormones and proteinious worm biomass. Hence, we can call earthworms as artificial fertilizer factors. The commonly used species are: i) *Eisenia foetida* (ii) *Perionyx excavator* iii) *Lumbricus rubellus*

Benefits of vermicomposting

(1) Enhancement of soil productivity.
(2) Recycling of organic wastes is achieved.
(3) They are good sources of vitamin and hormones.
(4) It is a cost effective pollution abatement technology.
(5) Waste creates no pollution, as they become valuable raw materials for the soil biotechnological processes.
(6) Vermicompost contains a wide range of beneficial microorganism.
(7) They promote the growth of microorganisms in their gut by favourable conditions.
(8) The cost of vermicompost is more as compared to other FYM or Compost, hence it is economically sustainable.
(9) The rate of decomposition of organic matter is faster than that of traditional composting process.

Bio-fertilizer

Bio-fertilizers are the products containing living cells of different types of microorganism which have ability to mobility nutritionally important elements from non-usable to usable through biological process. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants. Very often microorganisms are not as efficient in natural surroundings as one would expect them to be and therefore artificially multiplied cultures of efficient selected microorganisms play a vital role in accelerating the microbial processes in soil. Use of biofertilizers is one of the important components of integrated nutrient management, as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers. They can be grouped in different ways based on their nature and function.

A. Nitrogen fixing bacteria

a) Symbiotic N- fixing bacteria: Bacteria belonging to the genus Rhizobium are capable of fixing atmospheric nitrogen in association with leguminous crops**.** There are seven Rhizobium species so far recognizedwhich are found to be associated with various leguminous crops.

Rhizobium is a soil habitat bacterium, which can able to colonize the legume roots and fixes the atmospheric nitrogen symbiotically. The morphology and physiology of Rhizobium will vary from free-living condition to the bacteroid of nodules. They are the most efficient biofertilizer as per the quantity of nitrogen fixed concerned. They have seven genera and highly specific to form nodule in legumes, referred as cross inoculation group.

Cross inoculation group

A cross inoculation group refers to the collection of legume plant that develop nodules when exposed to rhizobia obtain from the nodules of any member of that particular plant group. More than 20 cross inoculation groups have been established as only 7 achieved associations.

Liquid bio-fertilizer

Liquid formulations (LFs) are being developed that ensure more quality over the conventional carrier based bio-fertilizers inaugurating a new era in the biological input technology. The liquid bio-fertilizer has got many benefits.

Table 6. Cross Inoculation group and their host specific.

Sl.No.	Rhizobium species.	Crops	Host Group	N fix kg/ha
1.	*Rhizobium leguminosarum*	Pea, lentil, lathyrus, vicia	Pea group	62- 132
2.	*R. trifoli*	Berseem	Clover group	130
3.	*R. phaseoli*	Bean	Beans group	80- 110
4.	*R. lupini*	Lupinus	Lupini Group	70- 90
5.	*R. japonicum*	Soyabean	Soybean group	57- 105
6.	*R.melliloti*	Alfalfa	Alfafa Group	100- 150
7.	*R.species*	Cowpea	Cowpea group	57- 105

Table 7.Dosage of liquid bio-fertilizers in different crops

Sl; no	Dosage of liquid Bio-fertilizers in Horticultural crops	Recommended Bio-fertilizer	Application method	Quantity to be used
1	Chickpea, pea, Groundnut, soybean, beans, Lentil, lucern, Berseem, Green gram, Black gram, Cowpea and pigeon pea	Rhizobium	Seed treatment	200ml/acre
2	Plantation Crops Tobacco	Azotobacter	Seedling treatment	500ml/acre
3	Tea, Coffee	Azotobacter	Soil treatment	400ml/acre
4	Rubber, Coconuts	Azotobacter	Soil treatment	2-3 ml/plant
5	Leguminous plants/ trees	Rhizobium	Soil treatment	1-2 ml/plant

Benefits

The advantages of liquid bio-fertilizer over conventional carrier based Bio-fertilizers are listed below:

- Longer shelf life -12-24 months.
- Less contamination.
- No loss of properties due to storage upto 45º c.
- Greater potentials to fight with native population.
- High populations can be maintained more than 109 cells/ml upto 12 months to 24 months.
- Easy identification by typical fermented smell.
- Cost saving on carrier material, pulverization, neutralization, sterilization, packing and transport.
- Quality control protocols are easy and quick.

- Better survival on seeds and soil.
- No need of running Bio-fertilizer production units throughout the year.
- Very much easy to use by the farmer.
- Dosages is 10 time less than carrier based powder Bio-fertilizers.
- High commercial revenues.
- High export potential.
- Very high enzymatic activity since contamination is nil.

Scope of Organic farming in NEH region of India

- ❖ The entire NEH region still practices the traditional agriculture.
- ❖ The possible contamination of soil, water and air in the hill regions like NEH states is low due to low use of inorganic pesticides and fertilizers.
- ❖ Government of Sikkim, Mizoram and Meghalaya are favouring organic farming.
- ❖ A large part of the region is forested (77% of NEH area) contributing significantly to the conservation of biodiversity.
- ❖ More than 60% of arable land is under traditional agriculture, where no synthetic inputs are being used.
- ❖ There is an urgent need to ensure premium prices for the produce grown in the regions.
- ❖ The people of NE region have apithy of use of chemical in agriculture.

Constraint of Organic farming NEH region of India

According to Bhattacharyya (2005) several constrains have been identified in organic farming. These are as follows:

1. Excessive cost of existing inspection and certification system which is not affordable by farmers.
2. Lack of proper transportation.
3. Unavailability of laboratory facilities for testing the quality.
4. Most of the places in NEH India still are in remotely located.
5. Low price of organic produce.
6. Lack of quality assurance of organic inputs and non-availability of standards.
7. Limited availability of local organic inputs like FYM, compost, and Vermicompost, biofertilizer.
8. Limited domestic market for organic produce.
9. Non-availability of organic packages of practices for all crops based on locally available inputs.
10. Non-awareness of farmer and NGOs on the impact of organic farming.
11. Risk of low production in initial years of organic farming.

Conclusion

Considering the advantages of climate and soil condition as well as the availability of chemical free organic inputs in NEH region, the organic agriculture and horticulture has wide scope for its momentum growth. Traditional agricultural practices and approaches of people of region arealso very much appreciated toward the organic cultivation. Central Govt, State Govt, NGOs and private companies need to be forward to provide more financial help and technical knowhow for organic production. However, it needs positive approaches by the growers to accept the concept of organic Horticulture for their more profit and sustainable production.

AUGMENTATION, UTILIZATION AND MAINTENANCE OF VEGETABLE GENETIC RESOURCE

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Introduction

Plant genetic resources can be described as the total genetic diversity of the cultivated species and their wild relatives. If we say 'Biological Diversity' it means the variability among living organism from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystem and the ecological complexes in which they are part; this way it includes diversity within species, between species and ecosystems (Article 2 of the Convention on Biological Diversity). In brief biodiversity can be defined as the quality, range or extent of differences between the biological entities in a given situation. Likewise, germplasm may be defined as the sum/ total of hereditary material of any crop species. About 400 species constitute the global diversity in vegetable crops. These prized materials along with their wild relatives serve, as building blocks that are used by plant breeders for development of improved crop varieties/hybrids. They also constitute a priceless reservoir that contains genes conferring better adaptation to stress environments and resistance to diseases and pests. The Indian sub-continent is considered to be the place of origin for a number of leafy vegetables like *Beta vulgaris* var *bengalensis*, *Basella rubra*, *Cichorium endivia*, *Enhyndra fluctuant*, *Lactuca indica*, *Amaranthus* etc. Most of the leafy vegetables possess good amount of diversity, which is acclimatized under extreme variation in altitude with long history of its cultivation. The wild relatives of different leafy vegetables possess valuable gene particularly for resistance to biotic and abiotic stress conditions. In its history of some 12,000 years, nearly 30,000 edible plant species have been utilized as source of food. However, a hundred odd plant species out of these have been propagated to provide about 90% of the world food and further, only 3 species among these, namely rice, wheat and maize produced the two-third. Despite improvements in global food supplies, malnutrition remains one of the most devastating problems. Malnutrition caused deficiencies in specific vitamins and minerals afflict some 40% of the world's population, especially women and children. The largest numbers of people suffering from micronutrient malnutrition live in South Asia whereas this region is rich in diversity of fruits and vegetables that are excellent sources of vitamins and micronutrients. The world declaration and the Plan of action on Nutrition, 1992, unanimously adopted by 159 countries at the International Conference on Nutrition, jointly organized by the FAO and the WHO, while recognizing that severely deficient populations may require short-term supplements, recommended to ensure that sustainable food-based strategies be given first

priority particularly for population deficient in vitamins A and iron. Wild plants have often played an important role in many diets due to their higher nutritional value than cultivated species. They also play an important role in saving human and animal life by providing food and fodder during famine. The bulb of greater galangal (*Alpinia galangal* family Zingiberaceae) can also be eaten raw. In the Garwhal areas, *Cornus capitata* and *Cornus controversa* (family Cornaceae) are also eaten raw. In Rajasthana, the whole plant of *Gisekia pharnaceoide* (family Mulluginaceae) is widely consumed during food shortage but in the South and West (Deccan Region) the leaves are used as greens, as like the leaves of *Glinus trianthemoides*. These are at the same time, hardy and resilient. An amaranth gene, Am1, reported to improve the protein quality in terms of lysine content, has been successfully incorporated into rice using biotechnological tools. A common bloom in the culinary world, available in a number of vibrant colors-most commonly yellows, oranges and reds which add flavor and spicy taste to the dishes. There are many plants whose buds and flowers are eaten raw or valued in cooking. Not only this, edible flowers may be preserved for future use by adopting preservation techniques such as drying, freezing or steeping in oil. They can be used in drinks, jellies, salads, soups, syrups and are can be used in mixed form, with other main dishes. Flavoured oils and vinegars are made by steeping edible flower petals in these liquids.

Vegetable genetic resources include:

(1) Land Races-These are primitive varieties, which had evolved without systematic plant breeding. They exhibit valuable genetic variability and are adapted to the local soil and climatic conditions.

(2) Obsolete Varieties-These varieties were developed by systematic breeding efforts, and were once commercially cultivated but are no more grown. They, however, do have some desirable features which can be utilized for further breeding programme.

(3) Cultivated varieties-The cultivated varieties are mostly being used in breeding programmes. They form a major part of a working collection. They are good sources of genes for yield, quality, biotic, abiotic stresses etc.

(4). Breeding Lines-These are lines/populations developed in breeding programmes. They also contain valuable gene combinations. It includes: nearly homozygous lines, mutant lines, lines derived from biotechnology programmes and now, transgenic lines.

(5) Wild species/ forms and wild relatives-The *wild relatives* include all other species, which are related to the crop species by descent during their evolution. Mostly cultivated crop species are directly derived from wild species. They can be crossed with the concerned crop species. Wild relatives are difficult to hybridize with crops than the wild forms. Both wild forms and wild relatives are sources of valuable genes for insect and disease resistance, tolerance to abiotic stresses like drought, cold, salinity etc., and even for quality traits and yield.

Distribution and diversity of genetic resources

These genetic wealth include both primitive/ native cultivars and their wild and weedy species, which are distributed to 12 primary centers of diversity. They have dealt elaborately in the "Dictionary of cultivated plants and their centers of diversity", listing species for different mega centres and the range and extent of distribution of genetic/varietal/ specific diversity etc. This includes centers of origin and distribution of diversity in 218 vegetable crop species in different regions of diversity viz. Chinese-Japanese (56), Indo-Chinese-Indonesian (31),

Table 1. Center of diversity of major vegetable crops

Gene Centre	Primary Center	Secondary Center
Chinese-Japanese	Eggplant, wax gourd, Chinese cabbage, Kangkong, welsh onion	Water melon, amaranth
Indo- Chinese	Wax gourd, Sponge gourd, ridge gourd, bitter gourd, sword bean, winged bean, taro, chayote, cucumber, bottle gourd, yam, yam	Chinese cabbage, bottle gourd, cucumber, yam, bean, amaranth, yard long bean, Kangkong
Hindustani centre	Eggplant, wax gourd, cucumber, ridge gourd, bitter gourd, sponge gourd, hyacinth bean, drumstick, okra, Kangkong	Water melon, melon, Roselle, bottle gourd, amaranth
Central Asia	Onion, garlic, carrot, spinach	Eggplant, water melon, melon, cauliflower
Near East	Onion, garlic, leek, beet	Okra
Mediterranean	White cabbage, cauliflower, water melon, broccoli, radish	Sweet pepper, garlic, okra
African	Eggplant, water melon, melon, bottle gourd, cowpea, okra, Roselle, locust bean	Onion, shallot, lima bean, White cabbage amaranth
European-Siberian	Lettuce	Onion, White cabbage, common bean, cauliflower, spinach, carrot
Central America & Mexican region	Tomato, hot pepper, pumpkin, squash, yam, bean, sweet potato, common bean	-
South American region	Tomato, hot pepper, cassava, pumpkin, lima bean, chayote, amaranth sweet potato	Common bean
North American	-	Tomato, Eggplant, melon, water melon, pepper, squashes, onion, lettuce, lima bean, okra, pumpkin

Australian (1), Hindustani (11), Near Eastern (4), Mediterranean (24), African (36), European- Siberian (29), South American (18), Central American and Mexican (6), and North American (2). Progressive improvement of these economic species over time by successive generations of farmers has led to evolution of today's crop plants giving rise to landraces and traditional cultivars. These prized materials along with their wild close relatives serve as building blocks that are used by plant breeders for development of improved crop varieties. Over 90% of plant species for food and agriculture are located in the economically developing parts of the world, namely, the African, Asian and Latin American continents and the Far East Islands.

Concentration of genetic diversity occurs more in Western Ghats and North-eastern Himalayas. The richness of plant diversity is largely due to ecological diversity superimposed with tribal and ethnic diversification, plant usages and religious rituals. Crops in which rich diversity still occurs in India include cowpea (*Vigna unguiculata*), common bean (*Lablab purpureus*), cole crops (*Brassica* species), okra (*Abelmoschus esculentus* and related species), Brinjal (*Solanum melongena* and related species), sweet potato (*Ipomoea batatas*), taros (*Colocasia* and *Alocasia*), yams (*Dioscorea esculenta, Dioscorea alata, Dioscorea deltoidea*), sword bean (*Canavalia species*), velvet bean (*Mucuna* species) and elephant foot yam (*Amorphophalu*s species). *Solanum spp.* are widely distributed in the Northeastern region; yams in western ghats and northeastern states, chives, leeks and other wild *Allium* spp. in Kumaon and Garhwal Himalayas; cluster bean in Western arid zone; Lablab bean in Deccan plateau; cucurbits in Rajasthan and M.P; and leafy vegetables like *Amaranthus*, and *Fagopyrum* spp. in Western Himalayan region. Variability distribution of different vegetable crops to different agro-ecological regions of India are presented in table-2

Table 2. Distribution of major vegetable crops and variability in different agro-ecological regions of India

Sl. No.	Agro-ecological regions	Geographical ranges	Variability in vegetable crops
1	Humid Western Himalayan region	J&K, H.P. and parts of U.P.	Cucurbits, radish, carrot, turnip, peas, cowpea, chillies, brinjal, okra, spinach, fenugreek, amaranth, *Solanum khasianum, Solanum hirsutum, Sechium edule, Basella rubra*
2	Humid Bengal/Assam basin	W.B. and Assam	Cucurbits, radish, cowpea, chillies, brinjal, okra, spinach, beet, *Abelmoschus manihot ssp. manihot*, amaranth, *Solanum indicum, Solanum khasianum, Solanum surattense, Cucumis sativus var. vikkimensis, Edgeria dargelingensis, Melothria assamica, Momordica cochinchinensis, Sechium edule, Tuladiantha coordifolia, Basella rubra*
3	Humid Eastern Himalayan	Arunchal Pradesh,	Cucurbits, radish, cowpea, pea, chillies, brinjal, okra, spinach amaranth, *Abelmoschus manihot ssp.*

	region and Bay Lands	Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Andaman & Nicobar islands	*tetraphyllus, Solanum khasianum, Solanum torvum, Solanum sisymbrifolium, Solanum ferox, Solanum verbasifolium, Cucumis hystrix, Luffa echinata, Sechium edule*
4	Sub-humid Sutlej Ganga Alluvial plains	Punjab, U.P. and Bihar	Cucurbits, radish, peas, brinjal, okra, spinach beet, fenugreek, onion, garlic, *Abelmoschus manihot ssp. tetraphyllus var. pungens, Abelmoschus tuberculatus, Solanum indicum, Solanum khasianum, Solanum torvum, Solanum surattense, Solanum hispidum, Cucumis hardwickii, Cucumis trigonus*
5	Humid Eastern and South Eastern uplands	East M.P., Orissa and A.P.	Cucurbits, radish, carrot, cowpea, chillies, brinjal, okra spinach, amaranth, garlic, *Abelmoschus manihot ssp. manihot, Solanum surattense, Solanum torvum*
6	Arid Western plains	Haryana, Rajasthana and Gujrat	Cucurbits, cauliflower, radish, carrot, peas, cowpea, chillies, brinjal, okra, spinach beet, fenugreek, onion, garlic, amaranth, *Abelmoschus tuberculatus, Abelmoschus ficuleneus, Abelmoschus manihot ssp. tetraphyllus, Solanum torvum, Solanum nigrum, Citrullus colocynthes*
7	Semi-Arid Lava Plateau and Central Highlands	Maharasthra and West M.P.	Cucurbits, cauliflower, radish, carrot, cowpea, chillies, brinjal, okra, spinach, fenugreek, amaranth, onion, *Solanum surattense, Solanum torvum, Solanum nigrum, Solanum khasianum, Cucumis setosus, Luffa acutangula var. acutangula*
8	Humid to Semi-Arid Western Ghats and Karnataka Plateau	Karnataka, Tamilnadu, Kerala and Lakshadweep islands	Cucurbits, chillies, brinjal, okra, *Abelmoschus crinitus, Abelmoschus angulosus, Abelmoschus ficuleneus, Abelmoschus moschatus, Abelmoschus manihot var. tetraphyllus, Solanum trilobatum, Solanum indicum, Solanumincanum, Solanum pubescens, Solanum surattense, Solanum torvum, Luffa acutangula var. acutangula, Melothria angulata, Basella rubra*

Evaluation of Vegetable Genetic Resources

In India tribal dominated region inhabited by different ethnic group provide another interesting situation for gene pool sampling of primitive types of vegetable germplasm. Such areas often possess rich diversity of various vegetable crops. The tribal family holds primitive cultivars of different vegetable crops and usually do not exchange seeds between the ethnic groups. In tribal areas particularly in Northeastern parts of Madhya Pradesh, Chhattisgarh, West Bengal, Bihar and Orissa, village markets/haats are most

desirable place to collect diversity in a number of vegetable crops. The areas that remain to be covered include remote and less accessible areas, hilly terrain and tribal dominated belt. The main task after collection of genetic resource is its evaluation for desired traits.

Traits of characterization/evaluation

Observations are recorded on qualitative and quantitative traits.

(i) Quantitative traits- Quantitative traits subject to environmental factors and are responsible for adaptation and productivity. These include productivity, quality components, resistance to disease and pest as well as tolerance to adverse conditions or stress.

(ii) Qualitative traits- Qualitative traits include morphological, physiological and biochemical characters related to survival and scored using a number of checks to be determining variation within and among the traits.

Much emphasis is presently given on multi-locational and multidisplinary approach of germplasm evaluation. For preliminary evaluation locally adapted cultivars should be used as check and screening for specific diseases under controlled conditions or at hot spots should be carried out. Augmented design is invariably used due to the large number of germplasm holdings under evaluation. Care should be taken to minimize natural cross-pollinated contamination and erroneous labeling. While, regenerating care should be taken to preserve original structure and productivity of accession. Main dangers are due to inappropriate handling of materials during sowing/planting, harvesting, threshing, cleaning, sub-sampling, packing and labeling. Frequent regeneration should be also be avoided by producing sufficient seeds during initial seed increase and conservation in medium term storage in case of working collection and long term gene bank as base collection. IPGRI, Rome has developed model lists of descriptors (= characters) for which germplasm accessions of various crops should be evaluated. It should be kept in mind that even such accessions, which do not possess a trait of some value to the breeders, should be retained in the collection. This is because what seems to be of no value today may become a highly valuable feature tomorrow.

Main issues related to germplasm evaluation

The main issues related to germplasm evaluation are discussed below:

- **Number of accessions and crops**

A curator needs to evaluate a large number of accessions of various crops. So it is a huge task to evaluate all the accessions, it requires, besides large and diverse technology base, huge land area, resources and times.

- **Soil heterogeneity-** Soil heterogeneity; its associated effects and the consequent interactions with germplasm accessions are major factors that curators must accommodate.
- **Evaluation environment-** To have reasonable information about the genetic potential of accessions, these are to be evaluated in the area of their adaptation or a similar environment.
- **Target environment-** A breeder works for more or less a defined area, though; in that process many widely adapted cultivars have been developed. In contrast, a curator's mandate is to generate information to be accessed by all breeders at least at the national level.
- **Target traits-** A curator is concerned with whole array of traits including those, which may gain importance in future. But breeder focuses on the biotic and abiotic stresses in the target area for which he/she

is working whereas a curator needs to generate data on all stresses prevalent in the country.

- **Number of environments-** The germplasm need to be evaluated over environments (locations, years etc.) to have precise information about the genetic potential.
- **Large diversity in germplasm-** Germplasm evaluation trials, as a rule includes materials of diverse nature, particularly for adaptation and plant type. The evaluation of such materials results in high genotype-environment interaction. To have realistic value of accessions, it is necessary to have an idea of the effect of genotype-environment interaction on the performance so as to have pragmatic guide of genetic potential.
- **Number of plants-**The curator deals more often with heterogeneous raw materials than a plant breeder. Further, he/she is interested not only in the mean performance but the range of expression also. Thus, data need to be recorded on a larger number of plants.
- **Inter–plot interference-**When diverse germplasms are grown side by side, large inter-plot competition affecting the performance of the neighboring accessions, may be expected. To minimize it the accessions should be grouped on the basis of adaptation, plant type and other relevant information.
- **Perennial crops-** The evaluation of germplasm of perennial crops is very difficult in terms of time. The recording of data on the same individual over seasons and years results in autocorrelation. The analysis of such data necessitates application of special statistical techniques.

Uniformity in evaluation

Plant breeder often makes visual observations and selects without recording the relevant data. Further, voluminous data remains in plant breeder's book and often goes unreported. Although, it is requested that the evaluation data may be sent to curator, but it is not mandatory and often not complied with. Therefore, it is important to record data in a uniform pattern using common reference/standard checks (s) so that these are of value to a number of scientists.

Evaluation/ characterization of germplasm using molecular markers

Molecular markers can be used for DNA fingerprinting, classification and clustering of germplasm collections. The classification of plant germplasm collections to different taxa was largely done on the basis of morphological traits, using subsequently some biochemical markers. The availability of DNA based molecular markers has revolutionized classification, characterization and construction of phylogenetic trees. There are two categories of probes or markers which are visualized and scored the following:

(i) Labeling and Southern hybridization

(ii) Primer synthesis and PCR amplification

Restricted fragment length polymorphism (RFLP) from genomic libraries and expressed sequence from $_c$DNA libraries were the first series of molecular markers used for construction of high density molecular maps in tomato. Simple sequence repeats (SSR) popularly known as microsatellite markers were subsequently developed and used as new series of co-dominant markers. The utilization of these markers was cumbersome, time consuming and required radioactive or non-radioactive labeling, hybridization, autoradiography, etc. Randomly amplified polymorphic DNA (RAPDs) involving single synthetic primers each of 10 nucleotide length were the first series of PCR

base markers. Amplified length polymorphism (AFLP) is one of the latest series of PCR based dominant markers providing high degree of genome-wide polymorphism. Sequence characterized amplification region (SCAR) and sequence tagged microsatellite sites (STMS) are the other of co-dominant sequenced based markers visualized by PCR. The anchored markers and maps are being extensively used for characterization and utilization of germplasm collections.

Utilization of Vegetable Genetic Resources

The ultimate goal of plant introduction to any region of the world is the use of germplasm to its fullest potential. Both indigenous and introduced diversity has been utilized to a great extent. To promote the use of promising germplasm/genetic stocks identified after evaluation, germplasm field days should be organized besides publishing research articles, crop catalogues (printed and electronic), etc. The development of core set of collection particularly in the crops having large germplasm collection can be a powerful tool for promoting utilization of germplasm. It is also important to accord recognition to those associated with the development of improved/unique germplasm and genetic stocks, such as, plant breeders, farmer-breeders or other developers/innovators. From exotic introductions, several selections/varieties could be directly released after their acclimatization in different locations and initial performance or evaluation. Also the exotic materials possessed several promising traits, which could be incorporated in to indigenous varieties through breeding.

Developing core sets and core subsets

The concept of core collection and the back-up reserve collection was proposed as a radical departure from the alternative conservation approaches.

Definition

Core sets: A core collection may be suitably defined as "A subset of base collection sampled in such a manner so as to represent the large collection is called as core set." Alternatively, the core is a sample drawn out from the base population which according to Frankel (1984) would represent with minimum of repetativeness the genetic diversity of a crop species and its relatives. Core was also defined by IBPGR, as the freely available part of the germplasm without restriction in contrast with the reserve collections restricted for distribution because of propriety or regulations (Annon., 1985). The usage of the core in the latter way is controversial and now redundant.

Core subsets: Instead of developing a single core from a germplasm population some situation specific subsets may be developed for special traits at several eco-sites assigned under the components of active collections which are ultimately linked to a single bse collection.

Why delineate Core?

There are several points in favour of setting up a core germplasm instead of selecting accessions at random or bulking of similar accessions. These may be enlisted as follows:

1. It provides efficient access to the base collection for germplasm utilization for a particular trait and gives further idea, based on passport data of the selected accession, to screen other germplasm of the same geographical origin, for the trait under question, from reserve collections.
2. It facilitates prioritization of representative diversity in base population for further evaluation and study of molecular or cytological variations.
3. It also facilitates conducting studies in relation to conservation aspects and regeneration criteria on the selected set of germplasm on priority.

4. The PGR management is facilitated in responding to generalized seed requests as more quantity of seed of a systematic representative sample is kept on hand by curators.
5. It is helpful for further research on germplasm management and utilization under limited budgetary provisions of developing countries and also it is a fund-saver for the lavish International germplasm programme aimed at the unique-ness of their product and its enhanced quantum of production across the globe.

Setting-up core germplasm

The germplasm base population may carry four conceptual classes of alleles based on their frequency and prevalence as follows:

Class	**type of allele**
Class I	Widespread, Common allele
Class II	Widespread, rare allele
Class III	Locallized, Common allele
Class IV	Locallized, rare allele

Thus several varieties selections could be developed possessing better yield, adaptability to biotic and abiotic stresses, and fitted under different agro-climates and cropping paterns: such as in tomato, pungent/sweet pepper, eggplant, cucurbits, peas, French bean, cowpea, pumpkin, okra, bitter gourd, cauliflower, radish, turnip, other Brassicae, carrot and onion.

It has been observed that primary introductions are successful only when species are shifted to climate almost similar to its home environment. Many a time such conditions are not fulfilled and performance of a species or a variety remains below expectation. Secondary introduction constitutes "The introduced variety may be subjected to selection or used in a hybridization programme to develop a superior variety". In general secondary introduction is much more common than primary introduction.

Some of the notable introductions during recent years are bacterial wilt and *Fusarium* wilt resistant lines of tomato from Taiwan, nematode resistant varieties Quinte and Early Rouge from Canada. Carrot variety Beta III has high carotene content. This has been used by many human nutrition programmes in India to cope up Vitamin A deficiencies. In watermelon high yielding varieties tolerant to *Fusarium* wilt have been introduced from USA. In muskmelon a multiple disease resistant line AC70-54 has resistance to Gummy stem blight, powdery and downy mildew. In cucumber also gynoecious line Gy-4 has been introduced which is being used for breeding high yielding multiple disease resistance including mildews and *Fusarium* wilt. In Chinese cabbage, heat tolerant and black rot resistant lines have been introduced from Taiwan. In cabbage, lines resistant to club rot, black rot and heat tolerant have also come from Taiwan. In capsicum, TMV tolerant, nematode tolerant and high yielding varieties World Beater and Yolo Wonder have all proved useful introductions. In chillies, hot peppers lines from AVRDC, Taiwan have been very successful at several locations in India.

Introduction of trait specific germplasm for hybrid seed production

Hybrids have been recognized world over for their superiority in different quantitative and qualitative traits. The development of superior hybrids takes 5-12 years depending on pollination mechanism involving in the crop concerned. Once a superior hybrid has been developed, it can be

released in other places having similar agro-climatic condition. Thus, a lot of cost and energy can be saved. A large number of F_1 hybrids have been directly introduced to India by private and public sectors through NBPGR. Additionally, germplasm possessing monoecy/dioecy, self-incompatibility and male sterility, have been introduced to facilitate hybrid seed production.

Introduction of transgenic

Genes have been introduced to develop transgenic varieties.

Maintenance of Vegetable Genetic Resource

The gradual loss of variability from cultivated species, and their wild forms and wild relatives is called *genetic erosion.* This variability leads erosion in nature over an extremely long period of time. Therefore, if allowed to be lost, it would be impossible to create it again during a short period. Genetic erosion is a creation of man since, ironically, man's success in plant breeding is the chief cause of genetic erosion. The varieties created by man using the natural genetic diversity are destroying the latter. It was clearly noted in the Agenda 21, at the Earth Summit in 1992. The FAO report on the state of the World Plant Genetic Resources, released at Leipzing in 1996, listed the main causes of plant genetic erosion in 154 countries. These mainly included over replacement of local varieties (80 countries), deforestation (over 60 countries), over-exploitation (nearly 55 countries) and population pressure and urbanization (45 countries).

The rich heritage and ethinic culture has favoured to preserve the richest diversity including rare landraces/ primitive types of useful vegetables like eggplant, cucumber, ridge and sponge gourd and a number of root and tuber crop species. A number of vegetable crops were brought to India from other regions by travelers, invaders like Persian, Turkey, Moughals, Portugese, Dutch, French and British which acclimatized and developed good amount of diversity. However, diversity for valuable genetic resources is threatened in recent times. Therefore, conservation of the vegetable genetic wealth particularly their wild relatives are thus essentially required for future utilization.

Table 3. Transgenic seed material introduced in India

Name of crop	Botanical name	Lines	Traits	Source	Indenter
Tomato	*Solanum esculentum*	EC676413	Insect resistant gene *ARg*	USA	Bejo Sheetal, Jalna
Cabbage	*Brassica oleracea L.* var. *capitata*	EC753911-15	HO4 and Cry 1B genes	USA	NBPGR, New Delhi

Germplasm can be conserved either (1) *in situ* or (2) *ex situ.*

(1) *In situ* Germplasm Conservation

Conservation of germplasm in its natural habitat or in the area where it grows naturally is known as in situ germplasm conservation. This is achieved by protecting this area from human interference; such an area is often called natural park, biosphere reserve or gene sanctuary. A gene sanctuary is best located within the centre of origin of crop species concerned, preferably covering the microcentre within the centre of origin. For majority of the situation, *in situ* conservation is ideal method of conserving wild plant genetic

resources and perennial vegetables, which either do not set or set recalcitrant seed, do not produce plants true to type. It usually allows increased probabilities of conserving a large range of potentially interesting alleles.

Merits

1- It usually allows increased probabilities of conserving a large range of potentially interesting alleles

2- It is specially adapted to species, which cannot establish or regenerated outside their natural habitats.

3- Allows natural evaluation to continue, a valuable option for conservation of diseases and pest resistant species, which can evolve with their parasites, providing, breeders with dynamic source of resistance.

4- It can serve several factors at once, since gene pool of value to different sectors (crop breeding, production etc.) may often overlap and so can be maintained in the same protected area.

5- It facilitates research on species in their natural habitats.

6- It assures protection of associated species of economic importance.

Role of biosphere reserve/gene sanctuaries for *In situ* conservation

The 'National Man and Biosphere Committee' of the department of Environment has already identified sites as potential areas for biosphere reserve. This covers all the major biogeographic regions of the Indian subcontinent where flora and fauna can be conserved in natural habitats. These areas have been identified based on their rich genetic diversity; floristic uniqueness endemic wealth flora/fauna and they are in totality representative of ecosystems occurring in different biogeographic regions.

***(2) Ex situ* Germplasm Conservation**

Conservation of germplasm away from its natural habitat is called *ex situ* conservation. *Ex situ* consevation requires collection and systematic storage of seeds/ propagules for short, medium and long term. NBPGR, New Delhi, is the nodal agency for *ex situ* conservation of PGR for food and agriculture, is maintaining active and base collections of various crop species and their wild relatives including vegetables in a network of gene banks in the country.

The conditions for seed storage depend mainly on the duration of storage. Generally, seed bank collections are classified into three groups: (1) base collections, (2) active collections and (3) working collections. This grouping increases the efficiency of use and the level of management of the collections.

1. Base collections. These consist of all the accessions present in the germplasm of a crop, which are stored at about -20°C with 5% moisture content; they are disturbed only for regeneration. Germination tests are done every 5-10 years. When the germination of an accession falls below, usually, 95% of its germination at the start of storage, the accession is regenerated.

2. Active collections. The accessions in an active collection are stored at temperatures close to O°C or at O°C, and the seed moisture is between 5 and 8%. The storage is for medium duration, *i.e.,* 10-15 years. These collections are used for evaluation, multiplication and distribution of the accessions. Active collections are usually maintained by multiplying the seeds of their own accessions. But from time to time, base collection material should be used for regeneration of these collections. This is essential to prevent any appreciable shift in these genetic make up of the collections.

3. Working collections. The accessions being actively used in crop improvement programmes constitute working collection. Their seeds are stored for 3-5 years at 5- 10°C and they usually contain about 10% moisture.

The breeders usually maintain these collections.

2-Seed conservation*:* Seeds are classified, mainly on the basis of their storability, into two major groups: (1) orthodox and (2) recalcitrant.

1. *Orthodox Seeds.* Seeds of this type can be dried to moisture content of 5% or lower without lowering their viability. Most crop seeds belong to this category. Such seeds can be easily stored for long periods.

2. Recalcitrant Seeds. The viability this group of seeds drops drastically if their moisture content is reduced below 12-30%. Seeds of many forest and fruit trees, and of several tropical crops like *Citrus,* cocoa, coffee, rubber, oil palm, mango, jack fruit etc. belong to this group. Such seeds present considerable difficulties in storage. Therefore, germplasms of such plants are conserved by alternative approaches.

Seed conservation includes

(a) *Low temperature storage of orthodox seeds (seed gene bank,)-* The seed genebank is responsible for conservation of seed accessions on long-term basis as base collections for posterity. It has 12 storage modules with a capacity to hold about one million accessions including vegetable at -20^0C. The present base collection holding of vegetables in the National Gene Bank (NGB) is 15032.

(b) *Cryopreservation: storage of orthodox seeds and recalcitrant (embryonic axes) seeds*- Cryopreservation is storage of biological samples in viable conditions at ultra low temperature of liquid nitrogen at –150 to –196 ^{0}C. A total of 388 samples have been cryopreserved at moisture content of 5-8% in the vapour phase of liquid nitrogen.

Further, investigations are on to develop protocols for cryopreservation of more recalcitrant seed species and establish their base collections. As an alternative complementary method, attempts are also being made to cryopreserve pollen in case of trees or vegetatively propagated species.

3-In vitro conservation*:* It includes (a) Conservation of cells, tissues, organs in glass or plastic containers under aseptic conditions through slow growth of cultures, (b) Cryopreservation of cultures (tissues, organs, pollen, somatic/zygotic embryos or embryogenic cell cultures in liquid nitrogen at –150 to –196 ^{0}C.). It may be called cell and organ bank.

4-DNA conservation or DNA Banks: In these banks, DNA segments from the genomes of germplasm accessions are maintained as cosmid clones, phage lysates or pure DNA (the last one being for relatively short periods). These DNA segments can be evaluated and the desired ones may be used to produce transgenic plants. This approach is applicable to the conservation of genetic materials of already extinct species since DNA extracted from well-preserved herbarium specimens can often be cloned. However, it is very expensive and highly sophisticated. A worldwide network of DNA banks for threatened/endangered species has been established. The basic objective in conservation of PGR is conservation of genetic diversity existing in the form of a functional unit called 'gene'. The whole genome in the form of genomic library or a sequence of DNA in the form of DNA library may be conserved following the appropriate DNA conservation method. Each technology is selected based on its merits in terms of utility, security, complementary and the advantages over the others.

ARUNACHAL PRADESH-A SUITABLE NICHE FOR TEMPERATE FRUITS

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Introduction

Arunachal Pradesh is located between latitude 26°30' N & 29°30' N and longitude 91°30' E & 97°30' E. The state has long international border with China in north and northeast, Myanmar in the east and Bhutan in the west. The terrain of the state stretches from snowcapped mountains in the north to the plains of Brahmaputra valley in the south. Over 90% of the area is hilly and around 2/3rd of the land is classified as forest. The annual rainfall in the state varies from 1000 mm in the higher reaches to 6000 mm in the foothills, spread over 8-9 months excepting the drier days in the winter.Arunachal Pradesh has tremendous potential for growth of horticulture sector which could be judged from the fact that 21.49% (18 lakh hectare) has been identified suitable for horticulture crop cultivation out of total geographical area of 83.743 lakhhactares. The state has favourable soil and climatic conditions and has great scope for temperate fruits. Presently stone fruits like peach, plum and apricot and pome fruits like apple and pear, and kiwi fruits are grown in small scale but the future is bright and there is great scope for the expansion of temperate fruit culture.

PROSPECTS OF TEMPERATE FRUITS

Apple

There is an immense scope for large scale cultivation of apple in some parts of Arunachal Pradesh owing to suitable agro-climatic condition. As at present 99% of the total apple produce in entire northeastern comes from Arunachal Pradesh and it ranks fourth in national production.Apple is one of the most important temperate fruits of the state covering about 13866 Ha (16.2 % of area under fruits) with production of 30505.2 MT (9.8% of total fruit production). Apple of Arunachal Pradesh is at par with that of Himachal and Kashmir in terms of quality and size. With the introduction of exotic varieties and dwarfing rootstocks, the apple production has increased many folds. It is cultivated mainly in the temperate areas of West Kameng and Tawang districts and expansion is being done to other potential areas like Ziro of Lower Subansiri, Mechuka of West Siang, Aniniof Upper Dibang Valley and Anjaw districts.

At present, there is only one State Horticulture Farm at Shergaon in West Kameng district, which was established in the year 1978. The total area of the farm is 120 hectares, out of which only 40 hectares is under cultivation. The farm also caters the needs for planting materials. The major area of the farm at present is covered under apple with few other temperate fruits like Cherry, Persimmon, Kiwifruit, Strawberry, Chestnut, etc. The apple varieties grown in this farm are Golden Delicious, Royal Delicious, Red, Gold, Mutsu, Jonathan, Ganu, Maharaji, Rajakori, Fokla, Crofton, McIntosh, Granny Smith, Ambri, Black Bendavis, Gani Gala, Rich-a-Red, Early Red One, Smoothee Yellow Delicious, Reinder's Golden Delicious, Starkrimson, Cooper-IV, etc.

Through there is a huge potential of apple production in the state with respect to area and climate but the present productivity of apple is the lowest with 1.73 MT/ha as compare to nation average of 6.1 MT/ha (NHB 2013). Hence there is an immense scope for productivity improvement in the state with adoption of scientific cultivation and farm management practices. Moreover, introduction of low chilling varieties of apple willexpand the scope of apple cultivation to warmer areas of the state. Some important low-chilling varieties are Michal, Schlomit, Anna, Tamma, Vered and Neonii, Tropical Beauty, Parlin's Beauty and Hari Man.

MAJOR DRAW BACKS

1. Non availability of quality planting materials.
2. Out dated farming practices and technologies are used by the farmers.
3. Lack of adequate extension services.
4. Remoteness of the location and difficulty in evacuation of the produce on time.
5. Lack of sorting, grading and packaging information.
6. Lack of market information
7. Lack of cold storage facilities
8. Non-availability of fertilizers and agro-chemicals

Kiwifruit

Kiwifruit is an economically important exotic crop, which is successfully grown in the hilly terrains of Arunachal Pradesh. Kiwi has been introduced during 2001-02 under Technology Mission programme and at present the state is largest producer of Kiwi in the country. The current area under Kiwi is 4050hectareswith the production of4960 MT. It is mainly cultivated in West Kameng district, Tawang and Zero area of Lower Subansiri district. Considering the higher economic returns due to limited supply and high demandof fresh fruit in all the major cities in the country as well as congenial climatic conditions for the crop production in the state,kiwi cultivation is being expanded to West Siang, Anini, Anjaw, Lower Dibang Valley, Tirap and other temperate areas. There is huge expansion potential for this crop in the state.

The present productivity of Kiwifruit in Arunachal Pradesh is 1.22 MT/ha as compare to nation average of 1.81 MT/ha (NHB 2013). Through the present productivity of kiwifruit in Arunachal is low but there is a scope of increasing the productivity up to 25 MT/ha under scientific management practices following bower system of plantation.

Advantages of growing kiwifruit in Arunachal Pradesh

1. High productivity: Kiwifruit yields up to 25 MT/ha which is much higher than majority of other fruits. Above all, there are no crop failures in this crop due to vagaries of climate and incidence of pest and diseases.

2. Congenial climate: The agro-ecological conditions prevailing in the Arunachal Pradesh is quite similar to the native place of kiwifruits in central China ensuring its successful growth and high production.

3. Free from pests and diseases: All the commercially grown fruits are being attacked by one or more serious pest or diseases reducing the margin of income of the growers due to adoption of spray schedule. Fortunately, no serious incidence of any pest or disease has been reported on kiwifruit so far.

4. Favourable handling and storage characteristics: Majority of commercially important fruits are highly perishable and have short storage life but kiwifruit, after harvest can be kept for a month at room temperature and in cold storage for many months. It does not require air or refrigerated transport and can be shipped to distance market easily.

5. High market demand: A very high global demand for kiwifruit already exists due to the marketing efforts of New Zealand. Even in India, it is needless to mention that demand has always been surpassing the supply.

6. High Vitamin C content: Besides the specific flavor, kiwifruit is also nutritious particularly in Vitamin C content which is higher than oranges.

Major varieties of kiwifruit grown in Arunachal Pradesh are Allison, Monty, Hayward and Bruno. Hayward requires more number of days for fruit ripening whereas Allison requires least number of days. Bruno fruits are bigger in size and contains high amount of Vitamin C. Harvesting of kiwifruit in Arunachal Pradesh starts from first week of October and peak season extends up to mid-December.

Walnut

Walnut is an important export oriented crop and India is a major exporter of walnut. The total production of walnut in the country in the year 2012-13 was 233.12 (000) MT from an area of 122.65 (000) hectare, with the largest area and production share contributed by Jammu and Kashmir (90 %). Arunachal Pradesh accounts for only 0.2 % share and ranks fourth in terms of total production of walnut in India. Area and production of walnut in Arunachal Pradesh during 2013-14 are 4.9(000) hectares with the production of 0.6 (000) MT (NHB 2013). Considering the highly suitable agro-climatic conditions for walnut production in Arunachal Pradesh, there is huge scope and opportunities for intervention in walnut cultivation, marketing and processing in the state. Implementation of scientific production technology and processing, and development of marketing channels can lead to larger benefits for the farmers and can give a boost to economy of the state.

The current productivity of walnut in Arunachal Pradesh is 0.13 MT/ha which is far less than the national average of 1.7 MT/ha. Hence, there is a huge scope for increasing the productivity of this crop by introducing improved varieties and by following improved production technologies.In this regard, a national workshop on "Promotion of Walnut in Arunachal Pradesh" was conducted by the Directorate of Horticulture, Govt. of Arunachal Pradesh on 10 to 11 April 2015 in collaboration with Amity Directorate of Science &Innovation and Amity University Uttar Pradesh. The main objectives of the workshop were: 1. to bring awareness among the farmers about the benefits of walnut in terms of nutrition, income generation and environment promotion 2. to discuss and formulate a strategy and action plan for area expansion of walnut in Arunachal Pradesh 3. to established state of Art, Centre of Excellence of walnut in Arunachal Pradesh.

At present the major walnut producing district in the state is West Kameng covering about 80 % of walnut produce in the state. There is a great scope for area expansion under walnut in different district of the state such as Tawang, Lower Subansiri (Ziro), Anini, Anjaw, West Siang, Siang, etc.

MAJOR DRAW BACKS

1. Non availability of quality planting materials.
2. Out dated farming practices and lack of adequate water supply.
3. Lack of processing, storage and orchard management facilities.
4. Improper storage, drying, grading practices at farm level.
5. Lack of sorting, grading and packaging information.
6. Lack of technical awareness among the farmers for proper post- harvest management

aswalnut requires immediate drying and hulling

7. Lack of pre-cooling and cold storage facilities

8. Non-availability of fertilizers and agro-chemicals

PEAR

Pear is next only to apple in importance, acreage, production and varietal diversity among the temperate fruits in India. It is grown under the temperate and subtropical conditions because of its wider climatic and soil adaptability. It is primarily grown in hills at 1,700-2,400m above mean sea level in Himachal Pradesh, Jammu & Kashmir, Uttarakhand and some part of North Eastern Hilly regions like Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur and Mizoram. In India, the improved pear cultivars were introduced in the later part of the 19th century and the cultivation got momentum with the success of Bartlett and Gola cultivars in the hills and Partharnakh in the sub-mountaneous region of Punjab. Amongst the delectable temperate fruits, the pear is next to apple in importance, acreage, production and varietal diversity. Because of its tolerance to a wide range of soil and climatic conditions, it is grown both in temperate and sub-tropical conditions. However, the lack of attractive shape and colour and perishable nature of the fruit are the serious impediments in expanding its cultivation on a very large scale.

Importance and uses

It is most important temperate fruit crops next to apple in India in the temperate region. The fruit is rich source of organic acid like malic and citric, vitamins like 1-50 I.U. vitamin A, 1-ii mg/100g ascorbic acid and the fruit peel is richer source of ascorbic acid and biotin than the pulp. Besides, it is also rich source of minerals like calcium, phosphorous, copper, sulphur and chlorine.

Area and production

The major pear producing countries are China, Italy, USA, Russia, Germany, Japan, Turkey, France and Spain. Although pear is produce in all the continents of the world, yet the exact area under its cultivation is not known. In India, pear occupies about 42.28 thousand hectares with a total production of 316.70 thousand tonnes. In India, production is mainly confined in Jammu and Kashmir, Himachal Pradesh, Uttarakhand and some part of North Eastern Hilly regions like Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur and Mizoram.

Varieties

The cultivars of pear mainly belong to three groups viz. European, Asian and their hybrids. In general, the European cultivars are predominant in cultivation as they are of superior fruit quality but susceptible to fire blight disease. The cultivars can also be classified on the basis of chilling requirement. The cultivars requiring high chilling are Anjou, Bertlett, Bosc, Beurre Hardy, Doyenne du Comice, Conference, Flemish Beauty, Starking Delicious, Winter Nelis and Pakham'sTruimph. In contrast, low chilling cultivars are Keiffer, Le Conte, Gola and Pattarnakh. Some of the important pear varieties are as follows-

European types: Bartlett, Max Red Bartlett, Anjou, Bose, Comice, Flemish Beauty, Hardy, Eldorado, Pakham'sTruimph, Magness and Moonglow.

Asian type: Nijisseiki (20th Century), Kieffer, Le Conte, Gola, Patharnakh.

Low Chilling Cultivar: Patharnakh, Le Conte, Keiffer and Chinese Sand Pear.

Varieties suitable under Arunachal Pradesh

Arunachal Pradesh has a wide range of climate ranging from subtropical to temperate

region. Places like West Kameng and Tawang region have temperate type of climate which will be suitable with the high chilling cultivars whereas other subtropical region will be suitable with the low chilling varieties like Patharnakh, Le Conte, Keiffer and Chinese Sand Pear. At present under the subtropical region of Arunachal Pradesh, low chilling requirement cultivar like Chinese sand pear is successfully growing in this region however it is not commercialized due to various problems like lack of planting materials, skill of training and pruning etc. Still it is mainly confined in the homestead garden only.

Favourable climate and soil

Pear is found growing in a wide range of climatic conditions, as it can tolerate as low as -26 ^{o} C temperature during dormancy and as high as 45 ^{o} C in the growing season. A large number of pear cultivars requires about 1200 hours below 7 ^{o} C during winter to complete their chilling requirement. However, spring frost is detrimental to pear production and temperature at -3.3 ^{o} C or lower kills the open blossoms. Arid and moderately hot climate is favourable for pear cultivation. A well distributed annual rainfall of 100 cm is ideal. The site selected for pear cultivation should be at a slightly higher level and northern aspect need to be selected, as ample moisture is available on the northern aspect as compare to southern aspect, where fruit size remains small but crops matures earlier.

Pear thrives on a variety of soils but deep, well drained, fertile, medium texture and relatively more clayey soil is the best. The trees are short lived on sandy and loamy soils. A soil depth of 180 cm with pH range of 6 – 7.5 is considered ideal. Highly fertile soil, very rich in nitrogen is not suitable as they increase the incidence of psylla and fire blight.

The soil and climatic condition in Arunachal Pradesh is suitable for the cultivation for this important temperate fruit crop since the climate is range from sun-tropical to temperate, acidic type of soil and well distributed rainfall during the monsoon period. It fruit is mainly harvested during July-August and it needs irrigation at 20 days intervals upto the end of October for better flush in the season spring season. Under East Siang district of Arunachal Pradesh, the rainfall period is mainly between April to September which will be suitable for growing this crop under rainfed condition.

Constraints for pear cultivation in Arunachal Pradesh

- Lack of available of good planting materials since the present pear plants are seedling origin local variety
- Lack of high yielding low chilling for subtropical and high chilling cultivars for temperate region
- Lack of scientific knowledge of cultivation among the farmers
- Lack of proper training and pruning system since pear bear on the spur which has a life span of 6-8 years only

Future scope for this crop

The temperate region is located in few pockets of Arunachal Pradesh therefore introduction of low chilling varieties will be suitable for large scale production in sub-tropical region for rapid expansion of it cultivation and production in the future.

Peach (Queen of temperate fruit crop)

Peach (*Prunus persica*) and its smooth skin mutant, the nectarine are temperate fruit rich in proteins, sugar, mineral and vitamins with excellent appearance and quality. It comes in the market early in the season, particularly from the low chilling cultivars grown in warmer regions. The first good crop of peach is obtained within 4-5 years of planting which is sooner than majority of the other temperate fruit crops. Therefore, it

cultivation is expanding on a faster pace in many countries and it fruit production is highest among all the stone fruits.

Importance and uses

It is a good source of vitamins and minerals being rich in carotene, thiamine, riboflavin and niacin among the vitamins and potassium, sodium, camcium, magnesium, iron and zinc of the minerals present in the fruit. Besides, it also rich source of organic acids like malic, citric and quinic and rich source of protein as almost all essential amino acids are present in it. It is used both as fresh and in preserved form. Among the stone fruit crops, it ranks first follow by plum in economic importance.

Area and distribution

In India, it was introduced during the latter half of the 19^{th} century. Today, it is being grown in the mid-hill zone of the Himalayans extending from Jammu and Kashmir to Khasi hills 1,000-2000m above MSL. Low chilling peaches are grown in sub-mountainous region and Punjab, Haryana, Delhi and western U.P. Besides, a limited scale in the hills of South India and North-eastern regions (Manipur, Assam, Tripura, Meghalaya, Arunachal Pradesh, Sikkim and Mizoram).

Favourable climate and soil

Peach require humid climate with cold winter and dry summer. It is moderately winter hardy and sensitive to low temperature injury. Swellings of buds are injured at -6.5^0C. The cultivated sites should be free from early spring frost as peaches bloom early in the season. The blossom period can be delayed by the application of GA @ 200ppm before the leaf fall. Deep valleys are not ideal sites because cold air settles in these areas, and frost and freeze are very common.

Deep sandy loam soil rich in organic matter is best for its successful cultivation. It is highly susceptible to water logging and perfect drainage is required. Fertile and heavy soils are hazardous as it makes heavy growth and result in winter injury. Acidic soil and saline soil are unfit for peach cultivation. Suitable soil pH is between 5.8-6.8.

Most of the soil condition of Arunachal Pradesh are acidic in nature particularly East Siang district ranging from 5.5-6.5 pH due to uniform heavy rainfall, which will be favourable for the cultivation of this fruit crop. Besides, among the temperate fruit crops it requires the minimum chilling requirement for the initiation of flowering. Therefore, it will be suitable for the sub-tropical region of Arunachal Pradesh for the cultivation of low chilling varieties for large scale production and high chilling varieties in the cold temperate regions of West Kameng and Twang region. However, although there is favourable soil and climatic condition, it is still confined in the homestead garden reflecting a high scope in the future its expansion.

Cultivars

Choice of suitable cultivars for any region is governed by factors, such as, (i) type of market to be served, (ii) distance to market, and (iii) adaptability to the local soil and climatic conditions. For table purposes, the cultivars should be yellow-fleshed, freestone, regular producer and relatively free from fuzz. The cultivars which ripen before the onset of rains are ideally suited for commercial plantations. For canning purposes, the fruit should have yellow flesh, freestone, small non-splitting pit, good symmetrical size and should mature evenly. For dehydration, white-fleshed sweet cultivars having freestone kernels are preferred.

Table cultivars : Elberta, J. H. Hale, Babcock, Cardinal, Dixigem, Redtop, Redhaven, Rio Oso Gem, Candor, Red Globe, Baifeng.

Canning cultivars : Cortex, Carolyn, Dixon 1, Halford, Fortuna, Crawford's Early, Golden Bush, Stuart,Vivian, Veteran.

Low chilling cultivars: These are preferred in Australia, India and Florida (USA). These are Early Amber, Early Grande, Flordabelle, Flordagold, Flordaking, Flordasun, Flordaqueen, Rio Grande, Sharbati and May Gold.

Nectarine is a non-pubescent (fuzzless) peach having the identical growing and fruiting characteristics as the peach. Its important cultivars under cultivation are Annqueen, Cherokee, Late Le Grand, Nectared 4, Sun Grand, Sunlite, Sunred, Sunrise, and Sunripe.

Suitable Peach varieties for Arunachal Pradesh:

High Hills: Elberta, J. H. Hale, Babcock, Cardinal, Dixigem, Redtop, Redhaven, Rio Oso Gem, Candor, Red Globe, Baifeng.

Low Hills: Shan-e-Punjab, Early Amber, Early Grande, Flordabelle, Flordagold, Flordaking, Flordasun, Flordaqueen, Rio Grande, Sharbati and May Gold

Constraint of peach cultivation in Arunachal Pradesh

- Lack of available of good planting materials since the present peach variety is seedling origin local variety
- Lack of high yielding low chilling for subtropical and high chilling cultivars for temperate region
- Lack of scientific method of cultivation among the farmers
- Lack of training and pruning since it required regular pruning due to it one year old spur lifespan

Future scope for peach

The present scenario of peach cultivation in Arunachal Pradesh is just in the initial stage although of it favourable soil and climatic condition. In the future, with the introduction of low chilling high yielding varieties, there is scope for enhancement for the yield and productivity of the important stone temperate fruit crop in this region.

PLUM

Plum (Prunussalicina) is an important temperate fruit which is used both as fresh and in preserved form. Of the stone fruits, it ranks next to peaches in economic importance. Two type of plum- European plum (*Prunus domestica*) and Japanese plum (*Prunus salicina*) were introduced during 1870 in Himachal Pradesh. After evaluation, only Japanese plum has recommended for commercial cultivation in the temperate region of the North-Western Himalayas.

Important and it uses

Plums are rich in sugars and carotenes. Plum pits which constitute about 2 to 7 per cent of the fruit, yield up to 26.7 per cent of kernels. The aroma of the plum blossoms is due to benzaldehyde. Plums are used either as fresh dessert fruit or cooked. They are also canned, dried and made into jam. Plums contain high proportion of solids, particularly sugars, are preferred for drying and are known as prunes. Prunes are also canned and used for the preparation of prune pulp and prune beverage. The prune pulp is used in ice-cream mix, confectionery products and meat sauces

Area and distribution

In India, it is predominantly grown in H.P., J&K, hills of Uttarakhand, some extent to Nilgiris hills of South India (Tamil Nadu) and North eastern region mainly Nagaland, Sikkim, Meghalaya and few pocket of Manipur (Mao region under Senapati district). In case for the world area and production, China rank 1st followed by Serbia (2nd) and USA (3rd).

Favourable climate and soil

Plum requires varying types of climates. It is grown from subtropical plans to

the temperate high hills. European plum thrive best at 1,300 m above MSL and Japanese plum in the mid-hill areas located at an elevation of 1,000 to 1,600m above MSL. European plum requires 1,000-1,200 hour below 7^0C during winter to break dormancy whereas Japanese plum requires 700 – 1000 hour below 7^0C. The area with frost free spring during flowering having good soil drainage, adequate sunshine in summer and well distributed rainfall (90-110 cm) are most ideal for plum cultivation. Prolong drought during fruit growth and development and excessive rain during fruit maturity hamper fruit quality resulting fruit cracking. Soil having deep, fertile, well drained and loamy soil having a pH (5.5-6.5) is most ideal. Very heavy soil and light soil are not suitable.

The soil and climatic condition of Arunachal Pradesh are suitable and there scope for it expansion of cultivation in the future.

Table 1. Recommended varieties of plum in temperate regions of different states of India

State	Early	Mid-season	Late
Himachal Pradesh	Sweet Early, Methley, Kelsey, Santa Rosa, Beauty, Early Red Beaut, Transparent Cage, Alucha Purple and Trtron	Starking Delicious, Satsuma, Burbank, Elephant Heart, Frontrier, Kanto 5	Maposa, Tarrol, Red Ace
Uttar Pradesh and Uttarakhand	Jamuni, Titron, Settler, Cloth of Gold, Ramgrah Maynard	Howe, Alubukhare, Sharbati, ZardaluChittidar, Burbank Elephant, Heart, Satsuma, black Chamba, Victoria	Late yellow, Kanto 5, Sweet Early, Santa Rosa, Mariposa
Jammu and Kashmir	Saharanpuri White, Plum First Ramgrah, Maynard Sharps, Early Subza	Formosa, Maynard, BryanstonesGanze, Burbank, Santa Rosa	Satsuma, Grand duke, Silver Wickson, Beauty, cloth of Gold, reine Claude, Bavy Golden Gage
Punjab	Sultej Purple	Titron, Kala Amritsari, kataruchak	Alubukhara

Constraints for plum cultivation in Arunachal Pradesh

- Lack of high yielding low chilling for subtropical and high chilling cultivars for temperate region

- Lack of scientific knowledge of cultivation among the farmers

Conclusion

In Arunachal Pradesh, at present it is mainly confined in the small scale home state garden and there is lacking of improved varieties. Therefore introduction and selection of suitable varieties according to the climatic condition (subtropical and temperate regions) will be helpful in rapid expansion of this important stone temperate fruit crop due to it available suitable growing climatic condition in the future.

DIVERSIFIED VEGETABLES FOR NUTRITIONAL SECURITYAND ECONOMIC PROSPERITY

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Introduction

In historical perspective, our ancestors were depended upon hunting, fishing and gathering for their sustenance. Finding food was very dangerous because of the world's 2, 50,000 plant species were poisonous. Over 10, 000 years of trials and error, however, our ancestors identified 20,000 species of plants with leaves, seeds, stems, fruits, pods, shoots, flowers, tubers or other parts that were safe to eat. They also found 2,000 edible mushrooms, and 3,500 mammals, 9,000 birds, some reptiles, amphibians (especially frog) and about 1,000 insects and used them as food materials. During this trial and error period, a few useful plants were probably selected and protected. Then about 10,000 years ago, agriculture began in earnest way and people started cultivating few promising plants. A very limited number of crops were cultivated as staple diets to meet the associated needs. About 30 crop species provide 95% of the world's food energy, whereas over 7,000 species have been known to be used for food and are either partly or fully domesticated in the past by human civilizations. Intensive promotion of few cultivars results in biodiversity losses in farm ecosystem. These lead to displacement of traditional varieties and species and simplification of human diets. Also, due to increasing pressure on population and growing human taste, the food basket has to be widened. In history, it is well mentioned that 'Plant Domestication" began independently in India, Africa, China, Middle East, South and Central America and Southeast Asia. The vast flora and fauna distributed on the mother earth planet from hot springs at the ocean bottom to the alpine meadows at the top of highest mountains have co-evolved with marvellous interdependence and co-existence. Three major physical resources in the world comprise land, water and the biological diversity. Plant biodiversity in general and Agro-biodiversity in particular not only maintains the diverse ecosystem on the planet, but also acts as vital links of all the food chains. Biological resources of the earth are vital to humanity too, because they depend upon them for clean environment, food security, health care, social needs, sources of livelihood, trade, industrial growth and economic development. Due to the ever-increasing human and domestic animal populations and demand for food, feed and fiber, conservation and sustainable use of the existing biodiversity is one of the most serious challenges of the mankind. Nearly 42.0% of the world population depends on agriculture directly and indirectly, which is more so in the developing countries. In India, 17% human and 11% animal populations of the world are depending on agriculture. The food security of people does not depend merely on what is cultivated, but it needs realization that what is available in a particular situation. Plant genetic resources (PGR) are the basic and essential materials for development of improved crop varieties designed to combine high yield potential with superior quality, resistance to

diseases and pests, and also a better adaptation to abiotic stress environments. Vegetable cultivation in the new world dates back to 7,000 to 5,000 BC. Root crops may have been among the earliest to be domesticated in the humid tropics preceding the seed crops. Only two vegetable crops (bottle gourd and Sweet potato) are known grown in both the Old and New Worlds; before 1492. Their presence in both Western and Eastern hemispheres suggest possible pre-Columbian agricultural contacts. After the discovery of new world Columbus, there was a rapid exchange of crops among the continents. Almost one third of the world's species originated in South Eastern Asia and most of the fruit and vegetable crops did come from the East and West Asiatic centre and Mediterranean centre of origin, while roots and tubers and tropical fruit trees are concentrated in the Central American and Andean Centres.

(I) Importance of genetic resources for nutritional security

Plant genetic resources comprise of the total genetic diversity of the cultivated species and their wild relatives support a lot of human and animals with different ways. Natural biodiversity is the main source of foods during famines. Food security can be assured by a lesser known/lessor importance crops in the area of adaptation because these resources (species, strains, cultivars etc.) are generally resistant to pests and pathogens. Wild forms of horticultural crops with high content of mineral substances, proteins, vitamins and resistance genes for biotic and abiotic stresses assume significance for their conservation and sustainable utilization from their centres of origin and diversity. The important vegetable crops/crop groups for which good native diversity occurs in the Indian Gene Centre include beans, brinjal, cucurbits (cucumber and other gourds), leafy vegetables, okra, onion and tuber crops (Taros and Yams). Natural biodiversity makes significant contributions directly to household food security, particularly in areas (NEH regions) where such biodiversity exists and people have access to it. Plant Genetic Resources meet out the basic human needs like nutrition, health care, clothing and fuel. More than 850 million peoples still continue to be underfed and undernourished. After a quantum jump in yield of principal cereals, wheat and rice, during green revolution in the 1970s near plateau has reached in their production and productivity. Substantial cultivated areas are being degraded, salinized and diverted to alternative uses.

When we analyze the nutritional situation of India, it reflects that 53% children are still malnourished. In fact, considerable imbalances persist in respect of the calories, proteins, minerals and vitamins availability. These deficiencies could be minimized to a considerable extent by broadening our food basket with various under-utilized /underexploited vegetables, fruits etc. Indigenous vegetables poses a vast potential. Progressive improvement of these economic species over time by successive generations of farmers has led to evolution of today's crop plants giving rise to landraces and traditional cultivars. These precious materials along with their close wild relatives serve as building blocks for development of improved crop varieties that are used by plant breeders. They also constitute a priceless reservoir of genes conferring better adaptation and resistance to stress environments caused by biotic and abiotic factors. Biodiversity is of tremendous importance in the daily diet of human being, who depends on the bark, young shoots, buds, flowers, fruits, leaves, roots, tubers and mushrooms, especially in the season of hunger, when other cultivated crops are unavailable. The tribal peoples certainly live entirely on these foods for four to five months every year, when agriculture is impractical, or

in periods before harvesting rice. Over 90% of plant species for food and agriculture are located in the economically developing parts of the world, namely, the African, Asian and Latin American continents and the Far East Islands.It is obvious that to ensure food and nutritional security to the ever-increasing population at the present level of consumption, cereal production has to be increased by 30-50% by 2025 from less area and cultivated germplasm of crop plants with narrow genetic base and higher vulnerability to biotic and abiotic stresses. Many indigenous vegetables are natural and rich source of vitamins, minerals and antioxidants. Underutilized legumes may be a cheap, alternate source of protein and can be alleviate protein malnutrition in rural areas. Nutritious pods of tree bean (*Parkiaroxburghii*) are consumed as staple legume vegetable in the NEH Region of India. Velvet bean (*Mucunapruriens*) is considered one of the most preferred legume vegetables in tribal belts of Uttar Pradesh and Bihar.

Table 1. Nutritional value of vegetable crops

Vegetable crops	Edible parts (per 100 g)	Water (%)	Protein (g)	Fat (g)	Minerals (mg)	Fiber (mg)	Carbohydrate (%)	Calories (k-cal)	Vit. 'A' (IU)	Vit. 'C' (mg)
Chenopods	-	89.0	3.7	0.4	2.6	0.8	2.9	30	2900	35.0
Kale	100	83.0	6.0	8.0	-	-	9.0	53.0	-	186.0
Poi	100	90.8	-	0.4	-	-	4.2	-	-	87.0
Brussels sprout	100	85.5	4.7	0.5	1.0	1.2	7.1	52.0	210	72.0
Cabbage	88	91.9	1.8	0.1	0.6	1.0	4.6	27	2000	124.0
Amaranths	39	85.7	4.0	0.5	2.7	1.0	6.3	46	10120	4.0
Colocasia leaves	89	87.9	4.0	1.2	1.7	1.0	4.2	44	17130	12.0
Coriander	70	86.3	3.3	0.6	2.3	1.2	6.3	44	11530	135.0
Fenugreek	59	86.1	4.4	0.9	1.5	1.1	6.0	49	3900	52.0
Bengal gram tips	-	68.0	8.2	0.5	3.5	-	27.2	146	6700	-
Salad	6	93.4	2.1	0.3	1.2	0.5	2.5	21	1650	10.0
Mint	45	84.9	4.8	0.6	1.9	2.0	5.8	48	2700	27.0
Mustard greens	-	89.8	4.0	0.6	1.6	0.8	3.2	34	4370	33.0
Green onions	-	90.3	1.2	0.8	1.0	1.4	5.3	33	-	-
Radish leaves	-	90.3	2.7	0.6	2.1	0.9	3.4	30	18660	103.0
Spinach	87	92.1	2.0	0.7	1.7	0.6	2.9	26	9300	28.0
Dil	-	85.2	3.4	0.7	2.5	1.5	6.7	46	-	-

Turnip leaves	51	81.9	4.8	1.5	2.2	1.0	9.4	67	15060	180.0
Carrot	95	86.0	0.9	0.2	1.1	1.2	10.6	48	3150	3.0
Colocasia	-	73.1	3.0	0.1	1.7	1.0	21.1	97	40	3.0
Onion	-	84.3	1.8	0.1	0.5	0.6	12.6	59	0	0.0
Potato	100	74.7	1.6	0.1	0.6	0.4	22.6	97	40	11.0
Radish	99	94.40	0.7	0.1	0.6	0.8	3.4	17	5	17.0
Sweet potato	-	68.5	1.2	0.3	1.0	0.8	28.2	120	10	15.0
Cassava	-	59.4	0.7	0.2	1.0	0.6	38.1	157	-	24.0
Turnip	65	91.6	0.5	0.2	0.6	0.9	6.2	29	-	25.0
Elephant FootYam	-	78.7	1.2	0.1	0.8	0.8	18.4	79	434	43.0
Ash gourd (Vegetable)	97	92.6	1.4	0.1	0.6	0.7	4.6	25	84	2.0
Bitter gourd	97	92-4	1-6	0-2	0-8	0-8	4-2	25	210	1-0
Brinjal	91	92.7	1.4	0.3	0.3	1.3	4.0	24	124	88.0
Cauliflower	70	90-8	2.6	0.4	1.0	1.2	4.0	30	51	12.0
Cluster bean	-	81.0	3.2	0.4	1.4	3.2	10.8	60	30	56.0
Arvi	86	94.0	0-3	0-3	1-2	0.6	3.6	18	174	49.0
Cowpea	-	85.9	2.6	0.2	0.8	2.0	8.5	46	941	3.0
Cucumber	83	96.3	0.4	0.1	0.3	0.4	2.5	13	-	7.0
Indian bean	93	86.1	3.8	0.7	0-9	1.8	6.7	48	312	9.0
French bean	94	91.4	1.7	0.1	0.5	1.8	4.5	26	221	14.0
Chilli	97	92.4	1.3	0.3	0.7	1.0	4.3	25	712	137.0
Knol-khol	74	92.7	1.1	0.2	0.7	1.5	3.8	21	36	85.0
Okra	84	89.6	1.9	0.2	0.7	1.2	6.4	35	88	13.0
Leek	100	78.9	1.8	0.1	0.7	1.3	17.2	77	30	11.0
Pointed gourd	95	92.0	2.0	0.3	0.5	3.0	2.2	20	225	29.0
Ridge gourd	82	95.2	0.5	0.1	0.3	0.5	3.4	17	56	5-0
Snake gourd	98	94.6	0.5	0.3	0.5	0.8	3.3	18	160	-
Round melon	9	93.5	1.4	0.2	0.5	1.0	3.4	21	23	18.0
Tomato	98	93.1	1.9	0.1	0.6	0.7	3.6	23	320	31-0
Ginger	-	80.9	2.3	0.9	1.2	2.4	12.3	67	67	6.0
Turmeric	-	13.1	6.3	5.1	3.5	2.6	69.4	349	50	-

Water melon	98	95.8	0.2	0.2	0.3	0.2	3.3	16	-	1.0
Snap melon	-	95.7	0.3	0.1	0.4	0.5	3.0	14	265	10.0
Muskmelon	80	92.8	0.6	0.1	0.6	0.5	5.4	25	450	32S.0

Source: National Institute of Nutrition, Hyderabad

Phyto-chemicals are very important for human health. For example anti-gastric ulcer compounds are available in *C. frutescens* (BhutJolokia/Ghost chilli). Some useful source(s) for different phyto-chemicals are given below

Table 2. Useful phytochemicals and their sources

Useful Phyto-chemicals	Source(s)
Lutein	Drumstick leaf, mustard green, spinach
Carotenoids (β-carotene)	Carrot, pumpkin, sweet potato cv. Gouri, Red chilli
Lycopene	Tomato, carrot
Curcumin	Turmeric cv. Lakadong
Betalains	Beet roots (Red Beets)
Anthocyanins	Red cabbage, Red Radish, Beet root, sweet potato
Oleoresin	Ginger, chilli, turmeric coriander, green onion
Gingerol	Ginger

Source: Asati and Yadav (2004)

There are many plants which buds and flowers are eaten raw or valued in cooking. Not only this, edible flowers may be preserved for future use by adopting preservation techniques such as drying, freezing or steeping in oil. They can be used in drinks, jellies, salads, soups, syrups and can be used in mixed form, with other main dishes. Flower flavored oils and vinegars are made by steeping edible flower petals in these liquids. As a history, the culinary use of flowers dates back thousands of years with the 1st recorded mention being in 140 B.C (Preethi *et al*., 2011).In the ancient Roman civilization flowers like mallow, rose, and violets were significantly used to lend aroma and flavor to the different kinds of eatables. The Chinese, Greeks, mid-eastern and Indian cultures have been consuming edible flowers from a very early period. In England particularly during the reign of Queen Victoria, edible flowers like rose were used in a wide array of dishes. Presently a number of plants are available in nature which buds and flowers are delicacies in human diets. For example buds of sunhemps, *Luffa* species, Lasora etc. and flowers of pumpkin, drumsticks etc. are very commonly available in the vegetable market. Some of the edible flowers are given below:

Table (3). Edible flowers of important crop

Common name	Botanical name	Description
Fuchsia	*Fuchsia X hybrida*	Blooms have a slightly acidic flower. Explosive colour and graceful shape make it ideal as garnish. The berries are also

		edible.
Garden Sorrel	*Rumexex acetosa*	Sorrel flowers are tart, lemon tasting. So, it can be used like a lemon: on pizza, a salad topping, in sauces, over cucumber salads.
Nasturtiums	*Tropaeolum majus*	Nasturtiums rank among most similar to watercress. Whole flowers are stuffed. Leaves add peppery tong to salads. Pickled seed/pods are less expensive substitute for capers. Entire flowers can be used to garnish platters, salads, cheese tartars, open-faced sandwiches and savory appetizers.
Pansies	*Viola X Wittrockiana*	Pansy is not only a decorative plant but it is also used in phytotheropy. Because of its purifying properties infusion of wild pansy is considered particularly useful for pediatric skin problems such as acne or eczemas, and as a supportive treatment of chronic lesions of urinary system. Flowers and petals are edible. They are also used as garnishes in green salad.
Peony	*Paeonia lactiflora*	In China the fallen petals are parboiled and sweetened as a tea-time delicacy. Peony water was used for drinking in the middle ages. Peony petals can be added to salads or in punches and lemonades.
Perennial Phlox	*Phlox paniculata*	The perennial phlox is edible. It is the high-growing (taller) and low-growing (creeping) phlox that grows from 90.0-120.0 cm tall. The flowers very from reddish purple to pink, some white. Flowers are slightly spicy in taste and good in fruit salads.
Tree olive	*Osmanthus fragrans*	Tree olive is also known as fragrant olive, sweet olive but this plant is called Xî or guîhuâ in China. It flowers called guîhuâ in China which literally mean “cinnamon flower” or “cassia flower”. The flowers are infused with green or black tea leaves, to create a scented tea called guîhuâchâ. In Chinese cuisine, the flowers are also used to produce osmanthus-scented jam, sweet cakes, dumplings, soups and even liquor.
Tuberous Begonia	*Begonia X tuberosa*	Only petals of the tuberous begonias hybrids are edible. The bright colours and sour, fruitytaste bring flavor and beauty to any summer salad. Begonia blossoms have a delicious citrus sour taste and a juicy crunch. The petals are used as a garnish and in salads. Stems also can be used in place of rhubarb. The flowers and stems contain oxalic acid and should not be consumed by individuals suffering from gout, kidney stones or rheumatism.
Yucca Petals	*Yucca* species	The white Yucca flower is crunchy with a mildly sweet taste and can be used in salads and as a garnish.
Elderberry blossoms	*Sambucus* species	The blossoms are a creamy and have a sweet scent and sweet taste. After harvesting elderberry flowers, they should not be washed as that removes much of the fragrance and also flavor. Instead they should be checked carefully for insects. The fruit is

		used to made wine. The flowers, leaves, berries, bark, and roots have all been used in traditional folk medicine for centuries. All other parts of this plant except the berries are mildly toxic. They contain a bitter alkaloid and glycoside that may change into cyanide. The cooked ripe berries of the edible elders are harmless. Eating uncooked berries may cause nausea, vomiting, and diarrhea.
Angelica	*Angelica archangelica*	Depending of the variety flower range from pale lavender to blue deep rose. It has a natural affinity with fish. The leaves have a stronger, clean taste and make an interesting addition to salads. In its native Northern Europe, even the mature leaves are used, particularly by the Lab landers, as a natural fish preservative. Many people in the cold Northern region such as Green land, Siberia and Fin land consider Angelica a vegetable and eat the stems raw, sometimes spread with butter. Young leaves can be made into a tea.
Anise Hyssop	*Agastache foeniculum*	Both flowers and leaves have a delicate anise or liquorices flavour. Some people say the flower reminds them of root beer. The blossoms make attractive plate garnishes and or often used in Chinese-style dishes. It is excellent for use in salads.
Bee Balm	*Monarda didyma*	Bee Balm also called wild Bergamot, wild Oswego Tea, Horse mint and Moriarda. The wild Bee Balm tastes like oregano and mint. The taste of Bee Balm is reminiscent of citrus with soft mingling of lemon and orange, the red flowers have a minty flavor. The Bee Balm blossoms can be used in place of oregano. The leaves and petals can be used in salads.
Bathua	*Chenopodium album*	Inflorescences are cooked as a tasty broccoli substitute.
Daisies	*Bellis perennis*	It has astringent properties and has been used in folk medicine as an antiseptic.
Dandelions	*Taraxacum officinale*	Dandelions leaves and buds have been a part of traditional Mediterranean and Asian, most notably Chinese and Korean cuisine. Dandelions leaves can be picked I the early spring before they become tough. They are best before the flowers bloom. Later in the season the plants can be blanched, i.e. covered to exclude light, to improve the flavour. The flowers can be sauteed in butter or oil as a vegetable dish or dipped in tempura batter and fried. The flower petals, along with other ingredients, are used to make dandelions wine. The medicinal properties of this flower are numerous and are extensively used in treating various liver, gall bladder and urinary disorders, against gall stones. Jaundice and cirrhosis and also in treating dyspepsia. Therapeutically, dandelion is a diuretic and also reduces the cholesterol level in the body.

Fig Leaf Squash or Malabar Gourd	*Cucurbita ficifolia*	The male flowers and buds are cooked as vegetable, used in soups, stews and salads in some region of Mexico.
Pumpkin	*Cucurbita moschata*	The male flowers and buds are cooked as vegetable
Sponge gourd	*Luffa cylindrica*	Buds are fried and eaten
Ridge gourd	*Luffa acutangula*	Buds are fried and eaten
Tree bean	*Parkia roxburghii*	The fleshy part of the flower stalk may be eaten as vegetable and mature flowers are used to make curries.
Dolichos bean	*Lablab purpureus*	Flowers may be cooked and eaten.
Drumstick	*Moringa oleifera*	Flowers may be cooked and eaten
Sunhemp	*Crotolaria juncea*	Buds are cooked and eaten

(II) Medicinal importance and curative properties

The annual demand of botanical raw drugs in the country is estimated to be 4,19,5000 MT for the year 2012-2013 valued Rs. 1963 crores. Nearly 6000 plants are currently being used by the herbal during industry in some form of the other. About 960 medicinal plants constitute the sources of 1289 botanical raw drugs with 178 species being consumed in volumes exceeding 100 MT per year. Most of this demand is met from the wild populations without any assessment of their actual availability on a sustainable basis.

This dependency on wild populations of plants for life saving drugs will not reduce for a longtime to come for at least two reasons:

(a) Non-availability of technology for domestication of the large set of species and

(b) Growing competition for land between cultivation and developmental activities.

The exploitation on exploitation of wild resources would continue unabated despite new regulations and controls.

A number of underutilized leafy vegetables of Indian origins are rich source of folic acid, commonly referred as folate, which is helpful to reduce risk of cardiovascular diseases. It is abundantly available in poi/spinach (123 µg/100 g), chenopods and leaves of drumsticks. Folic acid is crucial in foetal development in the early stage of pregnancy. Accordingly nutritionist recommends that child bearing women should consume the recommended amount (400µg/100 g) of folic acid by eating a healthy and balanced diet. Carotenoid (precursor of Vitamin A.) is the requirement of the day for everyone. Now it is realized that not only β-carotene, but also other carotenoids including lycopene may have important role in protection against major disorders including cancer and heart diseases. It is found in most of the green leafy vegetables, *Momordica cochinchinensis*, carrots, squash, melons, spinach and tomatoes which contain a highly conjugated carbon backbone and act as antioxidants. Ascorbic acid (Vitamin C) is the main water-soluble antioxidant in plasma and

is readily found in many vegetables. Brinjal species *Solanum khasianum* Clarke and *Solanum mammosum* L. is a wild but cultivated for solasodine alkaloid. Similarly, *Solanum xanthocarpum, Solanum spirale* and *Solanum ferox* L. is used for vegetable and medicinal purpose.

Table (4).Medicinal importance of vegetable crops

Sl. No.	Species	Medicinal properties
1.	*Alocasia macrorrhiza* (L. Donn.)	Stem juice is believed to relieve scorpion and nettle sting, leaves are used as rubefacient for joint pains.
2.	*Alocasia indica* (Roxb.) Schott.	Has easily digestible starch, leaf juice is an astringent, rhizome acts as mild laxative and diuretic.
3.	*Alpinia galangal* Sw.	Rhizome used for curing catarrhal affections, fever and rheumatism
4.	*Amorphophallus dubius* Blume	Tuber cooked in butter milk and fried in ghee and used for treating dysentery. It is also used as a carminative, expectorant and in the treatment of piles, rheumatism and haemorrhoids. Fermented juice of petiole is used for diarrhea.
5.	*Amorphophallus sylvaticus*	Fruits and seeds are crushed into a paste and used in the treatment against toothache, bruises and glandular enlargements.
6.	*Amorphophallus paeconifolius*	It used as a tonic and has restorative and carminative properties. Also used in the treatment of piles, dysentery and rheumatism.
7.	*Anaphyllumwightti*	Small tubers of 1.0 g size. Rare plant. Maximum tuber yield 5.0-10.0 g. used for the treatment of piles.
8.	*Arisneria pulchrum*	Used for treatment of piles.
9.	*Asparagus felicious*	Root possesses astringent properties.
10.	*Asparagus racemosus* Willd	Roots are used as a refrigerant, demulcent, diuretic, aphrodisiac, galactogogue, anti-dysenteric and for dyspepsia. Medicated oil is recommended for rheumatic complaints.
11.	*Asparagus sarmentosus* Linn.	Roots are aphrodisiac and hence taken as a nourishing drink.
12.	*Asparagus officinalis* Linn.	Roots have demulcent, diuretic, laxative, cardiac sedative, tonic and aphrodisiac qualities. Also used in the treatment of jaundice. It contains the essential oil-asparagine and tyrosine which are used in commercial purpose.
13.	*Asparagus adscendens* Roxb.	Tubers are used as vegetable as it possessed colling and demulcent properties.
14.	*Asparagus gonocladus* Baker	Roots are aphrodisiac. It is boiled with oil & applied in cutaneous disease and treatment against gonorrhea.
15.	*Canna orientalis*	The tuber has diaphoretic, demulcent and diuretic properties. It is also a stimulant and hence used during fever and dropsy
16.	*Canna edulis* Ker-gawler.	Easily digestible starch similar to arrowroot starch

17.	*Ceropegia tuberosa*	Big tubers toxic to rats
18.	*Chlorophytum borivilianum*	Root is a vitalizer. Hence used as a health tonic, curative for pre and post natal problems, alternative to Viagra and for immunity improvement.
19.	*Coleus forskohlii* (Willd.) Briq.	Root contains Forskolin which is a bronchodilator and used as a cardiotonic in the treatment of congestive heart failure, glaucoma therapy, anti-hypertensive, remedy for metastalic condition and thrombosis
20.	*Coleus amboinicus*Lour.	Juices of the leaves which contain an aromatic carminative are used in treatment of urinary disease, dyspepsia, chronic coughs, asthma, cuts and wounds.
21.	*Colocasia esculenta*(L.) Schott	Juice of the petiole is used as a stimulant and rubefacient. The corm juice is used against scorpion stings.*Colocasia* starch is used to prepare weaning baby food and cosmetics.
22.	*Corollocarpus epigens*	Used as medicine to cure skin disease.
24.	*Costus speciosus* (Koenig) Sm.	Roots used as antidote for snake bite and wounds, the rhizomes contains depurative and anthelmintic and purgative properties and used as tonic. Root powder is used in the treatment of urinary disease, body pain, fever and snake bites.
25.	*Cucrcuma aromatica*	Rhizome is used as a tonic, carminative and also for treatment of bruises and sprains
26.	*Cucrcuma caesia*	Rhizome is used as a stimulant and carminative and also in the treatment of asthma, bruises and sprains.
27.	*Cucrcuma zedoaria Rosc.*	Rhizome is a stimulant, carminative demulcent & expectorant. Also applied on bruises sprains, pains, dyspepsia, cold cough and bronchitis. Oil is used as an anti-irritant.
28.	*Cucrcuma amala*	Rhizome is a carminative and also used for stomach.
29.	*Cucrcuma malabarica* Vel*C. zedoaria*	Collected from forests by tribals (Kadar-Sholayar forest) sold in market for starch as well as for making cheap paints. It contains easily digestible starch which has antifungal and antibacterial properties.
30.	*Cyanotis tuberosa*	Nearly 99.0% watery. Used to prevent thirst.
31.	*Cyperusrotundus*	Staple food for wild folk. Broad spectrum of medicinal use.
32.	*Dioscorea deltoidea*	For production of diosgenin.
33.	*Dioscorea floribunda*	For production of diosgenin.
34.	*Dioscorea kumaonensis*	Tubers used in the treatment of arthritis and rheumatism.
35.	*Dioscorea pentaphylla* Linn.	Tubers are applied on swelling of joints and also used as a tonic to improve body immunity.
36.	*Dioscorea esculenta*(Lour.) Burk.	Tubers used for treatment of chest pain, nervous disorders and swellings.
37.	*Dioscorea hamiltonii*	Treatment of stomach ache.

	Hook.f.	
38.	*Dioscorea hispida* Dennst.	Tuber is used as an antidote in arrow poison.
39.	*Dioscorea oppositifolia* Thunb.	Kavalakizhangu is believed to be an excellent food tonic by tribals. Tubers are used in the treatment of swelling, scorpion sting and snake bites.
40.	*Dioscorea tomentosa* Koenig.	Edible tubers eaten after boiling.
41.	*Dioscorea wallichii*	Cooked tubers could be chewed & juice consumed for treatment of jaundice.
42.	*Drosera peltata*	Highly medicinal having red coloured tubers of 1-2 g. Seen around KMTR area during February. Used for the preparation of Thangabhasmam, a life drug.
43.	*Gloriosa superba*L.	Bears tubers. Red flowers. Seeds used for treatment of heartailments. Also, called as Kalappakizhangu, Kanmanippoovu. It is also used to kill intestinal parasites.
44.	*Hedychium spicatum* Buch.Ham.	Rhizome is stomachic, carminative, stimulative and used as tonic and for the treatment of dyspepsia
45.	*Hedychium coronarium* J. Koenig	Stem juice used against swelling. Rhizome is an antirheumatics and used as tonic and excitant.
46.	*Helianthus tuberosus* L.	Rhizome is a commercial source of levulose-sweetening agent for diabetic patients.
47.	*Ipomoea aquatica*	Root is purgative
48.	*Ipomoea batatas*	Tubers are laxative
49.	*Ipomoea carnea*	Root decoction reduces blood pressure.
50.	*Ipomoea disitata*	Root applied on swelling of joints
51.	*Ipomoea hispida*	Root used in the treatment of rheumatism, headache, epilepsy, leprosy and ulcers
52.	*Ipomoea alba*	Root is purgative
53.	*Ipomoea paniculata*	Aromatic. Tubers used for enhancing milking.
54.	*Martanta aurandinacea* L.	Rhizomes contain easily digestible starch, which are used in making face powder and special glues. It is a rubefacient and also applied on wounds and used for the treatment of ulcers.
55.	*Nelumbo nucifera* Gaertn.	Rhizome used as tonic and in the treatment of diarrhea.
56.	*Pueraria tuberosa* (Roxb.) D.C.	Roots are demulcent, used as refrigerant in fevers, reduce swellings of joints and a lactagogue
57.	*Sagittaria sagittifolia*	Roots used in treatment of skin disease, leaves used as an antidote to snake bite, insect bite and relieve itching.
58.	*Scripus grossus*L.	Tubers are astringent, laxative, cooling and have diuretic properties. Used for arresting vomiting and diarrhea. It is also used as tonic.
59.	*Scripus kysoor* L.	Tubers are used against diarrhea and vomiting.
60.	*Scripus lacustris*	Root stock is an astringent and used as diuretic.

61.	*Scripus maritimus*	Roots are astringent and diuretic.
62.	*Scripus tuberosa*	Roots are used as laxative.
63.	*Stepha niawightii*	Very big tubers, 6-7 kg, used in treating leprosy.
64.	*Teccaintegrifolia*	Tubers used in making tonic and in the treatment, diarrhea and dysentery.
65.	*Teccaleontopetaloides* (L.) Kuntze.	Tubers used in the treatment of piles, rubefacient, diarrhea and dysentery.
66.	*Theriophonum divaricatum*	Tubers are used against diarrhea.
67.	*Theriophonum minutum* (Willd.) Baill.	Dried & used after steaming
68.	*Typhonium roxburghii*	Tubers used in curing skin eruptions
69.	*Typhonium trilobatum*	Tubers contains a stimulant and is used in the treatment of piles, stomach complaints, haemorrhoids etc.

(III) Ritual importance

There are several vegetable crops which ritual association can be seen in the societies. For example tuber crops in Kerala:

(i)**Ettangadi:** A traditional dish associated with Thiruvathira festival. On the previous night of Thiruvathira, the women make "ettangadi" as a part of religious rituals of Hindus. Tubers of Colocasia, Elephant foot yam, Cassava, Chinese potato, lesser yam var. Cherukizhangu. Lesser yam var. Nanakizhangu and greater yam are baked and cut into pieces after removing skin. Into this, coconut, powdered pulses and jiggery are mixed to make ettangadi and offered to Gods Ganapathy, Siva and Goddesses Parvathi and Durga.

(ii) **Thiruvathirapuzhukku**: Elephant foot yam, *Xanthosoma*, *D. alata*, banana, Chinese potato and sweet potato are cooked with powdered green gram, coconut, red chillies, curry leaf, salt and turmeric to make this dish on the day of Thiruvathira.

(iii) **Hindu**: Hindu consumes cooked tubers of *D. alata* on the day of festival "Karthika".

(iv) **Thalukary**: Thalukary is a preparation made for giving to pilgrims at the Dhanwanthiri temple near Thakazhy in Kuttanadu, Kerala which is believed to have medicinal effect.

Conclusion

Many cultivated and wild vegetable species date back to pre-historic times and are associated to culture of a region/country. It is presumed that vegetable were among the first plant used by man. Lesser-known vegetables have their importance mainly in the areas of their occurrence due to climatic change, physiographic diversity and adaptation. In the Indian sub-continent there is tremendous scope for their acclimatization and they not only have potential to contribute towards food and nutritional security but also a source of rich wild gene pool for several important traits.

IMPACT OF CHANGING CLIMATE – A BOON FOR CULTIVATION OF LOW CHILLING TEMPERATE FRUITS IN SUB-TROPICAL AND TROPICAL ZONES OF NORTH EAST STATES

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Introduction

The North Eastern Hills Region, comprising the states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, represents a distinct agro climatic area of our country. The North Eastern Hills Region is bestowed with rich resources of soil and agro-climate making it one of the most suitable regions for horticulture industry. The vast areas of hills, interspersed with fertile valleys and plains represent an agro-climate of unique diversity, ranging from extreme temperature to tropical. One can see almost all types of fruits and vegetables growing in one or the other part, thereby suggesting the vast potentiality of this area for the growth and development of the horticultural industry.

Among the temperate fruits, cultivation of apple, pear, kiwi, peach and plum is done on commercial scale. The best suited tract for apple and kiwi cultivation is in Arunachal Pradesh. Cultivation of pear is promising in Sikkim, while stone fruits like peaches and plums are mostly concentrated around Maram and Ukhrul area of Manipur and around Shillong in Meghalaya which constitute sub-temperate areas. In the sub-tropical hills low chilling varieties of apple, peach, plum, apricot and pear are getting popularity as crop diversification.

The lack of quality planting material, package of practices, modern technology and trained manpower are the major constrains in enhancing the productivity of temperate fruits in general and stone fruits and kiwi in particular. The technologies generated in UHF Solan have been transferred to NEHR over the years. The technologies are now available for the farming communities in NE, particularly in high hills of Arunachal Pradesh and sub-tropical hills of Manipur and Meghalaya for low chilling varieties of stone fruits namely, peach and plum.

In North-Eastern states such as Arunachal, Nagaland, Manipur, Mizoram and Meghalaya sub-tropical hilly areas has the potential to grow low chilling varieties of peach, plum, apricot, green almond and apple. The outstanding work on development of peaches for warm winter climate done by Prof RH Sharpe in Florida was initiated in 1952. Several peach and nectarine cultivars released for commercial planting have been found very successful in subtropical areas of the country in general and North East in particular.

Although major plum growing areas are in temperate conditions, some low chilling varieties largely belonging to Japanese (*P.salicina*Lindl) group are grown in plains of North Western India possibly suitable for North-East India too. Some of the promising varieties grown in the lower hills are Titron, Alucha Black and Sutlej Purple.

The cultivation of apricot (*P. armeniaca*L) is confined to the North Western Himalayan region. It is considered the least adapted to the subtropical climate. Therefore, cultivars with moderate chilling requirement, New Castle, Early Shipley, St. Ambroise and Kaisha were tried but suffered from delayed defoliation due to prolonged dormancy as a result of inadequate chilling and consequently resulted in poor bloom and fruit-set. Four varieties of apricot viz. Quardi, Bebecco, Harcot and Canino introduced under Indo-Italian project in Uttar Pradesh are low chilling and may perform well in subtropical areas. Its cultivation could not spread due to damage by rain, high winds, frost and hails and lack of standard cultivars and proper pollinizers. A peach almond hybrid SLOH producing hard shelled stones resembling almond is getting popular.

Kiwi is the most important and fast emerging fruit in the North East region grown in High Hills and Upland Sub Tropical areas in states namely Arunachal Pradesh, Sikkim, Nagaland, Meghalaya and Manipur. The cultivation is being done for expanding area under commercial use. The complete cultivation package of practices will be discussed. Based on systematic evaluation carried out for more than 15 years on various pomological traits at the University of Horticulture, Solan has resulted in selection of some low chill apple cultivars like Tropical Beauty, Parlin's Beauty, Anna, Aziza, Mayaan, Mollies Delicious, Michal and Schlomit have been identified. These varieties have been found promising in low hills with sub temperate/sub-tropical climates having chilling hours during winter between 200-400 hours. It is presumed that under North-Eastern conditions the cooler areas around Shillong (Meghalaya) and low lying areas of Arunachal Pradesh are suitable for such low chill apple however, precautions are to be taken in controlling diseases and pests resulting into blackening of fruits due to prolonged rains during maturity. Recommended selection of low chilling pear varieties has resulted in development of strains like Punjab Beauty. In foot hills of Himalayas Laxton's Superb, Baggugosha, LeConte, Kieffer, Chinese Pear and Kashmiri Pear have been popularized. The plant material of improved varieties of pear can be useful in areas where apple production has suffered due to occurrence of diseases like apple scab and pre-mature leaf fall prevalent in states like Sikkim.

In subtropical regions, spring is generally frost free and chilling availability ranges from 50-500 hours. The North-East region is not considered proper for strictly temperate fruit growing but several low chilling varieties of apple, pear, peach, plum, apricot, green almond, kiwi and olive can be grown in these non-traditional areas. These areas being closer to international markets of Bangladesh, Myanmar and Bhutan offer better export potentials if proper pre/post-harvest technologies are made available to farmers. Peaches and plums mature early in subtropical areas and find an excellent market condition. These low chilling temperate fruits are fast spreading in subtropical climate and catching attention of both orchardists and consumers both in North-West India and North-East as well where thrust has been given to diversify temperate zone fruits in tropics and sub-tropics.

Conclusion

Thus, cultivation of fruit crops is a vital option for successful diversification of subsistence mountain farming into cash farming. Fruit growing areas of the Himalayas are experiencing wide fluctuations in climatic patterns seen in term of variations in temperature and decreasing annual snowfall. It is perceived to be linked to the decline in productivity and emergence of new social economic problems. Keeping these points in view future research strategies need to be framed for sustainable horticultural production. The technologies already available in the North-West Himalayas also need to be demonstrated and disseminated to the farming community of North-East hills.

PROSPECTS OF LITCHI PRODUCTION IN ARUNACHAL PRADESH

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Introduction

In recent past, efforts have been made to introduce litchi in Arunachal Pradesh. Most of litchi production in the country is confined to traditional area in Bihar, Uttarakhand, West Bengal and Jharkhand. In fact, Bihar alone, accounts for nearly half of the country's total litchi output. In recent years, litchi cultivation has begun to spread to non-traditional litchi growing areas such as Punjab, Himachal Pradesh, Assam, Tripura and Odisha. Moreover, some of these states have recorded higher crop productivity than that in the conventional litchi belt. The average per hectare output of litchi in Punjab during 2012-13, for instance, was estimated at over 15 t/ha, which was almost double of the output in Bihar. Besides, litchi grown in the Gurdaspur and Hoshiarpur areas of Punjab can be exported from the international airport in Amritsar. Spread of litchi in these new areas indicates that crop has ample scope for its expansion of areas in non litchi growing belt. The climate condition of NE India comprising of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura is very humid due to very heavy rainfall and free from scorching sunlight. These regions are organically rich and very fertile and well suitable for production of this precious fruits. There is good demand of litchi in national and international export. Presently litchi occupies an area of 0.84 lakh ha area and production is in tune of 5.85 lakh tones with the average productivity of 7 t/ha. Area, production and productivity of litchi in the country is given in table (1).

Table(1). Area, production and productivity of litchi in India (2013-14)

States	Area (000ha)	Production (000MT)	Productivity (T/ha)
Bihar	31.48	234.20	7.4
West Bengal	9.30	93.90	10.1
Jharkhand	5.27	58.24	11.1
Assam	5.38	48.08	8.9
Chhattisgarh	5.36	37.63	7.0
Uttrakhand	9.44	30.71	3.3
Punjab	1.85	28.00	15.1
Odisha	4.47	20.32	4.5
Tripura	3.88	20.18	5.2
Others	7.74	14.04	1.8
Total	84.17	585.30	7.0

Further, 3rd advance estimate for the year 2014-15 indicates that current year will not be good for consumers having preference for litchi and it is estimated that production may reduce 5.69 lakh tones only. Due to fast urbanization in several parts of the country, litchi production is getting set back with the conversion of litchi growing areas in construction of building and other rehabilitations. A clear cut example of sudden fall in area and production of litchi in Uttrakhand has been noticed with the declaration of Dehradun as state's capital and incessant growth of various towns in litchi growing belt. This is not a single case; other

states also have near about same conditions. In this context, it is utmost essential that efforts should be made to search new areas for its production.

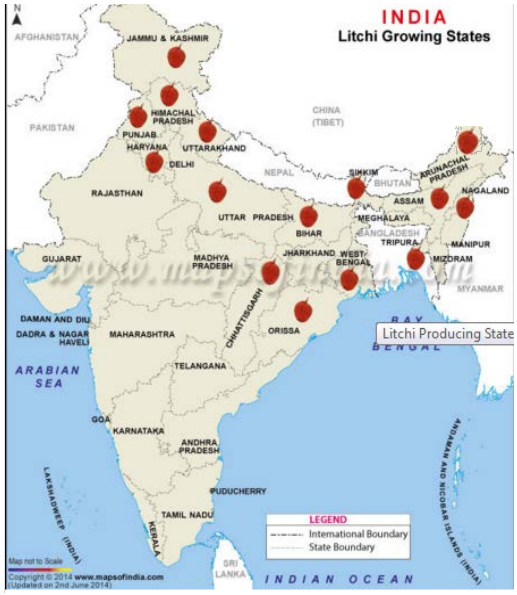


Fig. 1. Litchi growing states in India

In China, litchi has a long history of cultivation for more than 2000 years, reached Burma (Myanmar) by the end of 17th century and was introduced in India and Thailand about 100 years later. Litchi reached Madagascar and Mauritius around 1870 and was introduced in Hawaii in 1873 by a Chinese trader. It arrived in Florida, from India, between 1870 and 1880 and was introduced in California in 1897. Litchi was probably brought to Australia by Chinese migrants in 1954 and arrived in Israel sometimes between 1930 and 1940. China, Taiwan Province of China, Thailand, India, South Africa, Madagascar, Mauritius and Australia are now major litchi producing countries in the world.

Prolific Region of litchi cultivation in the world

Fig. 2. A litchi plant in College ofHorticulture and Forestry orchard

Fig. 3. Litchi growing in College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh

China

In China, litchi is widely spread across south China, between latitudes 31° and 18°N and longitudes 101° and 120°E, whereas the commercial production zone lies between latitudes 19° and 24°N . In south China Litchi has become a major industry since the 1980s. Litchi provides huge scope for employment of the local populace and about 320,000 people are involved in this industry. In 1999, litchi output was about 950,000 tonnes from 530,000 hectares for China as a whole. Guangdong Province is the most important area for litchi production in China. Other provinces where litchi grows well include Guangxi, Fujian, Hainan and Yunnan.

Thailand: Litchi is mainly grown in the northern part of Thailand where the climate is classified as sub-tropical. The major concentrations are in Chiang Mai, Chiang Rai, Phayao and Nan provinces in the north and Samut Songkhram in Central Thailand.

Northern Vietnam: In Vietnam litchi has been grown commercially for many centuries near Hanoi, but production has only expanded rapidly in the past five years.

Bangladesh: Litchi is grown in Dinajpur, Rangpur and Ragshahi districts.

Australia: Although Litchi was introduced into Australia about 60 years ago, major commercial plantings commenced only from the 1970s. About 50 percent of commercial plantings are found in northern Queensland, 40 percent in southern Queensland, and the balance in northern New South Wales.

Taiwan: Taiwan is the third largest Litchi producer. The production period in Taiwan extends from June to August, due mainly to the myriad varieties being grown.

Plant of litchi looks very attractive and its long green lustrous foliage well soothing to the pedestrian and it is centre of attraction in orchards. Litchi tree has dense foliage with round-topped and slow growing with evergreen leaves having 6-9 elliptic oblong and lanceolate abruptly pointed leaves. Colour of leaves varies from light green to dark green. Greenish white or yellowish flowers are borne in clusters. Fruits are round or heart shaped having thin, leathery skin. The colour of fruits varies with cultivar, and is red or rose or pinkish. The edible portion or fruit is the aril, which is immediately beneath the skin. Flavour of the aril varies with cultivar and it is quite distinctive. Seeds are bold but in some cultivars seeds are partially developed, due to failure of pollination.

Production of Litchi in North Eastern Region

Recently, litchi cultivation in NE region of India has received good attention of growers and exporters. Litchi cultivation is highly successful in areas having minimum temperature of 10°C from December to February and 38°C from April to June. However, temperature of 32° C during these months is considered to be optimum. It is highly specific to climatic requirement for its establishment and plant growth and fruiting. A moist atmosphere, receiving occasional rainfall, cool dry winter free from frost and hot winds are ideal for its cultivation. In India, the temperature of litchi growing areas varies from 21° C to 37.8°C during flowering and fruiting. It has been observed that flower initiation in litchi requires comparatively low temperature. Seasonal variation in temperature is favourable for proper fruiting. A dry climate, free from rains for about 2 months before flowering induces flower bud differentiation, blossom and consequently give high production. In most parts of the North Eastern region of the country these requirement of the crop is easily met. Author has observed that litchi orchard of North Eastern Region despite of not very specific attention of growers come very well and quality of the fruits are also good. Different litchi growing pockets of North Eastern Region is given as under:

Litchi growing pockets in North Eastern Region

Arunachal Pradesh: East Siang District, Namsai.

Assam: Dibrugarh, Goalpara, Sonitpur, Lakhimpur, Jorhat, Golaghat, Kamrup, Nalbari, Barpeta, Bongaigaon, Nagaon

Manipur: Imphal West, Bishnupur, Imphal East, Thoubal, Churachandpur, Chandel

Meghalaya: EastKhasi Hills, Ri-bhoi, Garo Hills

Nagaland: Kohima, Wokha, Mokokchung, Tuensang, Zunheboto, Phek, Kiphire, Longleng, Mon, Dimapur, Peren

Sikkim : North Sikkim (Phidang), East Sikkim (Majhitar, Bhasmey, Rorathang, Makha, Ralep, Mulukey), South Sikkim (Kitam, Pakzor, Chalamthamthang, Kichudumra), West Sikkim (Sagbari, Kamling).

Tripura : East and Central

Salient features of important litchi varieties grown in India has been given as under:

Shahi

This is the most popular cultivar grown in North Bihar, Jharkhand, Uttaranchal and Uttar Pradesh regions of India. Besides having high quality fruit, it has a distinct rose aroma and hence is called 'Rose Scented'. It is known as Shahi in Bihar, Rose Scented in Uttaranchal and Muzaffarpur in Western Uttar Pradesh. The vegetative flush of this cultivar is light, and fruit weight ranges from 20-25 g. This cultivar is earliest in maturity and ripens during the second week of May to the first week of June at various locations. It matures on 12-15 May in Jharkhand, the 25th May in North Bihar and by the first week of June in the Terai region of Uttaranchal. Trees of this cultivar are very vigorous and produce fruits ranging from 100-150 kg per plant. Mature fruits are prone to cracking in zones with low humidity and poor moisture content in the soil. Fruits are globous-heart or obtuse in shape having rose madder and fuchsia purple background with red tubercles at ripening. Pulp is greyish-white, soft, moderately juicy and sweet, and TSS ranges from 19.00 to 22° brix. Seed size varies. On the same plant larger fruits have big seeds while seeds in small fruits are shrunken. The fruits are known for excellent aroma and quality. This cultivar occupies a major area under litchi in North East India.

China

The origin of this cultivar is not known but the name indicates that it was selected for its superiority and named 'China'. It is tolerant to hot waves and fluctuations in soil moisture, which cause fruit cracking. It is known as Purbi, Calcuttia, Bengalia, Bombaiya and Manragi in different regions. This is a medium-late season cultivar. Fruits ripen during the end of May in West Bengal, the first week of June in Jharkhand and North Bihar and the third week of June in Uttar Pradesh. Trees are comparatively dwarf and high yielders but it is prone to alternate bearing. Rains at the time of fruit bud differentiation cause emergence of vegetative flush resulting in loss of crop. It bears fruits in cluster of 12-18. In some cases more than 30 fruits per cluster are also recorded. The plants bear less fruit in eastern and southern directions. Fruits are large in size, medium-heavy in weight, oblong in shape, and tyrant rose in colour with dark tubercles at maturity. The aril is creamy-white, soft, juicy, sweet having 18 to 17° brix TSS, 11 percent total sugar and 0.43 percent titratable acidity. Seeds are glaucous, dark chocolate in colour, oblong to concave or planoconvex in shape, medium in size (2.9 cm length and 1.5 cm diameter), and average in weight (3.49 g/seed). The ratio of rind:pulp:seed by weight is 16.42 : 69.22 : 14.36 .The flavour of the pulp is not pleasant like Shahi, but owing to its high yield and no cracking this cultivar is popular. This cultivar cannot be distinguished from Manraji and Purbi grown in the eastern part of Bihar state.

Early Bedana

It is also known as Early Seedless in Punjab because of its early ripening and small seeds. This cultivar has distinguishing leaf and flower characters. The cultivar is very much

popular in Uttar Pradesh and Punjab. Trees are medium, attaining an average height of 5.0 m and spread of 6.2 m. It is a medium yielding cultivar (50-60 kg/tree) but bears fruits regularly. Fruits are medium in size and weight ranges from 15 to 18 g having oval or heart shape, rough surface with uranium green skin covered with carmine red tubercles at maturity. Aril is creamy white, soft, juicy and sweet containing 17.2 to 19.8^0 brix TSS. Seed is very small, shrunken, glamorous, dirty chocolate in colour. The overall fruit quality of the cultivar is good.

Late Bedana

This cultivar is also known as Late Seedless. This is a late maturing cultivar, which usually ripens, in the last week of June in Uttrakhand, the end of May in Jharkhand and in first the week of June in Muzaffarpur. The trees are vigorous having an average height of 5.5 m and spread of 7.0 m., with yield ranging from 60-80 kg/tree. Although the fruit size is medium the pulp content is high. The fruits are conical in shape and vermilion to carmine in colour having dark blackish brown tubercles at maturity. The pulp is creamy white, soft, juicy, sweet having 18 to 2° brix TSS, but acidity is low. Seeds are very small, shrunken, glamorous, and chocolate in colour with fusi form shape. The new flush is dark pink in colour and its leaf can be distinguished from other cultivars. The panicle is compact.

Bombai

This is an important cultivar in West Bengal. It is a vigorous cultivar attaining a height of 6-7 m and spread of 7-8 m. The cultivar matures early (second week of May) and gives 80-90 kg fruit yield per tree. Fruits are large in size (3.5 cm long and 3.2 cm diameter), obliquely heart shaped, and weigh 15-20 g. The colour of ripe fruit is attractive carmine red with uranium green skin background. Like the Chinese cultivar 'Nuomici', this cultivar also has a tiny under-developed fruit attached to the fruit stalk of each fully developed fruit. The pulp is greyish white, soft, juicy, sweet, containing 17° brix TSS, 11 percent total sugar and 0.45 percent acidity. The elongated, smooth and shining seed of light chocolate colour is 2.3 cm long, 1.6 cm in diameter and weighs 3.4 g. This cultivar is akin to China grown in other states.

Dehra Dun

This is an important cultivar of Uttar Pradesh and Punjab where it is grown with the name of Dehra Rose. The fruits start ripening by the third week of June in Uttar Pradesh but in Jharkhand it matures with Shahi. It is a medium vigorous tree (5 m height and 7 m spread) which produces medium to high yield. Fruits are medium to large in size, measuring 3.7 cm in length, 3.5 cm in diameter, weighing 15.2 g and having oblique-heart to conical shape. Bright rose-pink coloured fruits of Dehra Dun look very attractive at ripening. The pulp of this cultivar is greyish-white, soft, moderately juicy with 18° brix TSS, 10.4 percent sugar and 0.44 percent acidity. Seeds remain small, light, shrunken, mostly oblong in shape and dark chocolate in colour. Under rainfed conditions this cultivar is highly prone to cracking. The name of the cultivar suggests that it is a selection made in Dehra Dun.

Gulabi

This is another late maturing cultivar of North India in which ripening takes place by the last week of June. Early rain hampers the quality of fruits. The medium vigorous tree of cultivar Gulabi bears profusely and regularly with medium to large sized fruits. The shape of the fruit is variable from oblong-oval to heart shaped whereas the rind colour at ripening varies from shrimp red to carmine red with mandarin red tubercles. The pulp is firm, greyish white, sweet with 18.2° brix TSS, 10.7 percent total sugar and 0.49 percent titratable

acidity. The seed is rather big, heavy, oblong-cylindrical in shape with a shining chocolate seed coat.

Ellaichi

This is an important cultivar in West Bengal having brighter prospects for commercialization. The trees are moderately vigorous, attaining an average height of 5-6 m and spread of 6-7 m. It is a mid season cultivar which ripens in the first week of June. The cultivar yields 50-60 kg fruits annually. Fruits are conical, marigold-orange red in colour with an average weight of 12-15 g. The pulp is creamy white in colour, sweet, soft and juicy with agreeable flavour. The cultivar has 18° brix TSS, 11.5 percent total sugar and 0.45 percent acidity, and 6.91 :1 pulp:stone ratio at ripening. Seeds are relatively small, shining, and weigh 1.5 - 2.0 g. Fruits are less susceptible to sunburn and cracking. This cultivar has not assumed commercial success.

Swarna Roopa

This is a late maturing, cracking resistant cultivar of litchi selected at the Central Horticultural Experiment Station (CHES), Ranchi. The fruits are a attractive red colour with small seed and high aril percentage. Leaves are similar to Bedana in shape and size. New flush is pink and mature leaves are dark in colour. The cultivar has 18.5-22.5 cm long, compact panicles. Fruits are medium in size weighing 12-15 g and have high pulp content. The pulp contains high TSS and low acidity. Total sugar content in the fruit is 13 percent out of which 8.5 percent is reducing sugar. The cultivar is suitable for extended harvest as it matures after China and is prized for its attractive fruit colour. This cultivar is recommended for commercial production.

CHES-2

This is a late maturing selection from the population of the China group. It bears fruits both at the outer and inner canopy, which helps in reducing the sunburn as well as fruit cracking. The fruits are deep red, conical shaped and appear in a cluster of about 15-20. The fruit has an average weight of 21.3 g containing 3.8 g seed and 16.1 g pulp. Vegetative characteristics are similar to China however flowering and fruiting is earlier. Litchi varieties which are commonly grown in the region are given in Table (3).

Table (2).Promising varieties of litchi grown in North Easter Region

States	Recommended var.
Arunachal Pradesh	Shahi, Bombai
Assam	Shahi, Bombai, China
Meghalaya	Shahi
Manipur	Late Large Red
Mizoram	Shahi
Nagaland	Late Large Red
Tripura	Shahi
Sikkim	Shahi

Organic Production of litchi

Organic production of litchi is getting momentum now days. During last year, about 2,100 farmers in Muzaffarpur district had organic litchis in as much as 1,200 hectare of land covering 76 villages of Motipur, Meenapur and Kanti blocks. In this context, North Eastern region have added advantage that itsmostofareas are under default organic. This condition can be taken as boon for export also.

Export of litchi from India

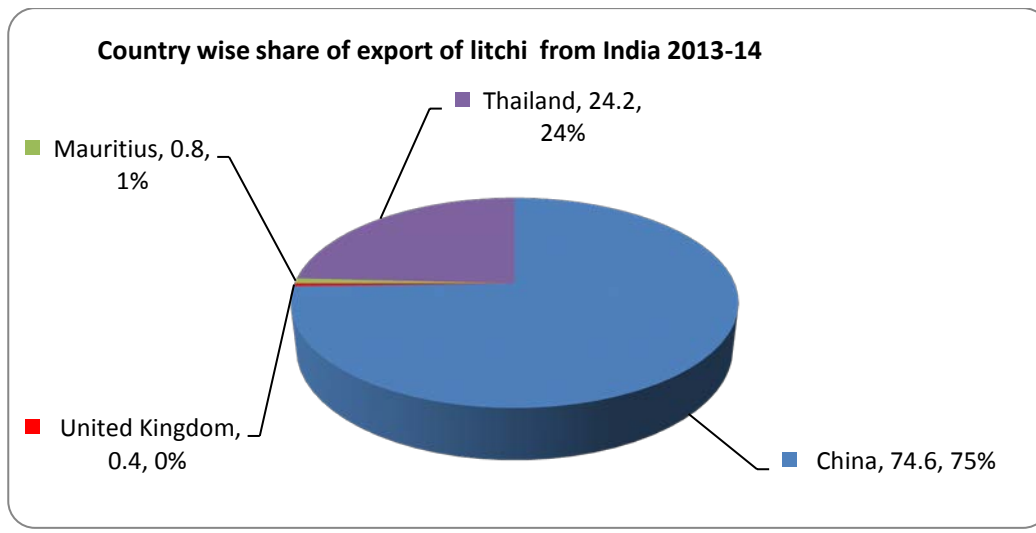
Export of litchi is mainly confined to SAARC countries, notably Bangladesh, Nepal, Maldives, and Bhutan, and the UAE. There is excellent potential for export of litchi to Gulf Cooperation Council countries at competitive prices compared to Thailand, as India

produces excellent quality litchi fruits and it is nearer to Gulf countries when compared with export competitors like Thailand and China. The European Union also imports sizeable quantities of litchi. With a narrow genetic base, under given climatic conditions, fruits are available only for 3-4 weeks. However, this limitation can be minimized by spreading the areas of production in North eastern region where litchi fruits are available from 15th April (Tripura) onwards up to the end of the June in Arunachal Pradesh.

Table (3).Export of litchi from India

Country	2011-12		2012-13		2013-14	
	Qty (MT)	Value (Rs. lakh)	Qty (MT)	Value (Rs. lakh)	Qty (MT)	Value (Rs. lakh)
China	0	0	20	10	87	62
Thailand	42	19	32	19	19	20
Mauritius	0	0	1	0	1	1
United Kingdom	0	0	0	0	0	0
Malaysia	0	0	0	0	0	0
South Africa	0	0	1	1	0	0
United Arab Emirates	1	1	0	1	0	0
United States	0	0	0	1	0	0
Total	42	19	55	31	108	84

SOURCE: APEDA WEBSITE JANUARY 2015



POST-HARVEST MANAGEMENT

Once litchi is picked, they start to dry out and brown. The mechanisms of pericarp browning, colour retention and pulp quality maintenance have been the worldwide focus of litchi post-harvest biology research. Progress has been made in litchi pericarp browning and colour maintenance. Fruits should be kept in high humidity and cooled to 5°C as quickly as possible. Hydro-coolers or cool rooms are

frequently used for this purpose. Sulphur fumigation has so far been the main post-harvest handling technology in prevention of litchi browning and maintenance of fruit quality. However, it has recently been questioned by both scientists and customers due to the chemical S residues and off-putting taste. At the moment the cool-chain system can provide satisfying resolution to litchi transportation, storage and marketing problems in developed countries. However, the cool-chain system is still at the very early stage of establishment in country.

Storage

At non-refrigerated temperatures, litchi fruit deteriorates rapidly within hour after harvest. Dehydration, brown discoloration of the pericarp and rotting reduce the post-harvest self-life of the fresh fruit. It is believed that pericarp browing is caused by a rapid degradation of phenols by the activities of polyphenol (catechol) oxidase (PPO) and peroxidase (POD) which were found highest in the epicarp, with progressively less activity in the mesocarp and endocarp

Table (4).Recommended storage conditions for litchi fruit

Temperature (^{O}C)	Relative Humidity (%)	Duration (days)
5	90	28-42
5-10	90-95	28-42
1.7	90-95	21-35

PESTS, DISEASES AND PHYSIOLOGICAL DISORDERPESTS

In the North eastern region following pest of litchi has been found damaging.

1. **Erinose mite** *(Aceria litchii)*

It is one of the most important pests of litchi. The characteristic symptom ofthis mite is chocolate brownvelvety growth on the ventral surface of the leaves, in which the mites take shelter, feed and breed. Spraying of kelthene (1.5 ml/1) before and after flowering gives the most effective result in reducing leaf curl and increasing fruit yield.

2. Leaf roller *(Statherotis leucaspis;)*

The caterpillars roll and web the tender leaves, feed inside and subsequently pupate. Occasionally they damage the flower buds. Heavy infestations cause extensive leaf damage, especially to developing flushes. Cypermethrin (0.006%) is most effective in controlling leaf roller.

3. Leaf miner and fruit borers *(Acrocercops cramerella)*

It is a major pest of litchi in Bihar. The larvae mine the leaves in August to February and migrate to *Eugenia jambolana*or *Cassia tora*during March to April. They come back to litchi in May and bore into the fruit and feed below the petiole. Spraying of methyl demetion (0.025%) and phosphamidon (0.05%) give the best control in 3 and 7 days after application.

4. Bark eating Caterpillar *(lndarbela tetraonis)*

This is an important insect pest of litchi in India. The adult moth lays eggs on old branches during May and June in groups of 15-25 which hatch after 8-11 days. The larvae feed on the surface of the bark till September. Afterwards they bore into bark and underlying tissues in the branches. These become full grown in December and pupate in late April. Plugging the holes with fumigants, such as carbon bisulphide: petroleum or formalin and then plastering with mud kills the catterpillar.

DISEASES

There are no serious diseases of litchi. In the Kangra valley of Himachal Pradesh, India, red rust, caused by an algal parasite

*Cephaleurosparasiticus*was first noticed in 1981. The disease first appeared on young unfolded tender leaves. On the infected young leaves, small lesions of velvety white growth appear on the lower surface. On the upper surface, just opposite the lesions, chlorotic patches occur. As the leaves unfold and increase in size, the velvety growth becomes more prominent and dense and larger areas of leaves are covered with this growth. Six sprayings of lime-sulphur, 3 during autumn and 3 during the spring season at fortnightly intervals give a highly satisfactory control of the disease.

Fruit cracking

Sun-burning and skin-cracking of developing fruit can be serious problems in litchi which is promoted by high temperature, low humidity and low soil moisture. Frequent irrigation during the critical period of aril

growth; spraying of zinc sulphate (0.5%) at weekly interval, starting from pea stage of fruit growth to harvest or spraying of GA3 at 40 ppm), ethephon at 1.0 to 10 ppm and 2,4-D at 20 ppm or NAA at 50 ppm reduced the incidence of fruit cracking.

Conclusion

Department of Fruit Science, College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh is keenly interested in making concerted efforts to popularize this crop in the state. During 2013 – 14, 3000 numbers of layered plants were developed and distributed among the growers. Research on different aspects of post-harvest handling and management has also been initiated. Harvesting season of litchi in Pasighat, Arunachal Pradesh starts from last week of May and continues up to 3rd week of June.

Air layering

Moreover, because of high humidity during this period, there is least fruit cracking, which is a boon for litchi production in this region.

OIL PALM -A POTENTIAL OIL CROP FOR NEH REGION

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Introduction

Oil palm (*Elaeis guineensis*Jacq) a native of West Africa is recognized as the highest and cheapest edible oil-yielding perennial crop. The crop is unique in producing 2 distinct types of oil *i.e.* palm oil and palm kernel oil, used for culinary and industrial purposes. Oil palm is the highest oil yielding crop per unit area. Oil Palm produces 4-6 tonnes of crude palm oil per hectare per annum and 0.4 to 0.6 tonnes of palm kernel oil from 4^{th} to 30^{th} year of its productive life span. The palm oil is derived from the fleshy mesocarp of the fruit, which contains about 45-55% of oil. The palm kernel oil, obtained from the kernel of stoney seed, is a potential source of lauric oils. Oil palm is the crop of present and future vegetable oil economy of world as well as India. Palm oil has good acceptance as cooking medium because of its price advantage. It is a good raw material for manufacturing oleochemicals used in making soaps, plasticizers etc. It is the crop that has a great advantage in productivity per hectare that is much higher than that of any major oil seed crop making it the best source to overcome the edible oil shortage in India. In the recent years, palm oil is being increasingly used as a source for biodiesel in a number of countries.

Through the implementation of appropriate research and development strategies, India too could emerge as one of the major producers of palm oil by cultivating oil palm as an irrigated crop in 2.00 million ha identified as potential area and there by producing 10 million tonnes of palm oil and 0.7 to 0.8 million tonnes of palm kernel oil.

The north eastern states need to take up palm oil cultivation in a big way to reduce India's dependence on edible oil imports and to benefit the farmers in the region, The country had to import edible oil worth more than Rs 61,000 crore in the year 2012-2013. Cultivation of oil palm on large scale in the NEH region will not only help in reducing the import of crude palm oil, it will also ensure the socio economic upliftment of the rural masses. So far only Mizoram has been promoting palm oil cultivation in an area of 20.377 ha, while Arunachal Pradesh and Nagaland have recently evinced interest in this sector. The Mizoram government has brought together agro-industrial companies, multinationals and cooperatives to implement

the scheme for cultivation of oil palm in the state. Godrej Agvovet Limited, Foods Fats and Fertilizers Ltd and Ruchi Soya Industries Ltd. are playing major role in developing and processing oil palm have committed to investing €43/US$55 million each to start their work to develop oil palm in the Kolasib, Mamit, Serchhip, Lawngtlai, Aizwal, Saiha and Lunglei districts of the state.

Union ministry of Agriculture has prioritized Arunachal as a potential Oil Palm producer and has approved to initiate Oil palm plantation initially with a target of 20,000 hectare in five from 2013-14. This initiative is in consideration of Agroclimatic suitability of the state and zeal of the national level major Oil Palm developers and processors who are the stake holders with buy-back assurance as is being done in Mizoram besides other states like Andhra Pradesh, Karnataka etc. The Govt. of Arunachal Pradesh has signed MOU with three national level Oil Palm developers and processors. These companies have started developing nursery in their respective allocated areas for the production of quality planting materials.

In Nagaland a Techno- Economic Feasibility study conducted by the Departrment of Agriculture to assess the feasibility of Oil Palm ventures in potential districts of Nagaland revealed that the Agro-ecological situation in Nagaland is suitable for Oil Palm plantation. The areas under study receive a well distributed monsoon for a period of around 8 months from March to October and during the remaining 4 months receiving little or no rain, the crucial irrigation requirement of Oil Palm can easily be met by the utilization of ground water through bore well or tube wells and pumps. The water table in the foothill areas is found to be high. Thus, the potential areas in Nagaland have a very congenial climatic condition for investing in the commercial plantation to this new crop. Vast areas of uncultivated and unutilized land significantly suitable for Oil Palm cultivation are available in these districts having potential for Oil palm plantation. Farmers and local denizens are reportedly very responsive and are socially very proactive groups. In the state of Nagaland, out of the 4, 01,510 hectares (24.22 % of the total geographical area) occupied by agriculture, 95,550 ha i.e., about 23.8 % of total area under cultivation is under Jhum (shifting cultivation). Jhum is one of the major causes of erosion, forest and ecological regression in certain areas. Moreover Jhum is becoming less productive with a shrinking or lesser Jhum cycle. Jhumias resettlement schemes have not worked well, nor can Jhuming be winded all at once. But, this problem needs to be tackled sensitively as Jhum cultivation is also a way for life for sustenance and livelihood. One rightful alternative to this age old, non-renumerative practice of Jhum cultivation in Nagaland can be diverted by a new initiative i.e., Oil Palm plantation. Oil Palm plantation can be visualized with a long term vision as an alternative to Jhum system cultivation prevalent in the state giving better alternative for sustainable agriculture. Any new initiative of Oil Palm plantation can be taken up in these areas under a cluster area approach. As

per the outcome of recent Techno- Economic feasibility study conducted to assess the feasibility of Oil Palm plantation in potential areas it was inferred that the foothills areas of Mokokchung, Dimapur, Wokha, Phek, Mon, Peren, Longleng and Zunheboto districts besides foothill areas of some districts with similar agro climatic conditions are the potential areas for Oil Palm cultivation. As Oil palm is tropical crop which can be best grown at an altitude between 450 to 900 m, it is suggested that the crop be taken up in the foothill areas at first in small clusters which can be expanded in future.

The north eastern region has a huge potential for oil palm cultivation. The prerequisite for successful oil palm cultivation is suitable climate, soil and evenly distributed rain fall (150 mm/month) or availability of irrigation water. The weather and the climate of the region are quite distinct from the rest of the country. The climate of the region is dominated by the Himalayan system and the altitudinal variations. The climate is highly hot and humid at the lower altitudes and in the valleys which will be favorable for oil palm. At the lower altitudes and in the valleys the average temperature during the winter months ranges from 15 to 21^0C while it ranges from 22 to 30^0C during monsoon. Between June and August, the temperature may go up to 40-42^0C. The rainfall of the region is the heaviest in the country. The annual average rainfall is usually more than 3000mm with maximum precipitation between May to September.

The soils are sandy and sandy clay loams in texture with good drainage conditions. Most of the soils are of virgin nature and have more of organic content, which is a positive character for good growth of oil palm. In areas where sloppiness is observed, terrace formation can be recommended for planting oil palm and to arrest the soil erosion. Since water is not a constraint in the region, as the region falls under high rainfall zone with maximum number of rainy days, oil palm can be cultivated as irrigated crop by harvesting the rain water for assured irrigation in the dry season (November to March). More over the region is blessed with a number of perennial rivers and streams which can be tapped for

Table (1):Mini Mission – II (Oil Palm)- clusters allocated to the companies for development of Oil palm Nagaland during 2014-2015 and onwards

Sl. No.	Cluster	Districts	Company	Remarks
1.	Cluster-I	Dimapur&Peren	Shivasais Oil Palm Pvt. Ltd.	MOU signed
2.	Cluster -II	Mokokchung&Wokha	3F Oil Palm AgrotechPvt. Ltd.	MOU singed
3.	Cluster -III	Mon &Longleng	Shivasais Oil Palm Pvt. Ltd.	MOU singed
4.	Cluster -IV	Zunheboto&Phek	Equator Palm Oil Pvt. Ltd.	MOU yet to be singed

irrigating the oil palm in the dry period. Various practices of watershed development can also be applied in sloppy terrain. In foot hill areas shallow aquifers may be tapped with shallow tube wells, dug wells or collector wells with infiltration galleries. Surface water or rain water resources could be developed through construction of check dams in series with sub surface dams and through construction of ponds for providing assured irrigation to the crop.

Conclusion

At present, the farmers are cultivating various traditional crops under shifting cultivation, which are giving yields of low economic returns. Shifting cultivation is leading to forest fires causing heavy loss to the environment. If oil palm is grown, burning of forest for shifting cultivation can be minimized since oil palm is a perennial crop the economic life of which is more than 25 years. As growing annual crops under shifting cultivation is creating problems of forest fires and resulting in low yields, oil palm cultivation under such conditions can be advocated in the beginning and later it may be shifted to irrigated condition by developing proper irrigation facilities. It will also ensure socio-economic upliftment of the farmers of the region by the following ways:

- There will be expansion of area under oil palm in the region thereby Oil palm processing units will come up in the region.
- Scope for marketing will enhance income of rural masses.
- Employment opportunities for the rural mass will increase.
- Cultivation of oil palm will reduce shifting cultivation and promote settled cultivation resulting in reduction of soil erosion in the undulating topography of the region.
- Palm oil will be the best source to overcome the edible oil shortage in the region.

IMPORTANCE OF LESSER KNOWN FRUITS IN HUMAN NUTRITION

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Introduction

Global food security has become increasingly dependent on only a handful of crops. Only 150 crops are traded on a significant global scale. Yet, surveys indicate there are over 7000 plant species across the world that are cultivated or harvested from the wild for food. These neglected, underutilized or lesser known species play a crucial role in the food and nutritional security, income generation and food culture of the rural poor. Lack of attention means that their potential value is under-estimated and under-exploited. It also places them in danger of continued genetic erosion and disappearance.

Among them underutilized fruits play a vital role in providing food, nutrition and other substances to the native communities and are an additional source of income. Underutilized fruits were known to mankind since the time immemorial and these fruits have been the prime source of food for the native people. These fruits are termed as underutilized not on the ground that their utility is less, but on the ground that these are not utilized to their fullest potential. Though, the wild and domesticated diversity are composed of nearly 3000 tropical fruit species, only a few have been cultivated on large scale. These underutilized fruits have great potential as a source of food, besides meeting multipurpose needs of local communities. In rural areas nutritional deficiency problems can be solved by utilizing degraded and marginal lands for planting underutilized fruit crops.

Various reasons for the under consumption of underutilized fruits:

1. Most underutilized fruit trees are not commonly cultivated on the farm and there is scant and dispersed knowledge about their fruits and their nutritive value.
2. People prefer to have fruits with good taste, since wild and underutilized fruits have high levels of the unpleasant tasting tannins and glycosides.
3. Underutilized fruits are neither large nor fleshy and contain lots of seeds.
4. The fruits are highly perishable and difficult to store in the fresh form.
5. Most underutilized fruits are not really easy and handy to eat.
6. Some fruit species are not acceptable as fresh fruit because of high acidity and/or strong astringent taste.
7. Most of them are often available only in the local markets and are rarely known in other parts of the country.

On the contrary, benefits of such underutilized fruits far exceed their limitations.

1. They are cheap and highly nutritious.
2. They have known medicinal and therapeutic properties and are used by the local people to cure various diseases.
3. Many of them, the fruit, seed, leaf of the plant are used as curative foods in the traditional Indian Medicine and Ayurveda. For example, amla is used

for treating diabetes, bael fruit for beating the heat, bael leaf for diabetes, and ber and phalsa being highly rich in vitamin C are used in cases of vitamin C deficiency.

4. In addition some have an excellent flavor and taste and are used for preparing delicacies at home. E.g. Pickle, chutney etc.

Recently, people have developed considerable interest in the production of underutilized fruits. There is a feeling among people not to remain dependent on income generated and nutritional requirement by a few fruit species but maintain rich diversity of fruit species in the region. The importance of these lesser-known fruits is increasing because people have realized the presences of various medicinal properties and essential nutrients in abundance such as carbohydrates, proteins, fats, vitamins and minerals in these fruits.

North eastern region has a very rich diversity of indigenous and underutilized fruit crops and its being rightly identified as one of the "Biodiversity Hotspot" areas in the world (Myers, 1998). The underutilized fruits of northeastern region are Rambutan, Bael, Aonla, Ber, Jamun, Pomegranate, Fig, Tamarind, Passion fruit, Persimmon, Carambola, *Delinia* (Chalta), Jackfruit, Guava etc.

Table (1). Nutritive values of underutilized fruit crops (per 100 g of edible crops)

Crops	Carbohydrates (g)	Protein (g)	Fat (g)	Iron (mg)	Vit. C (mg)	Vit. A (IU)	Ca (mg)	P (mg)	Fibre (g)
Rambutan	14	0.9	0.1	1.8	31	4	3	6	1.1
Bael	31.8	1.8	0.39	0.3	8	-	43	25	-
Aonla	13.7	0.5	0.1	1.2	600	-	50	20	3.4
Ber	12.8	0.8	0.1	300	70	-	30	50	-
Jamun	14	0.7	0.1	190	18	48	20	10	0.9
Pomegranate	26.44	1.46	0.46	0.34	16	166	12.07	4.91	0.9
Fig	9.59	4	1.5	4	1	100	200	7	1.5
Tamarind	70.8	3.1	0.4	11	-	-	170	110	3
Passion fruit	13.6	9.4	0.1	0.2	30	717	3.6	12.5	--
Persimmon	24.97	0.47	0.20	0.25	11	2710	8	28	4.9
Carambola	7.83	0.54	0.35	0.26	50	560	4	16	2.7
Delinia	2.9	3	0.1	-	4	-	0.5	26	-
Jackfruit	18.9	1.9	0.1	500	-	540	20	30	1.1

Guava	11.88	0.82	0.6	0.31	183.5	31	20	25	5.4

Medicinal values of the following underutilized fruit crops.

Crops	Medicinal values
RAMBUTAN 	Root decoction for fevers. Leaves for poulticing. Bark used as astringent for tongue maladies. Fruit used for dysentery and as a warm carminative in dyspepsia. Fruit decoction used for diarrhea.
BAEL 	Ripe or unripe fruit is used in curing dysentery and diarrhoea. It is also said to aid digestion and improve appetite. Ripe bael fruit could be used as an excellent laxative. A decoction made out of the root and bark of bael tree is used in treating fever. The bael root could also prove a useful home remedy for getting rid of ear problems. An infusion made of bael leaves is effective in treatment of peptic ulcer. Fresh bael leaves also help in treating diabetes.
AONLA 	The fruits are diuretic and laxative. Fruits are useful in the disorders associated with the digestive system and are also prescribed in the treatment of jaundice and coughs. *Aonla* is one of the three ingredients of the famous *ayurvedic* preparation, *triphala*, which is given to treat chronic dysentery, biliousness and other disorders. The plant is considered to be an effective antiseptic for cleaning wounds and also one of the many plant palliatives for snakebite and scorpion-stinging. The leaves of *aonla* are used as a mouth wash and as a lotion for sore eyes. An ointment is made from the burnt seeds and the oil obtained is applied to cure skin infections.
BER 	Fruits are used as an ingredient in the preparation of 'Joshanda' (An Aurvedic medicine used in chest trouble). The fruits are laxative and invigorating. The leaves are used to treat conjunctivitis. The bark is used for the treatment of diarrhoea. Root decoction is used in fever and its powder is applied to ulcers and old wounds.
JAMUN 	The berry is known for its hypoglycemic (lowering blood sugar) properties. The seed is used in various alternative healing methods in Unani, Ayurveda and Chinese medicine for digestive ailments. The leaves and bark are used for gingivitis and controlling blood pressure. Oral administration of jamun extracts, from the bark and seeds, boosts insulin levels in diabetics. Fresh seeds are better than the dried ones to serve this purpose.

POMEGRANATE  **E**	Fruits are good for stomach inflammations, chest pain, diarrhoea and dysentery. Juice is useful for leprosy patients. The stem and root bark are useful in destroying parasitic worms and cure of fever. The dry rind is useful in teeth and gum disorders.
FIG 	Fruits are laxative and rich in protein digestive enzymes. It is also effective in the treatment of piles, constipation, asthma, corns and chronic cough. It is an excellent tonic for weak people who suffer cracks in lips, tongue and mouth.
TAMARIND 	Tamarind pulp is useful in treating fevers. Pulp of the ripe fruit is useful in the treatment of bilious vomiting, flatulence and indigestion. It is also beneficial in constipation. An infusion of the pulp prepared by softening it in water is particularly useful for loss of appetite and lack of inclination for food intake. The tender leaves of tamarind tree are an effective remedy for treating burns. Its leaves prevent oedema and help in the growth of healthy and normal skin. The oil keeps the affected part well protected against moisture and entry of harmful germs.
PASSION FRUIT 	The juice but mainly the leaves of passion fruit contain the alkaloids, which has blood pressure lowering, sedative and antispasmodic action. The flower of passion fruit has a mild sedative and can help to induce sleep. Passion flower has been used in the treatment of nervous and easily excited children, bronchial asthma, insomnia, nervous gastrointestinal disorders and menopausal problems. Passion flower is sometimes used as a mild hallucinogen.
PERSIMMON 	Perhaps most important is the use of the fruit as an astringent for treating sores in the throat and mouth. They also used that quality of the fruit to treat hemorrhoids and they chewed the bark to treat heartburn. Truly, persimmon fruit has a lot of medicinal properties. The calyx of the persimmon fruit where it is connected to the branch of the tree can be used to make a calyx tea. Drinking calyx tea is good for stopping hiccup, and is also good for bed-wetting. For bee sting, paste a grinded astringent persimmon is very effective.

CARAMBOLA 	The ripe fruit is digestible, tonic and strengthening. The juice of fruit, when used as eye drop, is also considered to be useful for vision. The leaves are antipruritic, antipyretic and anthelmintic. They are useful in scabies, various types of poisoning, pruritus, intermittent fevers and intestinal worms. According to the physicians of Yunnani system of medicine, the ripe fruit stops diarrhoea and vomiting. These fruits also allay thirst. The ripe fruit is said to be a good remedy for bleeding piles, particularly the internal one. The dried fruit is given in some parts of India in fevers. It is considered one of the best Indian cooling medicines. The leaves are employed in the treatment of scabies. The fruit is considered as anti scorbutic. It is given as a refrigerant in fevers.
DELINIA  **(Chalta)**	Fruits are consumed as tonic and laxative. The fruit juice is mixed with sugar and used as a cooling beverage in fevers and as a cough mixture. Green fruits are very effective against rheumatism.
JACKFRUIT 	Root extract is used to treat fever and diarrhoea. The root is a remedy for skin diseases and asthma. The bark is used as a poultice. The wood has a sedative property. The jackfruit pulp and the seeds are considered a tonic by the Chinese. It also helps one get over the influence of alcohol. The starch from the seeds is used to relieve biliousness. The roasted seeds are said to be an aphrodisiac. The burnt residue of jackfruit leaves mixed with burnt corn and coconut shells is used to heal ulcers.
GUAVA 	The pulp from guavas aids constipation. It also has hypoglycaemic and anti-bacterial properties. The fruit, when eaten whole helps reduce both high blood pressure and cholesterol levels. It is also supposed to increase the good cholesterol. Guavas also help against ageing, and are often used in the preparation of body and face creams and lotions. The guava leaf extract is also effective in treating gastrointestinal problems as it is rich in quercetin and other flavonoids. A drug used for the treatment of diarrhoea has been developed using guava leaves for this very reason. The bark extract is also supposed to protect the heart and improve its functionality and has been recently used to treat irregular heartbeats. Guava leaves are also supposed to be good for weight loss.

Conclusion

Presently nutritional situation in the country is alarming because 36 % of children's are affected with malnutrition in the world are Indians. Anaemia is prevalent in 60% of our children. 33% of children are born underweight in the country, which is maximum in the world. Nearly, about 20,000 children become blind every year due to deficiency of vitamin A. These malnutrition problems are more acute in poor segment of our population which resides mostly in hill and tribal regions of the country. Moreover, these regions are backward because of illiteracy and inaccessibility. This means that the people of these regions are unaware about the importance of fruits and vegetables in daily diet. Underutilized fruits which are usually grown in hill and tribal regions can definitely provide a solution to the problem of malnutrition.

GENETIC DIVERSITY OF CHRYSANTHEMUM IN INDIA

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Introduction

Genetic diversity of any crop plays a very important role in developing new and novel desired forms through breeding and selection. Knowledge of diversity and its response to natural/human selection through hybridization is necessary for future breeding plan. All the present day colorful varieties of Chrysanthemum morifolium Ramat have been developed through complex interspecific crosses among elemental species, open pollination, indiscriminate intervarietal hybridization, spontaneous and induced mutation, selection and management of chimera. In floriculture industry there is always demand and necessity for new varieties. There is an urgent need for developing crop wise database. There is no record of total chrysanthemum varieties developed through classical breeding in different countries. Present article will provide maximum information generated in India on classical and mutation breeding on chrysanthemum along with important publications in chrysanthemum by other research institutions.

Inbuilt genetic diversity of any crop is explored by breeders to develop desirable genotype through repeated hybridization and selection. Breeders develop the most promising genotypes by selection procedure. It depends upon the genetic reservoir of the crop. Knowledge of diversity and its sensitivity to natural/human selection through hybridization is necessary. Nature of crop is very important in this regard. An attempt has been made to explore the genetic diversity of an important ornamental crop chrysanthemum. Range of phenotypic expression of genetic diversity in chrysanthemum can be recorded from existing varieties. Scientists/breeders working on chrysanthemum should develop a database of all the available varieties country wise. This will give a clear picture of genetic diversity for different phenotypic characters and their response in terms of segregation/expression to human selection pressure. Today, commercial floriculture is the most profitable business and expanding rapidly all over the world. Science based techniques have given an impetus to the growth of this industry in various parts of the world. Floricultural production contains a wide variety of different types of plants and plant materials. The flower industry comprises the cultivation and trade of cut flowers, cut foliage, potted plants and bedding plants. The main cut flower is the chrysanthemum, followed by the carnation and the rose. The top ten cut flowers in Netherlands are rose, chrysanthemum, carnation, tulip, lily, freesia, gerbera, cymbidium, gypsophila, alstroemeria. Chrysanthemum morifolium Ramat is one of the most interesting ornamental groups of plants in the world. Chrysanthemum has its admirers and enthusiasts all over the world for its use both as a commercial flower crop and as a popular exhibition flower. The unique position of chrysanthemum may be attributed to the great amount of variation in the flowers and plant characteristics as well as to their wide adaptability to various agro-ecological conditions. The chrysanthemum flowers vary greatly in shape, size and colour. All these variations have occurred due to the interplay of genetic factors meaning thereby that the

genetic resources have played a key role in bringing to the chrysanthemums their present fame and glory. Chrysanthemum stands third in the world cut flower trade and first in Japan and China, 3rd position in Germany, 2nd position in United Kingdom. A great deal of genetic variability is required in chrysanthemum to meet the demands of millions of its lovers who earnestly desire to have all sorts of shapes, colours and all plant forms. The primitive cultivars and wild relatives of chrysanthemum plants constitute a pool of genetic diversity which provides the raw materials for future breeding programme. The objective of creating new varieties is to combine in them constellation of characters by careful choosing of parents. All the present day colourful chrysanthemum varieties have been developed through complex interspecific crosses among elemental species, open pollination, indiscriminate intervarietal hybridization, spontaneous and induced mutation, selection and management of chimera. The main agencies responsible for varietal improvement are individual enthusiasts, nurserymen and breeders working in research institutes and agricultural universities. Being a cross pollinated crop, new varieties arise mainly as seedlings obtained either by natural or conscious cross-pollination. Farmers have been altering the genetic makeup of the crops since the practice of agriculture began. The main drawback of breeding experiments by private breeders is that they never disclose the parentage of new varieties. With advancement of genetic knowledge, plant breeders used what they knew about the genes of a plant to select for specific desirable traits to develop improved varieties. Conventional plant breeding has been going on for hundreds of years, and is still commonly used today. The genetic system of a taxon controls its heredity and variation and one of its important components is the breeding system. Breeding system exercises considerable influence on the genetical architecture and nature of its variability. Chrysanthemum and rose have been under investigation from this point of view and data are being generated about the range of genetic diversity for developing new forms.

New varieties of chrysanthemum are being developed throughout the world mainly through hybridization and induced mutagenesis. New varieties are also developed through sports. International Atomic Energy Agency, Vienna is maintaining a data base for new varieties developed through induced mutagenesis of all crops including chrysanthemum. But unfortunately, there is no record of total chrysanthemum varieties developed through classical breeding in different countries. There are several papers which report the new chrysanthemum varieties developed through different breeding methods. Present article will provide maximum information generated by the authors on classical and mutation breeding on chrysanthemum along with important publications in chrysanthemum/floriculture by other research intuitions/universities. Readers can collect more information from referred publications or from authors. Efforts have been made to highlight all the new chrysanthemum varieties developed in India exploiting all available techniques. Extensive research is going on chrysanthemum breeding at CSIR and ICAR institutions in India. National Botanical Research Institute (NBRI), Lucknow, India is one of the pioneer institutions under Council of Scientific and Industrial Research (CSIR) which has done a commendable work on chrysanthemum on both basic and applied aspects. Interdisciplinary research on chrysanthemum is going on under All India Coordinated Research Project on Floriculture at ICAR institutes with State Agricultural Universities.

Large flowered chrysanthemum White: Beatrice May, Beauty, Bharat Mata, Casa Grande, Dee, Dorrige Queen, Frosty Whisker, General Petain, Green Goddess, Green Sleeves, Gypsy Queen, Icicles, Imperial, Jet Snow, John Webber, June Bride, Kasturba Gandhi, KokkaSoun, Maudjafferies, Mrs C Tolly, Nightangale, Pennylane, Purnima, Shamrock, S S Arnold, Snow Ball, Snow Don, Tokyo, Valiant, White Cloud, White Snow, White Sport of Pink Cloud, Willium Turner, Woolman Century, White Sport of Pride of Madford.

Yellow: Autumn King, Betty Barnes, Bhima, Bob Pulling, Chandrama, Cossak, Diamond Jubilee, Duskey Queen, Ella Dalby, Mahabi, Evening Star, Florida, Garden State, J S Salisbury, KikuBiori, KokkaYamata, L C Philips, Mountaineer, Mrs J A Miller, Mr Roger, Thompson, Mrs Nancy, Ferneaux, Pitamber, Queen of Tamluk, Rohinhood, R Venkatraman, Senyo No Rya, Sheila Morghan, Shin Mei Getsu, Sonar Bangla, Super Giant, Surya, Tamra, Thiokinga, Yellow Reflex, Yellow Rayonette.

Red: Alfred Wilson, Arjuna, Black Hawk, Bicolour Incurved, Crimson Tide, Dorrige Velvet, Dragon, Gusman Red, Party Time, R.M. Quittenton, Red reflex, Leviathan, Mrs W A Reid.

Mauve: Ajina Purple, Allahabad Reflex, Angeles Belle, Belur Math, Cover Girl, Coronation Pink, Edith Cavel, Fish Tail, Hope, H Townsend, Incurve Dwarf, Julius Brinas, KenrokuKangiku, Kingford Smith, K N Modi, Kunchit, Mahatma Gandhi, OtomeZakura, Pink Brocade, Peacock, Pink Cloud, Pink Casekt, Pink Intermediate, Pink Rayonette, Pink Turner, Potamac, President Viger, Pride of Jamshedpur Raja, Royal Pinch, Royal Purple, SatishModi, Scater's Waltz, SenkyoEmaki, Shefali, Spoon, Sport of H, Towensend, Tata Century, Taiho Tozan, Violent Queen, (M- 45), (M-61).

Terracota: Achievement, Alfred Simpson, Appart, Autum Blaze, Bhai- Bhai, (T-10), T-1, Captain Kettle, Chengis Khan, Dignity, Distinction, Gambit, Gen-Carpenter, Goliath, Heather James, Jane Sharp, Miss Universe, Mrs Helmipot, Orange-Fair Lady, Paul, Ronaldo, Sancho, S L Andre, Spider Bruno, Thiching Queen, Red Fair Lady, Red Quill.

Small flowered chrysanthemum

Summer season cultivars: Himanshu, SU-1, Jwala, Jyoti, Su-3, Su-4, Phuhar.

Sept-Oct blooming cultivars: Ajay, Sharda, SharadKiran, SharadShobha, Vijay, Vijay Seedling.

October blooming cultivars: Arunima, SharadKanti, SharadMukta, SharadSandhya, White Dwarf (OO-8).

Oct-Nov blooming cultivars: Chakra, Double Korean, Hemanti, Lalpari, Makhmal, Megami, Mohini, Nanako, SharadHar, Sharad Mala, Tricolour, White Prolific, Yellow Prolific (NN-14).

Nov-Dec blooming cultivars: Archana, Apsara, Birbal Deep Pink, Cotton Ball, Jayanti, Jubilee, Kundan, Ping Pong, Ratna, Yellow mutant of Ratna.

Dec-Jan blooming cultivars: Ratna, Button, Gauri, Gulal, Jaya, Khumaini, Lalima, Lilith, Mauve Spoon, Nilima, Puja, Purplish Red, Sunayana, Sunil, Vasantika, (X-1).

Dwarf (No pinch no stake mini cultivars): Akita, Appu, Apurva, Arun Kumar, ArunSingar, Bindiya, Bronze, Cameo, Haldighati, HemantSingar, MahendraSingar, Mini Queen, Minihar, Orange, Pancho, PeetSingar, Pink Princess, Rangoli, Red, Red Anemone, Sengoku Ban, SharadSingar, Shizuka, SuhagSingar, ShvetaSingar, SwarnSingar, White Dwarf, White Pincushion, Yellow Charm.

Decorative: Alankar, Astral, Iiar, Jwara, Kalyani, Kanpur Yellow, Navneet, Pink, Renukoot, Seedling, Shyamal, Sonalitara.

Double Korean: Aparajita, Batik, Cissie, Fatima, Flirt, Hindalco, Juno, Jyotsna, Khurso,

Lalpari, Lalquila, Man Bhawan, Priya, Red Gold, Shabnam, Tara, White (Korean Double), (O-6), (O-21), (O-2).
Pin Cusion: Malika, Mayur.

Following new varieties of chrysanthemum have been developed through conventional breeding at CSIR-NBRI, Lucknow and in some other ICAR institutions in India.

CSIR-NBRI: Ajay (1990), Appu (1982), Apsara (1977), Apurva (1987), ApurvaSingar, Arun Kumar (1983), ArunSingar (1982), Bindiya, BirbalSahani (1976), Dhawal, Diana (1999), Gauri, Gulal, Guldasta (1986), Haldighati (1988), HemantSingar (1981), Himanshu (1982), Jaya (1980), Jayanti (1979), Jubilee (1980), Jwala (1981), Jyoti (1980), Jyotsna, Kargil 99 (2000), Kaumudi, Kiran, Kirti, Kundan (1980), LalKila (1980), Lalima (1990), Lalpari, Lilith, Maghi (1989), May-Day (1981), Mayur, Meghdoot (1982), : Mini-Queen, Mohini, Mother-Teresa (1997), NBRI Pushpangadan (2011), NBRI Khoshoo (2010), NBRI Kaul (2010), NBRI Himanshu (2009), NBRI Little Orange (2009), NBRI Little Hemant (2009), NBRI Little Kusum (2009), NBRI Little Pink (2009), NBRI Yellow Bud Sport (2011), Neelima (1980), Niharika, Nirmal, Pancho, PeetSingar (1981), Phuhar (1982), Priya, Prof. Harris, Puja, Ragini, Rangoli, Sadbhavna (2000), Shanti (2000), Ratna (1989), Sharda (1978), SharadKanti,' Sharad Kumar, Sharad Mala (1976), SharadMukta, SharadSandhya, SharadShobha, SharadSingar (1977), Shizuka, Shyamal, SuhagSingar (1981), Sujata, Suneel (1991), Sunayana (1976), Suparna, Surekha Yellow (1992), Surya, SwarnSingar, SwetaSingar, Tushar (1982), Vandana, Vasantika (1980), Vijay, Vijay Kiran (2009), Vinaya, White Charm, White Profile, Y2K (2000), Yellow Charm, Yellow Prolific, NBRI Yellow Bud Sport (2011).

Indian Institute of Horticultural Research, Bengaluru*:*
Arka Ganga (White with pink tinge 1999), Arka Pink star (Pink 2009), Arka Ravi (Peach 1999), ArkaSwarna (Yellow 1999), Chandrakant [1990, white], Chandrika [1994, white], Indira [1980, yellow], Kirti [1994, white], Nilima [purple], Pankaj [1994, pink], Rakhee [1980, yellow with red stripes], Ravikiran [1993, Greyed-red], Red Gold [1980, Greyish-Orange to golden-yellow], Yellow Star [1994, yellow], Yellow Gold (1992, Yellow with brick-red), Usha Kiran (2001, Yellow)

Punjab Agricultural University, Ludhiana*:* Anmol, Baggi, Gul-E-Sahir [yellow], Royal Purple, Yellow Delight, Autumn Joy, Garden Beauty, Winter Queen.

Tamil Nadu Agricultural University, Coimbatore*:* CO.1 [1985, Canary Yellow], CO.2 [1985, Rhodamine purple], MDU [1985, Sulphur Yellow].

Dr YSPUHF, Nauni, Solan*:* Solan Mangla

To maintain the authentic record of all the chrysanthemum varieties, passport data of all the chrysanthemum varieties, available in India at different institutions and universities has been prepared.

National Botanical Research Institute, Lucknow*:* 300 varieties; Regional Plant Resource Centre, Bhubaneswar – 104 varieties, Dr Y S Parmar University of Horticulture and Forestry, Solan – 55 varieties, MaharanaPratap University of Agriculture and Technology, Udaipur – 39 varieties, Tamil Nadu Agricultural University, Coimbatore – 75 varieties, Birsa Agricultural University, Ranchi – 45 varieties, University of Agricultural Sciences, Bangalore – 23 varieties, Punjab Agricultural University, Ludhiana – 23 varieties, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar – 40 varieties, Mahatma Phule KrishiVidyapeeth, Pune – 28 varieties, Acharya N.G. Ranga Agricultural University,

Rajendranagar, Hyderabad – 22 varieties, Indian Institute of Horticultural Research, Hessaraghatta – 76 varieties

Mutant varieties developed in India: CSIR-NBRI, Lucknow – Agnishikha (1987), Alankar (1982), Anamika (1974), Aruna (1982), Asha (1974), Ashankit (1974), Basant (1979), Basanti (1974), Batik (1994), ColchiBahar (1985), Cosmonaut (1984), Gairik (1974), Hemanti (1979), Himani (1974), Jhalar (1975), Jugnu (1991), Kanak (1974), Kansya (1974), Kapish (1974), Kumkum (1987), Kunchita (1974), Lalima Head Shape, Lalima Tubular Mutant, Lohita (1974), Man Bhawan (1982), Navneet (1987), Navneet Yellow (1993), Nirbhaya (1974), Nirbhik (1974), Pingal, Pitika (1974), Pitamber (1977), Purnima (1977), Raktima (1996), Rohit (1979), Shabnam (1987), Shafali (1974), SharadHar (1992), Sheela (1985), Shweta (1974), Surekha Yellow (1992), Sonali (1991), Subarna (1991), Tamra (1974), Taruni (1979), Tulika (1985).

Punjab Agricultural University, Ludhiana: Punjab Gold (1999, coppery red to golden yellow).

Conclusion

It is very clear that chrysanthemum is very rich in genetic diversity and it is very sensitive to human selection. It has been very successfully utilized for development of desired genotypes of usefulness. It appears that genetic stock of chrysanthemum has not been exhausted. It will be utilized the more and more new combinations of genetic diversity will develop. Documentation and characterization of varieties will help to identify the novel genes and their utilization in developing further new varieties through future gene transfer technology. There is always demand and necessity for new varieties in floriculture industry. Genetic diversity of any crop is very important for developing new varieties. Unfortunately, there is no international database crop wise. There is no record of total chrysanthemum varieties available worldwide. Present article reports the total chrysanthemum varieties developed in India through classical and induced mutation and total mutant varieties developed world wide.

NORTH EASTERN REGION - A HUB FOR MEDICINAL PLANTS

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Introduction

The North Eastern Region of India is comprised of 8 states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Tripura, Nagaland, Mizoram and Sikkim. The NER of India is a boon to the world of Medicinal plants having a huge diversity in flora, vegetation, culture, climate etc. The region's Flora and medicinal plant wealth is known through several works in the past. The region being underdeveloped and many parts inaccessible, the resource availability is not fully known nor it is harnessed in a manner whatsoever fit to the sustainable use and market needs. The major share of usage is in the form of traditional healing practices and local applications. Some of the most economical plant species found in the region include *Acorus, Andrographis, Aquilaria, Dioscorea, Oroxylum, Rauvolfia, Tinospora, Withania*etc in low altitudes. While for high altitudes it is *Aconitum, Coptis, Gymnadaenia, Illicium, Panax, Picrorrhiza, Rubia, Taxus,* etc. and several others. They can not only cure our ailments but can also be potential source of economy to the region. It will open up avenues in cultivation, processing, packaging, marketing and industrial application. Some of them are much sought after by pharmaceutical companies. Quite obviously it is the rural people, particularly the unemployed woman and children, who would be benefited by these ventures. Varied climate and topography is found in the region which includes tropical forests, sub-tropical forests, pine forests, temperate forests and alpine forests. In these varied agro climatic conditions numerous types of herbs, climbers, shrubs and trees are found in wild. This Himalayan region is comprised of a large variety of wild-growing plants that are used for food and other subsistence needs by the local communities. NER is one of the hotspots of Medicinal and Aromatic Plant biodiversity and a large portion of the area is still covered under unexploited and inaccessible forests which harbors immensely important flora and fauna. It is known that about 90% of the world's medicinal flora is found in the Himalayan range and lack of transport and communication facilities and mountainous topography bestowed with a large area of virgin forests, unexplored and beyond reach which is the home and reservoir of many unknown and useful MAPs, which may not be found anywhere in the world.

The land and habitat

The eight states forming northeast region of India put together has an area of 262,179 sqkm and has a forest cover of 173219 sqkm. The landscape consists of plains, valleys, hills to snow clad peaks supporting divergent vegetation ranging from tropical forests, subtropical forests, temperate forests, alpine forests etc. with a number of subtypes within each of the broad vegetation types. An estimated 52 forest types are recorded in the region which is the highest for any region. Each state has its own forest coverage which is higher than the national average of 21.05%. The prevalent jhum

agriculture in the region also results in secondary vegetation that offer habitat for medicinal plants suitable for these habitats. The jhum fallows are in fact ideal locations for augmenting the resource. The region is also known for large rivers and wet lands that offer habitat for aquatic and marshy vegetation and medicinal plants unique to these habitats. *Acorus, Trapa, Euryle, Baccopa*, etc are glaring examples of species in demand from these habitats. The High altitude species inhabiting the temperate and alpine zones are also unique as such habitats are not seen commonly elsewhere in the country. However country's over 90% of the medicinal plants occur in wild state or under cultivation by forest departments for their sustainable production, country needs long term planning.

The people of NEH Region have expertise themselves with nature and they care the plants and trees found around them. Lack of transport and communication and modern medicines in many parts of the region also forced the people still to depend greatly on the traditional heath care system. Many medicinal plants are consumed as vegetables on daily basis by the people. Since ancient times, conservation of medicinal plants (forests) is done - in the form of sacred groves, community forests, clan forests. Seedlings and small saplings from the forests are spared from picking and harvesting. Medicinal practitioners do not promote over extraction of medicinal plants from the forests. Prohibition from entering the forests is observed in certain days and months in a year. Fines and punishment are imposed to those who failed to observe. Due to over and unsustainable exploitation of MAPs from the wild, there is an urgent need of protection, conservation and development of cultivation practices for these species in this region also.

Table 1:Important indigenously found MAPs and their uses

PLANT NAME	PART USED	USES FOR AILMENTS/ DISEASES
Ageratum conyzoides	Leaves	Warm leaf infusion is given for 3 days as antidysenteric and antidiarrhoreic
Alocasia macorrhiza	Rhizome	Pain reliever of insect bite
Alpinia malaccensis	Rhizome	A piece of fresh rhizome is taken as anthelmetic
Andrographis paniculata	Shoot	Infusion of dry shoot soaked is given to infant once in a day to control irregular stool and also used as anthelmintic. Use against fever
Begonia josephii	Shoots & leaves	Paste of Shoots & leaves is given 2-3 times a day for antidysenteric
Calamus erectus	Seed, Tender shoot	Fresh seed are taken as dyspepsia. Tender shoot are taken as vegetable and anthehelmentic
Centella asiatica	Whole plant	Fresh whole plant extract is taken 2-3 times a day as stomachic
Chenopodium album	Leaves and young shoots	The leaves and young shoots may be eaten as a leaf vegetable, either steamed in its entirety, or cooked like spinach

Clerodendrumcolebrookianum	Leaves	Tender leaves are taken as vegetable to check blood pressure
Coptisteeta	Stem	Malarial fever, backache, stomach disorder, aphrodisiac
Dillenia indica	Fruit	The inner part of the fruit after removing the outer skin is taken with a little salt as a remedy for stomachache; used for preparing pickle also.
Drymaria cordata	Whole plant	Fresh whole plant mixed with *psidiumguajava* fruit is taken in gastritis
Eryngium foetidum	Leaves	Leaves are taken as chutney (condiments) believed to be appetizer. Paste from stem and leaf is applied together on forehead as a remedy for headache
Gynura cripidiodes	Leaves	Taken as a food, it makes a nice addition to salads, and can also be eaten when cooked. It is purported to have properties that help lower cholesterol
Houttuyni acordata	Shoot	Extract of tender shoot is given for stomachache. Warmed leaves are packed in banana leaf foe snuff or massage to get from sinusitis.
Lagerstroemia macrocarpa	Stem	Decoction of stem bark is given twice a day as anti-dysenteric
Mucuna pruriens	Leaves, Stem	Stem- juice is applied on eyes to relieve pain, Roots are considered useful to relieve constipation, nephropathy and ulcers. Leaves are aphrodisiac and useful in general debility.
Musa sepiatum	Fruits, Leaves	Fruits and stem are taken as food. Boiled fruit is given once/daily to stop loose motion. Juice of stem and leaves are applied over swollen feet and skin disorders.
Mussaenda roxburghii	Leaves	Leaves are cooked and served as vegetable
Ocimum canum	Ariel parts	Taken as salad. Aphrodisiac & digestive
Oxalis corniculata	Whole plant	Whole plant is taken as vegetable, as ant dysenteric and to relive intoxication from wine.
Paederiafoetida	Leaves	Boiled leaves and twigs are taken with rice as vegetable in digestion, dysentery and diarrhea.
Physalis minima	Fruit	Fruit extract is administered for gastric problem
Piper mullesua	Fruits	Used as Culinary and used as rejuvenating and detoxifying purposes, it is used to intoxicate fish which then can be easily caught.
Piper pedicellatum	leaves	Leaves are eaten raw or boiled with salt to

		improve skin
Plantagoerosa	Leaves	Leaves either raw or boiled as vegetable and considered as remedy for constipation and it also improves digestion.
Portulaca oleraceae	Stem & leaves	Stem & leaves are taken as vegetable with boiled rice for stomachic
Pouzolzia viminea	Leaves	Eaten as a vegetable and it is considered by *Adi* tribe to increase lactation in women.
Sidaacuta	Tender leaves	Tender leaves are cooked and eaten as vegetable to improve
Solanumnigrum L.	Stem,leaves & berries.	Stem and leaves are used as vegetable and considered digestive and liver tonic. Berries are eaten raw or cooked.
Solanum spirale	Leaves, Fruit	Tender leaves used as stomach disorder, Warm Decoction of fruits is used in stomachache and also as vegetable, chutney and salad
Solanum torvum	Fruit	Berry is taken raw as well as in cooked form. Good for cough and tonsillitis.
Solanum xanthocarpum	Fruit	Expectorant, tooth-ache, cough, cold, respiratory problems
Spilanthes paniculata	Flowers	Flowers are chewed to cure Toothache; leaves taken as vegetables
Trichosanthes cordata	Root	Root decoction along with salt is used for dysentery and diarrhea,
Zanthoxylum hamiltonianum	Fruits	Fruits are crushed and made into paste solution - to prevent malaria.

Conclusion

One of the very important problems in MAP is that the most of the plants are collected from the forest and natural habitat injudiciously. Overharvesting, destructive collection technique and the conversion of habitats to crop based agriculture make our rare and important species threatened and push towards extinction. The same problem is facing in the region due to urbanization, deforestation, human settlement, unscrupulous exploitation. The need of the hour is the *in situ* or *ex situ* conservation of the locally available species in this region before it is too late. Governmental and non-governmental organization should work hand in hand with the local people for an immediate action. So domestication, development of cultivation practices needs to be developed as soon as possible like other cultivated crops.Organized cultivation for MAP is not well developed as a result forest remains as the only sources for raw material collection. Plant species should be selected depending on the agro climatic conditions and market demand and proper agronomic practices should be followed and proper consultations with the experts should be made before venturing into cultivation of MAPs. Marketing channel is one the most important factors and should be well explored. Mixed cultivation with field crops and trees can be explored for a better return.

WATER HARVESTING AND MICRO APPLICATION OF WATER IN NEH REGION

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Introduction

Water productivity in agriculture can be enhanced by storing water where it is scanty and by disposing water where it is excess. Water harvesting refers to storing rainwater or runoff water in the soil profile or in structures for use mainly by the plants. However, the stored water can be used for irrigation, domestic consumption, livestock, poultry and fishery purposes. However, the valuable stored water is mainly utilized for irrigation through micro-mode during the dry period when the crops are water stressed. Contour bunding, trenching, terracing, land levelling and grading, pond construction, etc. are the common structures of water harvesting. They promote groundwater recharge, which becomes available for use. The system of rainfall and runoff water utilization through water harvesting existed in India and other countries long ago before the development of irrigation projects. Due to changes in social structures and as a consequence of availability of water from the reservoirs, barrages, deep tube wells and urbanization with piped potable water supply, gradually the interest on water harvesting waned and they become non-functional. However, due to the ever increasing population and climate change the decreasing share of freshwater for domestic use, irrigation and industrial need, the water harvesting is again gaining its importance among the end users and policy makers.

A typical water harvesting system usually consists of a catchment or water collecting area, a water storage facility and auxiliary components like conveyance, sediment control structure and spillway to dispose excess water coming into the storage. In slopping land runoff flows out faster without letting the soil to be soaked to deeper depths. Levelling and grading slows down the runoff flow rate and allows the soil to absorb larger amount of water. Land levelling is done manually in small areas and by machines in large areas. Fast and accurate laser grade controlled levelling equipment are used for precision levelling and grading works. The design grade to slow down the runoff flow rate is less than 0.5%. In shallow soil and steep slope, providing a slope of less than 0.5% will entail large earthwork, which will expose the unproductive soils of the lower depth and hence is not recommended for such conditions. The design procedure involves surveying of the target land at close interval (usually 30m) grid points by finding the difference between the plane of the land; calculating the cut and fills at the grid pints by finding the difference between the plane of the desired slope and the existing elevations; identifying these points of cuts and fills and marking the quantum of cut or fill in stakes; followed by manual and machine operation till the desired grade obtained.

The rain water harvesting and reusing the stored water through micro-mode is one of the economic and feasible techniques of

irrigation water management for crops cultivated in the sandy, porous and gravelly soils of Arunachal Pradesh. The soils have very low water holding capacity as shown in the figure 1. The cultivated crops suffer from water scarcity in the six months from October to March and even in rainy season due to erratic rainfall pattern.

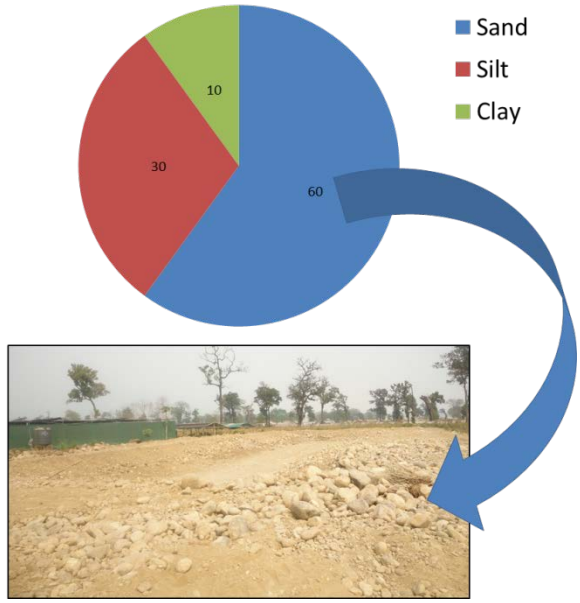

Fig. 1 Characteristics of soil East Siang, Arunachal Pradesh

Rainwater harvesting in the present context

The state loses the lion share of the rainwater through runoff. It is in this background that the rainwater harvesting assumes significance. It can be implemented as a viable alternative to conventional water supply considering the fact that any land anywhere can be used to harvest rainwater. Rainwater harvesting is in reality extending the fruits of the monsoon based on the principle "Catch the water where it falls" (Vijayanand, 2004). Rainwater harvesting besides helping to meet the ever increasing demand for water, helps to reduce the runoff, which is choking storm drains, avoid flooding of roads, augment the ground water storage and control decline of water level, reduce groundwater pollution, improve quality of groundwater and reduce soil erosion. This is considered an ideal solution of water problem where there is inadequate groundwater supply or where surface resources are either not available or insufficient. The other advantages are that it helps to utilize rainfall runoff, which flows into sewer or storm drains and therefore helps reduce flood hazards. The rainwater is bacteriologically pure and free from organic matter and soft in nature. The structures required for harvesting rainwater are simple, economical and eco-friendly.

Rainwater harvesting, irrespective of the technology used, essentially means harvesting and storing water in days of abundance, for use in lean period. Storing of rainwater can be done in two ways; (i) storing in an artificial storage and (ii) in the soil media as groundwater. The former is more specifically called roof water harvesting and is rather a temporary measure, focusing on human needs providing immediate relief from water scarcity, while the latter has the potential to provide sustainable relief from water scarcity, addressing the needs of all living classes including crop plants in nature. The rainwater or runoff in the form of a spring or stream can be harvested in RCC/ ferro-cement/ plastic/ fibre tanks or various types of low-cost lined ponds for utilizing in lean periods.

Of the above measures, the tendency from the part of implementing agencies is to plan and implement drainage line treatment and ignore the aspects of land improvement as well as the natural groundwater recharge measures. Activities under the sustainable water security measures are location specific and can be adopted as per the local conditions.

Rainwater collection in large lined ponds

For domestic water needs, taking the economy and durability of tanks into

consideration, ferro-cement tanks of cylindrical shape in capacities ranging between 4,000 lt. and 15,000 lt. are most suitable. Requirement of Institutions and small communities for RWH Structures will be larger than that of individual households. Such structures will have to professionally investigate and plans have to be prepared on a case-by-case basis. Ferro-cement requires only a few easily available materials - cement, sand, galvanized iron (GI) wire mesh, and mild steel (MS) bars - in small amounts compared to masonry and RCC. The rainwater can be collected in large quantity in ferro-cement or plastic line ponds. Generally big ponds are constructed and subsequently lined with plastic films like silpaulin. The roof water, runoff water (after filtration) or spring water may be diverted to the pond. A large sum of water can be harvested using such ponds, which in turn may be used for irrigation or household purposes. The cost of construction will be less than one rupees fifty paisa per litre in the first year and the rate per liter of water will be decreased year by year. Moreover it is durable, easy to construct and having less maintenance cost. Average life of silpaulin lined water harvesting pond can last up to six years with care that there should not be any type of physical injury to the silpaulin film.

Types of water harvesting pond

Normally three types of ponds, viz. embankment type, excavated (dugout) and dugout-cum-embankment type are constructed for collection of excess runoff. Embankment type and dugout-cum-embankment types of ponds are feasible in hilly and undulating topography. Embankment type of ponds are created by constructing a small length of dam across a water course whereas dugout-cum-embankment type of pond can be created by excavating a site surrounded by hillocks from two or three sides and making the embankment from excavated soil on remaining sides. In flat areas these two types of ponds are not feasible. In such areas, dugout ponds are constructed.

Site selection

Selection of suitable site for construction of a pond is one of the important components. The site selected should ensure that the catchment is neither too small nor too big. Too small catchment may not contribute sufficient water to fill the pond while too big catchment may result in rapid siltation of the pond. Catchment having either forest or horticulture as major land use or well protected by conservation measures such as bunds, terraces and trenches will contribute less silt to the pond. Stony site should be avoided.

Design principles

The design principle of water harvesting structures is similar to the other hydraulic structures requiring a wide range of input. In many regions local thumb rules are used for designing the ponds. For hydrological design a more or less universal criterion is followed which is basically “the ratio of the catchment area to the command area.” Where this ratio is known or assumed, the possible size of the field to be irrigated i.e the command area by the harvested water can easily be determined.

The size of catchment area can be assessed either by conducting field survey to estimate in the field or measured from the topographic map of the catchment, provided that the map is available. In several parts of the world, the value of thumb rule varies from 1:5 to 1:4, depending on rainfall magnitudes and its distribution; watershed characteristics, runoff coefficient and water requirements of the existing crops to be irrigated.

Hydrologic design

Hydrologic design involves the estimation of peak rate of runoff to be passed safely through the pond and runoff volume from catchment of the pond. The runoff is estimated for design frequency of 25 years. In other words, we have to consider those values of intensity and amount of rainfall, which are expected to occur or exceeded once in 25 years.

Rainfall intensity-duration-recurrence interval relationship

$$I = \frac{KT^n}{(t+a)^b}$$

Where,

I=rainfall intensity for a given rainfall duration in cm/hr

T= recurrence interval in years

t= storm duration in hours

K, n, a & b= constants for a particular location

The following values for the constants may be taken:

K = 6.933; a= 0.1353; b= 0.50 and n= 0.8801

Estimation of peak rate of runoff

(i) Rational method

$$Q_p = \frac{CIA}{360}$$

Where,

Q =Peak rate of runoff in cumecs

C =Runoff coefficient varying from 0 to 1 depending upon watershed conditions

I = Rainfall intensity in mm/hr for the design frequency and for duration equal to the time of concentration.

A =Area of catchment in ha.

(ii) SCS method

$$Q = \frac{(P-0.3S)^2}{(P+0.3S)}$$

$$S = \left(\frac{25400}{CN} - 254\right)$$

Where,

Q =actual runoff in mm

P = rainfall in mm

S = potential maximum retention

Hydraulic design

This includes determination of storage capacity and storage dimension (length, width and height) of the pond and dimensions of spillway for safe disposal of excess inflow to the pond. Water should flow through the structure safely without overtopping the embankment and when water leaves the structure; its energy should be dissipated. Standard weir formula for determining the crest length is used.

$$Q = CLH^{\frac{3}{2}}$$

Q is the peak discharge, C is a constant, L is length of the crest and h is depth of flow over the crest of weir.

Capacity of the pond is calculated by Trapezoidal or Simpson's rule as in figure 2 (Schwab *et al.*)

Trapezoidal rule

$V = d/2 (A_1 + A_2)$

V is the volume of storage between two contours, A_1 and A_2 are the area enclosed by the contours, and h is the interval between two contours.

Simpson's rule

V = d/3 (twice the area of odd contours + 4 times the area of even contours + area of first and last contour). For using this formula, the number of contours should be odd. (Schwab *et al.*)

(i) For a rectangular farm pond,

$$\text{Capacity} = \frac{d}{6}(A_1 + A_2 + 4A)$$

Where,

$A = (A_1 + A_2)/2$

(ii) For a square size farm pond,

$$\text{Capacity} = \frac{d}{3}(A_1 + A_2 + \sqrt{A_1 \times A_2})$$

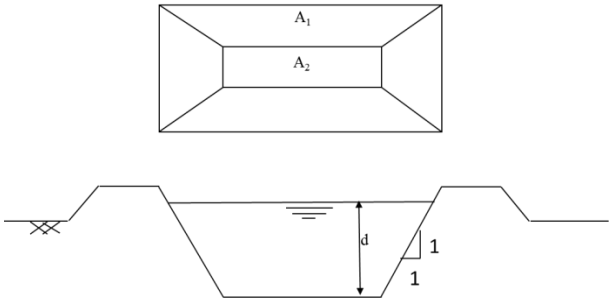

Fig.2. Plan and elevation of rectangular/ square size water harvesting pond

Water requirement and gross storage

Unless otherwise prescribed for an area, following general guidelines may be used to determine the water requirements of a village community and the gross storage capacity of the pond.

1. Irrigation: Provide about 0.67 hectare metre of capacity for a hectare of irrigation. However, irrigation demand may be calculated from the irrigation requirement of the crops to be grown in the command area and their allotted area.

2. Animal Needs: Provide at the following rates:

i. Beef Cattle: 54-68 litres/day

ii. Dairy Cows: 68 litres/day (drinking)

iii. Dairy Cows (drinking + barn needs): 158 litres/day

iv. Pigs: 18 litres/day

v. Sheep: 9 litres/day

3. Domestic Water Needs: 40 litres per head per day

4. Fish Culture: Ensure about 1.85 m depth to provide proper temperature environments.

The storage capacity should be at least double the total water requirement to take care of evaporation and seepage losses. As a rough guide, 10 per extra storage may be provided for sediment deposition. For example if the total annual water requirement is 10,000 cum and pond will have only one filling, its gross capacity should be 22000 cum (2 × 10,000 + 10%).

Construction of silpaulin lined pond

Rainwater can be harvested in a dugout-cum-embankment pond at the mid or lower reaches of the hill slope for multiple uses including drinking water supply, recycling in winter season for crop production and fish production. The soil in the entire region except at few places, have low water holding capacity and seepage losses are very high. In the hill slopes or in valleys the pond construction needs some measure to prevent the seepage of stored water. Silpaulin lined small tanks can be constructed in the terraces. Low cost and durable technology is available for preventing the seepage. The pond or the tank can be lined by 200-400 micron UV stabilised silpaulin film. Any size of silpaulin film can be procured from the supplier by giving the total surface area of the tank to be lined. Silpaulin film is easily available for use.

The pond is constructed at the suitable location more preferably in unused natural depression in plain. The excavated soil is kept as embankment surrounding the tank. As the exposed soil of the tank is embedded with stones, about 2" of stone free soil is spread over the surface cushioning. A trench of at least 1foot × 1foot is made surrounding the upper surface of the tank. Then the silpaulin film is unfolded at the centre of the tank and gradually stretched towards the sides. Care should be taken during unfolding of the silpaulin film to prevent form any of damage. The size of the silpaulin film should be spread in such a way that one fold of film should be in the centre and sides for future expansion under pressure of stored water. At last the remaining portion of the film is inserted in the trenches and covered over soil with subsequent compaction. If the size of the silpaulin film is found to be large than the required size, the extra part of the film can be inserted inside the silpaulin film as double layer, which strengthens the surrounding sides of the tank.

The sides are used for walking during pisciculture and other use. The construction of the WHP is given in figures 3 a and b.

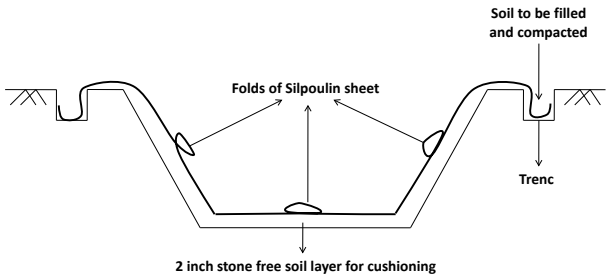

Fig.3a. Layout of silpaulin lined rectangular/ square size water harvesting pond

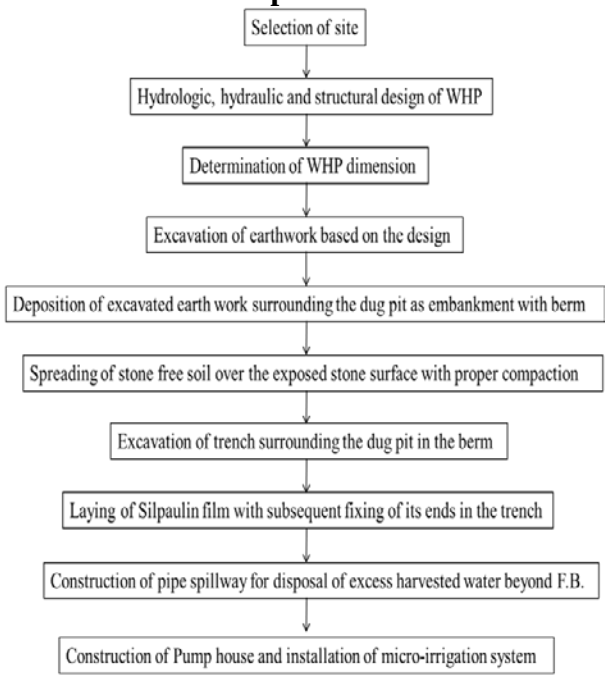

Fig.3b. Flow diagram of methods of construction of silpaulin lined WHP

Micro-Application of stored water

The stored water in the water harvesting pond can be applied as irrigation to the horticultural crops through micro-mode only. The micro-mode means micro-irrigation system. Micro-irrigation system consists of sprinkler, micro-sprinkler and trickle or drip irrigation systems. The water is delivered directly into the root zone of the plants and thereby saving water considerably. Water soluble fertilizers can also be applied along with the water which is the most suitable method of water and nutrient application in sandy and porous soil. The water is supplied from the WHP through a system of head unit, which consists of pump, filter and fertigation components. Then the water enters into the distribution unit which consists of main, sub-main and lateral pipe lines. The water is then delivered directly into the root zone of the plant through drippers/ emitters and micro-sprinklers as shown in the following figures.

A case study:

Six numbers of large sized water harvesting ponds are constructed in the farm area of the College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh. The top size varies from 22-43m × 36-70m. The depth varies from 2m to 3.3m. The case study explains about a typical rainwater harvesting system. In this system no catchment area is required as the high rainfall (average annual rainfall of 4510mm) is sufficient to fill a water harvesting pond (WHP) having depth upto 3metres considering all losses. The cost involved in the catchment area treatment is saved. The main criteria in the site of selection for construction of the WHP is unused area location like the area of meeting point of natural drains/ nalas or in one corner farm. The construction was made as per the pre calculated design as discussed above.

The climatic condition of the location is shown in figure 4. This shows the period from October to March is the driest part of the year when the crops are severely water stressed. During this period evaporation is more than the rainfall occurs. The WHP was made full by the month August-September by the *in situ* rainfall. The detail layout and construction are given in figures 6, 7, 8, 9 and 10. Care should be taken that the runoff produced surrounding

the WHP should not enter the pond. For this if required an embankment (trapezoidal in section) along with a diversion drain was provided to divert the runoff which is coming from the upper cultivated lands. In no case the WHP should be constructed along a natural drain. If so the WHP should be protected from the subsurface runoff coming from the upstream side.

The harvested water of the water harvesting pond is pumped onto a Tank, which is constructed at a higher site in the tank is supplied to the control unit of the micro-irrigation system, from where the water along with water soluble fertilizer at desired rate is sent to the various horticultural crop plots. It was observed that oil palm crop irrigated by micro-jet irrigation has shown good growth in the porous and gravelly soils due to the fact that the crop are well irrigated and fertigated. The micro-jet irrigation is successfully provided to the oil palm crop by utilizing the harvested water from the water harvesting pond. The six year old irrigated oil palm crop has productivity of 10 t/ha in comparison to the without irrigated productivity of 2t/ha. Litchi (*Litchi chinensis*) crop is irrigated by the trickle irrigation system using the harvested water from the WHP. The yield obtained from four years litchi plant was 12 kgs/ha. Pisciculture is also practiced in the water harvesting pond. Precaution is taken care of when the harvested water is pumped into the tank. Mean yield of fishes from the silpaulin lined pond is 15.1 q/ha by practicing composite fish farming system. Average total cost of production per ha is found to be Rs. 1,30,000/- and benefit-cost ratio is 1.91. Fish species Silver carp, Catla and Grass carp shows better growth in the polythene lined pond in comparison to Common carp, Rohu and Mrigala.

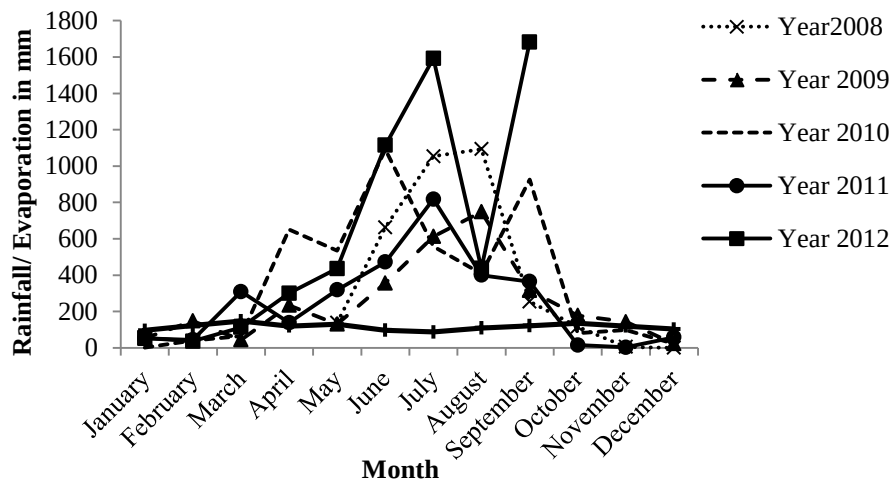

Fig. 4 Monthly variation of rainfall vs evaporation showing the dry months at Pasighat, Arunachal Pradesh

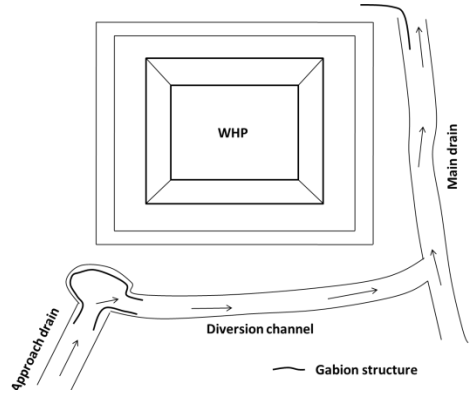

Fig. 6 The WHP should be protected from surrounding runoff

Fig.7. Harvesting of in-situ rain water in the water harvesting pond

Advantages of silpaulin lined ponds

It is observed that the construction of a dugout pond and lining it with strong and durable plastic films for harvesting rain and spring water has the following advantages:

(i) Effective storage of harvested water by hindering seepage losses

(ii) Low capital investment per litre of collected water

Effective storage of harvested water by preventing seepage losses

The seepage studies conducted in the porous and gravelly soils had shown that the unlined dugout-cum-embankment type ponds had high rate of seepage and percolation, and could not hold water during the crucial dry season. However, the maximum percolation rate through the silpaulin-lined pond is nearly zero . It was also found that the seepage loss from silpaulin lined water harvesting pond is almost zero.

Economics of harvested water

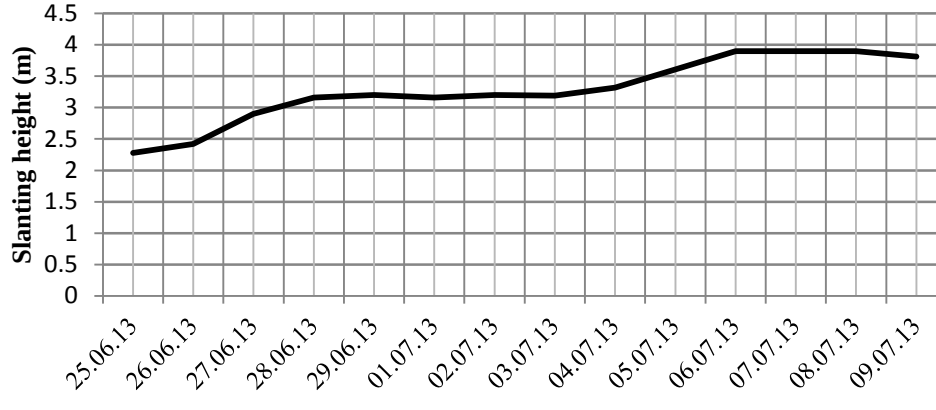

Fig.8. Variation of slanting water level height w.r.t. days

Costs involved in different works of the ponds with silpaulin plastic lining were observed. Detail analysis of the cost revealed that cost of construction of the plastic lined pond per cubic meter of water storage capacity have been to the tune of only Rs. 1500/- in the very first year. The cost reduces to about 50 paise per liter in subsequent years. The cost of construction includes the cost involved in land preparation, digging of the pond, lining and other finishing works. The cost of silpaulin plastic film is about rupees eight per square feet. The depreciation cost of silpaulin film is also taken into account and the average life of the film is about 6 years.

Important issues of Rainwater management in the context of hill state-Arunachal Pradesh

Some of the important aspects of rainwater management and the major scope for enhancing irrigation facilities in the terrain can be envisaged as follows:

• Management of runoff on slopping land use and in-situ retention of rainfall by adoption of appropriate soil conservation measures and land use practices.

•Ensuring safe disposal of surplus water from higher to lower level.

•Increased utilization of stream flow through diversion works at feasible locations.

•Storing surplus water at appropriate locations by constructing small reservoirs and recycling it in the same area.

•Stream flow lift irrigation.

•Conjunctive use of surface and ground water on rotational basis.

Conclusion

Porous, gravely and sandy soil is characterized by low water-holding capacity and excessive drainage of rain and irrigation water below the root zone, leading to poor water and fertilizer use efficiency by the crops. The crops in these soils suffer from severe water stress during the water scarce months from October to March in Arunachal Pradesh condition. The locally adoptable low-cost technologies for rainwater harvesting can be implemented as a viable alternative to conventional irrigation to tackle this problem considering the fact that any land anywhere can be used to harvest rainwater. Rainwater harvesting, irrespective of the technology used, essentially means harvesting and storing water in days of abundance, for use in lean days. Storing of rainwater can be done in two ways; (i) storing in an artificial storage and (ii) in the soil media as groundwater. The former is rather a temporary measure, focusing on human or small-scale irrigation needs, providing immediate relief from water scarcity. The rainwater or runoff in the form a spring or stream can be harvested in low-cost silpaulin lined water harvesting ponds for utilizing in lean periods. The studies suggested that these technologies are sustainable, locally adoptable, cost-effective and affordable to the farmers. The harvested water can be used through micro-irrigation system as life-saving irrigation for the water scarce months. It requires equitable involvement of local people to analyze localized problems and to arrive at the best possible solutions regarding natural resources management activities in the corresponding watershed area. The people can contact available experts for location specific proper design of the rainwater harvesting system for the safety and longevity of the structure. The Oil palm and litchi crops have shown good growth in the porous and gravelly soils due to the fact that the crops are well irrigated and fertigated. The micro-jet irrigation and trickle irrigation are successfully used to irrigate the oil palm and litchi crops by utilizing the harvested water from the water harvesting pond.

MANAGEMENT OF CITRUS PESTS IN NEH REGION- STRATEGIES AND OPTIONS

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Introduction

Over 250 species of insects and mites have been reported to infest citrus in India and elsewhere with over dozen species being the major pests. Some of the insects like lemon butterfly, citrus leaf miner, citrus psylla, citrus blackfly, citrus whitefly, etc. cause severe damage in nurseries and young plantations whereas some others like citrus trunk borer, damage severely grown up plants. Even the mature fruits are also damage by fruit sucking moths, fruit fly, etc. In this paper, different management practices of some important insect pests of citrus is briefly discuss.

Citrus is the second most important fruit crop of the world in terms of area, production and utility. India ranks fifth in total *Citrus production of the world (*en.wikipedia.org, 2008). Total area under citrus is 1.008 million ha and 11.147 million tonnes with a productivity of 10.3 matric tonnes /ha (www.nhb.gov.in, 2014). Karnataka recorded highest productivity with 21.9 matric tonnes(MT)/ ha followed by Punjab (20.7 MT/ha). Over 250 species of insects and mites have been reported to infest citrus in India and elsewhere with over dozen species being the major pests (Pruthi and Mani, 1945, Tandon, 1993, Broeksma et al. 1993). Citrus psylla, white flies, scales, mealy bugs, trunk borer, leaf miner, fruit sucking moth and lemon butterfly are major pests in many areas.

Important insect pests for nursery and young plants

1. Lemon butterfly, *Papilio demoleus* Linnaeus (Papilionidae; Lepidoptera)

Papilio demoleus, Linnaeus and *P. polytes* Linnaeus are widely distributed throughout India. *P. demoleus* attack almost all *citrus* species but prefers *C. sinensis* and *C. grandis* (Butani, 1979b). In the plains, *P. demoleus* is found throughout the year, whereas in the mountains where winter is very severe, it hibernates in the pupal stage (Atwal and Dhaliwal, 2008). Adult butterflies are beautifully patterned, body ventrally yellow and wings ornament with yellow and black markings; hind wings without tail – like projection and having a brick red oval spot near upper margin and a blue spot near lower margin. Wing expense is 80 to 100mm (Butani, 1979). The butterflies emerged from the hibernating pupae in March and lay eggs on tender shoots and fresh leaves. The eggs are placed singly or in groups of 2-5. The eggs are glued firmly on to the surface of the leaf and are pale and greenish yellow, when freshly laid, but later turn brown, becoming dark grey just before hatching (Atwal and Dhaliwal, 2008). A female lays 75 to 120 eggs in 2 to 5 days during summer and as many as 180 eggs in 3 to 6 days in winter (Bhutani, 1976). They hatch in 3- 4 days during summer and in 5-8 days during winter. The young larva emerges by cutting a round hole through the egg- shell. On hatching, the young larvae first eat the empty egg shell and this scavenging habit persists throughout life and the larvae eat their own exuviae after each moulting (Atwal and Dhaliwal, 2008). Young larvae are tuberculate, blackish- brown with milky white conspicuous

markings and are often mistaken for birds' excreta. Full grown caterpillars are 28 to 35 mm long, brilliant rich green in colour, smooth and velvety (without tubercles) and have dusky brown oblique bands on lateral abdominal segments that do not meet on dorsum. When disturbed, the caterpillars throw out a befit, red, 'Y' shaped osmaterium from behind the head which also emits strong odour (Bhutani, 1976). The larval life last for 8 – 16 days in the summer and about 4 weeks during November – December (Atwal and Dhaliwal, 2008). Pupation takes place on a branch or twig, in an upright position, with the typical band of silk around the thorax to retain the chrysalis in that position (Hill, 1987). The pupal stage lasts about 8 days in the summer and 9 – 11 days in the spring and autumn.

The newly emerge caterpillars feed on young leaves biting from the edges towards midrib and feeding throughout the larval stages. The lemon butterfly is most destructive to citrus seedling as well as to new flush (Bhutani, 1979). They may cause complete defoliation that result in serious setback to plant growth. The outbreaks of the pest on Nagpur mandarin were reported from Central India in 1940, 1969, 1982- 83 and 1996 (Shivankar and Singh, 2006).

Management:

For monitoring the pest population five apical twigs per tree, each from top, middle and bottom portion can be randomly selected and the number of larvae per twig can be noted. Record the incidence of the pest throughout the year (Shivankar and singh, 2006). Picking up and killing of larvae is an effective control measure. In less than 4 hours time, one man can destroy the larvae from an acre of nursery area (Brar, 1959). Insecticides like monocrotophos (0.05%), deltamethrin (0.0025%), permethrin (0.01%), cypermethrin (0.01%), fenvalarate (0.01%), acephate (0.08%) and carbaryl (0.2%) are effective against the pest (Radke and Kandalkar, 1986, Salunke and Deshpande, 1991; Nandihalli *et al.,* 1991). Atwal and Dhaliwal (2008) suggested for application of quinalphos 25 EC 1. 45 litres or carbaryl 50 WP 2.0 litres in 1250 litres of water per ha during April (after fruit set) and October (after rainy season). Spray of *Bacillus thuringiensis* (Dipel 0.05%) or 5% neem seed extract is effective against the pest (Raj and Devi, 2004). Larval parasitoids, *Apanteles papilionis* and *Melalophacharops* sp. and pupal parasitoids, *Pteromalus puparium* and *Holcojoppa coeloyga* are the potential parasitoids. Entomopathogenic bacterium, *Serratia marcescens* and fungus *Fusarium* sp. killed substantial population of *Papilio* spp. (Singh 1994b). The coccinellid, *Vedalia orientalis* and the preying mantis feed on lemon shoot butterfly, *Chilades laius* and *P. demoleus* (Singh and Singh, 1998). Entomopathogenic nematodes, *Steinernema* sp is effective against the pest (Singh, 1993 b). Singh (1994a) suggested for release of *Trichogramma chilonis* @ 5000 adults per hectare at the beginning of egg laying after the mass emergence of hibernating population in winter and subsequent release at 7 to 10 days interval. Release of *T. chilonis* can be followed with a spray of *B. thuringiensis* var. *kurstaki* (0,5 kg/ha).

2. Citrus Leaf miner, *Phyllocnistis citrella* Stainton (Phyllocnistidae; Lepidoptera)

The pest is a native of South – East Asia (Liotta and Manzella, 1995). It is one of the most important pests of citrus nursery. Adults are minute moth with a 4mm wingspread. It has white and silvery iridescent scales on the forewings, with several black and tan markings. A distinct black spot is present on each wing tip. The hind wing and body are white, with long fringe scales extending from the behind wing margins (www.dpi.nsw.gov.au/). At rest the wing are

folded straight over the back. They are active during early morning and early evening (www. cals.arizona.edu). Adult female lays her eggs singly on the underside of small tender leaves less than 6.5 mm length. Under high population densities, more eggs may be laid on a leaf. Eggs are usually laid along the leaf's mid-vein usually towards the petiole of the leaf. The number of eggs produced per female ranges from 30 to 75 eggs. The fresh eggs are translucent and whitish in colour, and resemble tiny water droplets. Later on they become yellowish and opaque. They are extremely small measuring 0.2 x0.3 mm. The eggs hatch in 2 to 10 days depending on temperature. The larval stage undergoes four larval instars, with a total development time of 5 to 20 days. The first three instars are sap – feeding forms, while the fourth instar is a non-feeding spinning form. After hatching, the larva mines beneath the epidermal cell layer of the leaf. These larvae are translucent, light green in colour. The second and third instars are translucent, yellowish- green and can reach a length of 3 mm. The larger larvae are visible. The mines will meander along the underside of the leaf in a serpentine pattern. The third instar makes it way towards the leaf margin where it will molt into the forth instar which form a silken cocoon within the mine. As the silk dries it curls the leaf edge over the cocoon forming a protective pupal cell. The pupa is yellowish – brown and darken with age. The pupation stage requires 6 to 22 days to complete. The entire life cycle requires 14 to 50 days depending on temperature (www. cals.arizona.edu). Depending on foliage flushing cycles and weather condition, as many as 9 to 13 generations of the pest can be expected in a year (Raj and Devi, 2004).

The larvae form serpentine mines in the leaves. These mines are filled with a central line of frass. The mines show characteristic silvery colour due to entrapping of air (Sohi and Varma, 1965). Leaf mining results in leaf deformation, partial leaf chlorosis, necrosis and some leaf drop, which ultimately results in a reduction in the tree's photosynthetic capacity. A single larva can consume 1 to 7 cm^2 of leaf area and leave a 15 to 28.7 cm mine (www. cals.arizona.edu). The larvae even mine the tender shots (Nucifora, 1996) and in rare cases stems and fruit too (Gracia and Alvarado, 1996). *P. citrella* may help in spread of citrus canker because of leaf damage from the mine (Ando *et al.*, 1985).

Management

Control decision of *P. citrella* can be made through sampling for active larvae, primarily on trees three years of age or less. Monitoring should begin when 50% of the trees are actively flushing. Ten leaves can be randomly selected from ten pieces of flush and the presence of live larvae can checked. On young trees, treatment can be started when 30 % of the leaves have active mines with live larvae (www. cals.arizona.edu).The citrus germplasms *viz. Ponicirus trifoliate* (L) Raf, Carrizo, Citrumelo (*P. trifoliate* x grape fruit), morton, sacaton, savage and Troyer were found least susceptible against *P. citrella* (Batra and Sidhu, 1981). Less incidence of *P. citrella* was recorded *citrus reticulate, C. reshmi* and *P. trifoliate* among the germplasms of citrus (Singh, 1994b). Knapp *et al.*, (1993) suggested for manual removal of early and late growing flushes and pre- flush pruning to create uniform flushing resulting in desynchronisation between flushing and *P. citrella* population peaks. The attacked leaves should be clipped off (Ayyar, 1963 and Quilici *et al.*, 1995). The spray timing are most important in managing leaf miner because before entering in leaf tissue it is highly susceptible to the toxic effect of pesticides (Pradhan, 1969). Monocrotophos 0.07%, metasystox 0.03 %, BPMC(fenobucarb) 0.15%, fenvalerate 0.01%, cypermethrin

0.01%, permethrin 0.01%, decamethrin 0.0025% and dimethoate 0.03% are effective against the pest (Karimulah and Ahmad , 1988; Reddy *et al.,* 1988 ; Radke and Khandalkar,1990; Singh and Sharma, 1990; Tandon, 1993). The addition of oil to systemic insecticides protected more flush against reinfestation (Dhouibi and Wadoud, 1997). Addition of mineral oil@ 500g g/ hl helps in improving the efficacy of the insecticides used (Liotta and Manzella 1995). Natural enemies such as *Tetrastichus phyllocnistoides, Cirrospilus quadristriatus, Bracon phyllocnistoids, Tetrastichus* sp., *Simpiesis purpurea*, *Kratosysma* sp, *Pediobius* sp. *Sysmptesis* sp have been found commonly parasitizing *P. citrella* (Singh, 1994b). *Ageniaspis citricola* alone cause more than 80% parasitism of *P. citrella* in Punjab (Atwal, 1964). Singh (1994a) suggested for using *Mallada boninensis* against the pest. *M boninensis* larva consumed on an average 149.1 larvae of *P. citrella* (Chen *et al.,* 1989).

3. Citrus Psylla, *Diaphorina citri* Kuwayama (Pshllidae; Homoptera)

Asian cirus psylla, *Diaphorina citri* is common in Asian countiers and African citrus psylla' *Trioza crytreae* Del Guerao (Triozidae) in Africa. *D. Citri* develops preferentially in hot and dry climate and up to 400m attitude, whereas, African psyllid, *T. crytreae* is prevalent in cool and moist areas above 400 – 500m (Shivankar and Singh, 2006).Both the species serve as a vector of a serious citrus disease called greening disease. This disease is responsible for the destruction of several citrus industries in Asia and Africa (Manjunath *et al*., 2008).

The adults are 3 to 4mm long with a mottled brown body. The head is light brown. The fore wing is broadest in the apical half, mottled, and with a brown band extending around periphery of the oter half of the wing. The antennae have black tips with two small, ligt brown spots on the middle segments. A living *D. citri* is covered with whitish, waxy secretion, making it appear dusty. The nymphs are 0.25mm long during 1st instar and 1.5 to 1.7nn in last (5th) instar. Their color is generally yellowish- orange. There are no abdominal spots as in *T. crytreae*. The wing pads are large.

The pest breeds throughout the year. The maximum activity of the pest has been reported during spring and autumn and least in monsoon and winter. Almond shaped eggs are laid in the fold of half open leaves, on leaf petioles or between flower buds. A female lays 500- 800 eggs and even as many as 900 eggs, singly or in clusters on all the tender part of the plant, during it is life time of 190 days in winter and 12- 26 days in summer. The eggs are elongate, thicker at base and tapering towards the distal end, provided with a slender stalk for thrusting the eggs into plant tissue. Incubation takes 3 – 6 and 10 – 20 days and nymphs (5 instars) 5 and 47 days during summer and winter, respectively. Total life cycle is completed in 8 week with 9 – 10 or even upto 16 overlapping generations in a year (Khan *et al.,* 1989; Bhagat and Nehru, 1999). Over wintering adults may live over 6 months (Mangat, 1966).

Nymphs and adults suck sap from leaves, buds and tender shoots resulting curling and drying of buds and shoots. Nymph of African psylla is causes conspicuous pitting on the lower surface of leaves. The pest is suspected to secret some toxin along with its salvia which kills even those branches not attacked by this pest (Hussain and Nath, 1927). The nymphs also secrete whitish crystalline honey dew that covers growing shoots and leaves on which sooty mould grows. Continuous feeding by pest may result

in death of branches and ultimately the complete tree (Garg, 1978). Heavy deblossoming particularly during spring leafs to the extensive loss of fruit set (Shivankar *et al.*, 2000).

Besides causing direct damage the 4th and 5th instar nymphs and adults acts a vector for citrus greening disease. Capoor *et al.* (1974) described greening symptoms of citrus as trees showing stunted growth, sparsely foliated branches, unseasonal bloom, leaf and fruit drop nd twig dieback. Young leaves are chlorotic, with green banding along the major veins and mirib are yellow. In severe cases, leaves become chlorotic and have scattered spots of green. Fruits are small, unevenly coloured, hard and poor in juice. The columella (the internal, central column like structure found in citrus) was found to be almost always curved in sweet orange fruits. Most seeds are small and dark coloured. The disease is caused by a phloem- limited bacterium, *Liberobacter asistium.* According to Capoor *et al.*, (1974), *D. citri* requires an incubation period of 21 days to transmit the pathogen The pathogen is retained inside throughout the life following a short access feeding (15 to 30 minutes) on disease plant. Adults emerged from the nymphs developed on healthy plant can also transmit the greening in a minimum infection feeding of 15 minutes but the percentage of transmission was low. They strongly indicated that the pathogen multiplied in the body of the psyllid but there is no transoverial transmission.

Management

Psylla populations can be effectively monitored with one yellow stick trap placed in the most northern, one in most southern and one in the central row of citrus orchards (Shivankar and Singh, 2000).

For chemical control, Bindra *et al.* (1970) recommended soil application of phorate 15 or 20 g a.i or dimethoate@ 16 ml a.i./ tree. Before opening of flower on spring flush, spray of dimethoate (0.03%) or methyl demeton(0.025%) or monocrotophos (0.04%) or fenitrothion 0.05% has been suggested (Anonymous, 1995). If necessary, the spray should be repeated after the fruit set. Second flush of growth should be covered in august – September with one of these insecticides. All the plants including hedges should be sprayed (Raj and Devi, 2004). Foliar spray of monocrotophos @ 0.7 ml or quinal phos @1.0 ml, acephate @ 1 gm or thiometan @0.8 ml per litre of water at bud burst stage or as and when infestation noticed is recommended. Second spray should followed after 10 – 15 days (Shivankar and Singh, 2000) The period of control measures to be taken during the flushing period are- i) second fortnight of February to 1st fortnigh of March, ii) whole of July and iii) whole of November (Shivankar and Singh, 2006).

The extracts and oils of *Azadirachta indica* A. Juss, *Pongania glabra, Madhuca longifolia, Ricinus communis, Cymbopogon nordus leaves, Alpinia galangal* bulbs etc. were found effective against the pest (Borle, 1974; Pandey, 1982; Anonymous, 1989, chin, 1990; Katole *et al.*, 1993). Commercial neem formulations could effectively control *D. citri* (Shivankar and Singh, 2006).

Conservation and augmentation of natural enemies (predators) such as *chilocous nigritus* Fbr., *Coccinella septempunctata* Linn, *C. rapanda* Thumb., *Menochilus sexmaculatus* Fabr., *Brumus suturalis* Fabr., *Chrysopa* spp. and syrphids will play an important role in its control (Raj and Devi 2004.

Two eulophids, *Tetrastichus phyllocnistoides* (Narayana) and

Diaphorencyrtus aligharensis are reported from Vidarbha. The ectoparasite *T. radiatus* Waterson gave as high as 95% parasitism in north India (Bindra, 1969 and Singh, 1993a) whereas, in central India two peaks of parasitism, 33 and 20% (even upto 90% parasitism at certain location) in March and July, respectively, though sporadically, were recorded (Kalidas and Shivankar, 1994, Shivankar *et al.,* 2002a). Singh (1994) suggested release of *Encarsia Iahorensis* Howard @ 2000/tree coinciding with the availability of favorable pest stage for management of the pest.

4. Cirus black fly, *Aleurocanthus woglumi* Ashby (Aleyrodidae ; Homoptera)

Citrus black fly, *A. woglumi* Ashby is a serious pest of citrus of Asian origin. The life cycle from egg to adult ranged from 45 to 133 days depending on the temperature. Eggs are laid in a spiral pattern on the underside of the leaves. Each female lays two to three egg spirals during her 10 to 14 days life span. Eggs hatch within 7 to 10 days (Dowell *et al.,* 1981). The first instars are elongate- oval, averaging 0.30mm long x 0.15 mm wide and are brown in colour. They last for 7 to 16 days. The second instars are more ovate and convex and are dark brown in colour with numerous spines covering the body. Their period ranges from 7 to 30 days. The body of the third instars measure, an on average, 0.87mm in length and 0.74 mm in width. Their body is shiny black with stout spines and more numerous than the second instars. Duration of third instars ranged from 6 to 20 days (Dietz and Zetek, 1920; Smith *et al.,* 1964). The pupae are ovate and shiny black with a marginal fringe of white wax. The sex is readily distinguishable. Females (1.24 mm long x 0.7 mm wide) are larger than the males (0.99 mm long x 0.61 mm wide). The pupal period is 16 to 50 days (Dietz and Zetek, 1920; Dowell *et al.,* 1981). The adult emerge after making a 'T' shaped split at the anterior end of the pupal cage. The newly emerge adults have pale yellow colour head, whitish colour legs and reddish brown eyes. Within 24 hours after emergence, the insect is covered with a fine wax powder which gives it a state blue appearance (Dietz and Zetek, 1920). In India, the pest has 2 – 3 broads in a year, the first in March – April and the second and third in July – August to October (Shivankar and Singh, 2006).

Both nymphs and adults suck cell sap and the numerous nymphs excrete voluminous honey dew on which black sooty mould (*Capnodium* sp., *Meliola camelliae*) grows. Sooty moulds can severely impair leaf respiration and photosynthesis. The plants are devitalized due to excessive desapping and the fruit bearing capacity of the tree is also greatly affected. Heavy black fly infestation *viz*. 5 to 10 black flies/ cm^2 leaf area or 50 to 100 nymphs/ leaf cause extensive drain on cell sap and reduction of leaf ' nitrogen' content to less than 2.2%, affecting flowering and fruiting and, thereby, the yield (Shivankar and Singh, 2006).

Management

Close planting and water logging encourage black/ white fly infestation. Hence, these should be avoided. For better management, initial infestation can be checked by clipping off and destroying the infested shoots (Raj and Devi, 2004). Two foliar spray at 15 days interval during each flushing season i. e. during 1^{st} fortnight of April, 2^{nd} fortnight of July and 1^{st} fortnight of December alternately with monocrotophos @ 1.0 ml, acephate @ 1.5 g, imidiacloprid @ 0.5 ml or phosalone @1.5 ml/ litre of water gives effective check of the pest. Any additional spray with any of the above insecticides against the adult population is very effective as

it eliminates the egg laying population itself (Shivankar and Rao, 2001). Spray of 0.03 % dimethoate, 0.05 % phosphamidon or 0.05% acephate is very effective (Potineni , 1993). Spraying should be commenced at the initiation of new flush and repeated at 10 to 12 days interval (Raj and Devi, 2004).

The abundance of hymenopteran parasitoids, *Encarsia opulent* (Silvestri), *E. bennetti* (Hayat) *Eretmocerus gunturiensis* (Silvestri) and the predators, coccinellid *Serangium paresetosum* Sicard, chrysopid *Mallada boninensis* Okamoto promises a good scope for biological control of black fly (Shivankar and Singh, 2006).

Natural enemies viz. *Amitus* sp., *Encarsia clypealis* (Silvestri), *E. citrifolia, Chrysoperla* sp., *Pullus xerampelonus* (Mulsant), *Aschersonia* sp., and *Verticillium lecanii* (Zimmerman) have been recorded from Kodagu (Karnataka). 90% parasitism of the pest by *Encarsia divergenes* and *E. merceti* in Guwahati, 80 – 90 % by *E. clypealis* in Pune and 80% by *E. clypealis* and *Amitus hesperidium* in Bombay and Bangalore, respectively was reported by Singh (1991). The parasitoids are highly effective in their respective zone of distribution where pesticides are not used indiscriminately. But in areas where pesticides are used, release of parasitoids @ 200/ tree coinciding with the availability of favourable pest stage and obsevering a waiting perod of 15 days for initiating spraying if necessary may be adopted (Singh 1994).

5. **Citrus White fly, *Dialeurodes citri* Ashmead (Aleyrodidae ; Homoptra)**

The pest is a native of India. The winter is passed in the mature nymph stage, usually on the underside of leaves. Early in the spring pupae appear and, in March and April, adults emerge. The adult is a tiny, mealy – white insect with wing expanse measure 0.31 cm. Both the pair of wings is covered with a white powdery wax. Eggs are yellow in colour and laid on nearly smooth surface of leaves. The incubation period is 8 to 24 days depending on season. Unfertilized eggs developed into males. The nymphs soon settle to feed and do not more about until the adult stage is reached. The nymph is a flat, elliptical, scale- like, closely fastened to the underside of leaves. Like the scale insects, white flies lose their normal legs and antennae after the first molting. Nymphs are translucent, oval in outline and very thin. Nymphal life averages 23 to 30 days. Pupae are similar with the nymphs but are thickened and somewhat opaque and eye spot of the developing adult can be seen through the pupal skin. Pupal development requires 13 to 30 days. Adults lives an average of about 10 days but can be extended upto 27 days. An adult female lays about 150 eggs. Nature of damage citrus white fly is similar with the *A. woglumi*.

Management

The parasitoids *Encarsia lahorensis* Howard and *Eretmocerus* sp. have been reported parasitizing nymphs of white flies (Saini, 1964). According to Singh (1994), *E. lahorensis* is the key parasitoid of citrus whitefly in India particularly in the state of Punjab and adjoining areas. The parasitoids along with certain coccinellid predators and entomofungus *Aschersonia papillata* Petch keeps the population of white fly under check is several distribution zone of white fly.

Insect pests for grown up plants:

6. Citrus trunk borer, *Anoplophora versteegi* Ritsema (Cerambycidae: Coleoptera)

Ghost *et al.* (1982) reported *A. versteegi* as the most important pest of

mandarin orange in the North – Eastern region of India and were responsible for 20-30 per cent mortality of the plant species. Adult beetles emerged during late March to early May. They are grayish blue with black specks and dots on the elytra and thoracic dorsum. Body length of adult female ranged from 25 to 30mm whereas the males measures from 19 to 24 mm. Antenna lengths in case of females are about one and half of the body length and two times of the body length in case of males. After emergence, beetles feed on leaves along the midrib living the margin of leaf intact; sometimes they also scrapped the tender barks. After about 3-5days of emergence, adults mate. The pre- oviposition period is about 9-12 days. Adult females make a cut on the bark and insert the eggs beneath the bark. They prefer to lay eggs near the collar region of the trunk. The incubation, larval and pupal periods of *A. versteegi* fed on *Citrus reticulata* ranged from 6 to9, 271 to 292 and 29 to 39 days, respectively. Adult males survived longer than the females. Females laid 32 to 63 eggs during oviposition period of 28 to 54 days (Singh and singh, 2012). In the host preference studies, *A. versteegi* laid eggs in *Citrus reticulata*, *C, sinensis*, *C. limon*, *C. jambhiri*, *C. grandis*, *C. medica* and *C. aurantifolia*. In both multiple and single host test, highest number of eggs were deposited in *C. reticulata* closely followed by *C. sinensis*. In field survey, maximum infestation upto 58 per cent in *C. reticulata* was recorded among different citrus species.

The young larvae feed just beneath the bark for 14 to 30 days and then start making horizontal tunnel boring inside the wood till they reach the centre of the trunk. After reaching the centre of the trunk, they prepared vertical tunnel upward. Appearance of resinous exudation is a common symptom in the early stage of infestation. Sawdust like powders are seen expel from the entry holes as well as from the exit holes in the later stage of infestation. Larvae are creamy white with brown colour head.

Management

Adults of *A. versteegi* are sluggish and can easily be dislodged by shaking the tree (Nath and Basu, 1969). Collection and destruction of adult during April to July by shaking the trees to dislodge the adults feeding on leaves and twigs was suggested as mechanical method for controlling the pest. Smearing of trunk upto 1 m height with a mixture of monocrotophos + Lime + Water (1:10:100) or 3 ml of monocrotophas 36SL in 1 lit. of enamel paints two times during April to June and foliar application of profenophos (0.05) or monocrotophos (0.05%) or quinalphos (0.05%) or neem formulations (4 ml/litre of water) 3 times during April to July can be included in the IPM practice against the pest (Singh and Wangchu. 2008). Shylesha *et al*. (1996) reported that management practices using mechanical methods like collection and destruction of eggs, grubs and adults were effective against the pest. Egg laying site can be located by checking the injure areas at the base of the plants and killed the eggs. Barks oozing resinous substances can be removed (small area) to locate the young grubs and killed mechanically. Regular survey during May to August is required for the operation. When the bore holes are shallow i.e. during May to August, the holes can be poked with sharp pointed sticks or metal wires to kill the grubs. Stem injection @ 10ml / hole with monocrotophos (0.07%) or dichlorvos (0.05%) or petrol at the bore holes and plugging the hole with mud or cotton plug after injection was suggested for management of the pest (Kalita *et.al.* 2003). According to Shylesha *et al*. (1996) integration of mechanical and chemical control could give control of 100 per cent control of borer incidence. Encouragement for existence of predatory ants

like *Oecophylla smaragdina*, *Camponotus compressus*, *Tetraponera rufonigra*, *Pheidole* sp., *Monomorium floricola*, etc. will play an important role in the natural control of the pest.

7. Fruit sucking moth, *Othreis fullonica* Linnaeus (Noctuidae: Lepidoptera)

Bhutani (1979) reported a number of species of fruit sucking or fruit piercing moths on citrus fruits but *Othreis fullonica* Linnaeus, *O. materna* Cramer, *Calpe emerginata* Fabricius and *Achaea janata* Linnaeus cause considerable damage. In this chapter, emphasis is given to *O. fullonica*. This moth is native to Indo-Malaysian region and widespread throughout the Pacific basin, Asia and Africa. The duration of life cycle from egg to egg-laying adult was 35 to 49 days in Fiji (Kumar and Lal, 1983) and 30-33 days in warmer conditions of New Caledonia (Waterhouse and Norris, 1987). They were active throughout the year. Adult females laid hemispherical, yellowish green colour (1mm diameter) eggs. They were deposited in batches of 100 or more depending on the density of the adult females. Eggs are generally laid on the underside of leaves but may be found on the bark or other plants nearby. Eggs hatch in 3 to 4 days at 23 to 33^{o}C. (Kumar and Lal, 1983). The larvae undergo five stages and after each molt, the discarded skins are eaten by the newly emerged caterpillars. Caterpillars were 0.51 to 0.85cm in length during the first larval stage (Hargreaves, 1936) and reached 5.08cm when fully grown (Tryon, 1898). The last segment (11th segment) is considerably humped (Tryon, 1898), a feature that develops during the second instar (Hargreaves, 1936). They are either dark green to black or pale green to yellow (Comstock, 1936, Hargreaves, 1963). The dark colouration occurs when larval densities are high and the light coloured larvae are found with isolated larvae (Waterhouse and Norris, 1987). On the second and third abdominal segments, there are paired, lateral markings resembling eyes (Waterhouse and Norris, 1987). On the upper surface of the body, they have numerous small creamy-white spots and bars edged with black that tend to coalesce in some places. Durations of the five larval stages at temperatures between 23 to 33^{o}C are 3 to 5, 3 to 5 days, 2 to 3 days, 2 to 5 days, and 4 to 10 days, respectively (Kumar and Lal, 1983). Young larvae drop to the ground at any sign of danger, while the older larvae take an aggressive attitude by hanging on to the food plant with their hind legs and swaying the rest of their body from side to side (Mosse- Robinson, 1968) Pupation takes place within a cocoon spun between leaves and woven together with silk. The leaves containing the cocoon may remain on the host plant or dry and fall to the ground (Waterhouse and Norris, 1987). Pupae are very dark brown with a purplish cast. Pupation last for 14 to 21 days. If the pupation occurs under dry conditions the adult may not be able to emerge successfully (Hargreaves, 1936). Adult moths have stout body with wing spread 90-100mm. and 5cm in body length (Waterhouse and Norris, 1987). Head and thorax are greenish grey and abdomen is orange in colour. Fore wings are grayish green with numerous faint striated reddish lines. Hind wings have marginal black band and a round spot in the centre. *O. materna* have brownish colour forewings with grey colour patches. Hind wings have marginal black colour band with kidney shape band at the centre. After emergence from pupa, females have a preoviposition period of 4 to 8 days before she begins to lay her eggs. Each female may lay upto 750 eggs during her lifetime. Females live for 27-30 days and males 26 to 28 days (Kumar and Lal, 1983). Adults moths are very strong fliers and can travel great distances from their breeding grounds in search of fruits. They fly mainly between the hours of dusk.

The host plants of larvae of different fruit sucking moths are the wild shrubs like Gulvel (*Tinospora cardifolia* Miers, *T. smilacina* Benth), Vasanvel (*Cocculus villosus hirsutus* L.) and chandvel (*Cirampelos pariera* L., *Convolvulus arvensis* L., *Trichisia pattens* Oliv. and *Pericampylus glaucus* Lam Blatter) which are often found near citrus orchards (Gahukar, 1972; Radke,1995). Damage to the citrus fruit is caused by the adults. The moth parts of the moth are about 2.5cm long and strong enough to penetrate through tough-skinned fruit. Feeding occurs at night. The adult moths pierce the fruits for sucking the juice and make a puncture on the skin of the fruit. Fruit flesh damage by the moth becomes soft and mushy differing from the fruit damaged by fruit flies which is more liquid (Hue *et al.*, 1985). This moth is a known vector of *Oospora citri*, a fungus that rots the fruit. Other microorganisms that gain entrance into the fruit and caused rotting include *Fussarium* sp., *Colletotrichum* sp. (BSnziger, 1982) and several types of bacteria (Hargreaves, 1936). The damaged fruits usually drop to the ground and on pressing give out a jet of the juice from the puncture hole. About 20-40% ready to harvest fruits is damage in central India (Shivankar and Rao, 2001).

Management

Since this moth is not easily disturbed from fruit once it has begun to feed, netting and killing of moths is possible. This is best accomplished on hour after sunset when there is sufficient darkness with the aid of torches or a strong flash light. Nomura (1965) reported a substantial reduction of moths by 60% in Japan through illumination of the orchard. These moths are attracted by ultraviolet light and repelled by white light. If exposed to green- yellow light of mercury lamps, they adapt to the light and assume to their resting daylight behavior (Bosch, 1971). Since the moths are attracted to ultraviolet light, UV lamp can be used for trapping the adults. Smoking of the orchard for obscuring the smell of the ripe fruit was suggested by Baptist (1944). In this method containers full of inflammable material, oil, tar and some green plant materials to enhance smoke were placed within the orchard at a rate of 2 to 4 per acre. The smoking process was started a half an hour before dusk and continued for 2 to 3 hours after nightfall. This period represents the time in which the moths are seeking their night time feeding grounds. If the smell of the orchard is masked, the moths choose various wild hosts and remain on them throughout the night to feed. However this method was found ineffective in Thailand (BSnziger, 1982). Bagging of the fruit with brown paper or transparent oil paper bags can also protect the fruit from the pest, however this method is feasible only when the value of the fruit is very high, easily accessible for bagging and fruit size is large. Regular collection and proper disposal of all attacked and spoiled fruit as a method for reducing the attraction of the moth to the orchard was suggested by Baptist (1944). However, Ramachandrachari *et al.* (1960) suggested for keeping the drop fruit at the tree basins after cutting it into two halves to attract the adults and the attracted adults can be easily caught with nets and destroyed. When severe infestation is anticipated, the damage may be avoided by harvesting the entire crop as soon as a sign of fruits ripening is observed (Baptist, 1944). Poison baiting with 20 gm malathion W. P. or 50 ml diazinon + 200gm gur with some vinegar or fruit juice in 2 litres of water @ 2 bottles per 25-30 30 trees was suggested by Shivankar and Singh (2006). Trapping and killing moths with poison bait (1 kg sugar + 50 ml dichlorovas in 10 litres of water) was found effective against the pest (Raj and Devi, 2004). Bosch (1971) reported some success of citronella oil as repellent of the pest. Egg parasitoid

Trichogramma chilonis and larval parasitoid *Microplitis maculipennis* as important natural enemies of *A. janata* was reported by Singh, 1990. *T. chilonis* and *Euplectrus plathypenae* are important parasitoid of *O. fullonia* in Hawaii (Heu *et al*. 1985). Release of egg parasitoids *Trichogramma chilonis* from 45 days before starting of the fruit ripening around the citrus orchards particularly where the host plants of the larvae are available can reduce the pest problem.

Beside these two important insect pests for grown up plants, citrus psylla, white flies black flies also infest grown up plants and cause severe damage under favourable conditions.

DELAYED RIPENING OF FRUITS AND VEGETABLES THROUGH GENETIC ENGINEERING

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Introduction

The ripening process has evolved as a seed dispersal mechanism. In the case of fleshy fruits, as the seeds mature the surrounding tissues undergo profound changes in composition that alter the texture, flavour, aroma and nutritional value. These changes serve as attractants to seed dispersing organisms by converting an unpalatable tissue into one that is attractive and nutritionally rich.Ripening is a normal phase in the maturation process of fruits and vegetables. Upon its onset, it only takes about a few days before the fruit or vegetable is considered inedible. This unavoidable process brings significant losses to both farmers and consumers alike. Efforts are being made to delay fruit ripening so that farmers will have the flexibility in marketing their goods and ensure consumers of "fresh-from-the- garden" produce.Ripening is associated with change in composition, i.e. conversion of starch to sugar. On the basis of their ripening process, the fruits are classified as:

1. **Climacteric Fruits**

   Climacteric Fruits are defined as fruits that enter 'climacteric phase' after harvest, i.e. they continue to ripen off the tree/plant. Ripen in response to ethylene. Most ripened climacteric fruits are too soft and delicate to withstand rigours of transport and repeated handling. These are harvested hard and green, but fully mature. Ripening is done near the consumption areas. Examples: Mango, Banana, Papaya, Guava, Sapota, Kiwi, Fig, Apple, Passion fruit, Apricot, Plum, Pear.

2. **Non-Climacteric Fruits:** Fruits that do not ripen in response to ethylene, once harvested, they do not ripen further. Examples: Orange, Mosambi, Kienow, Grape fruit, Grapes, Pomegranate, Litchi, Watermelon, Cherry, Raspberry, Blackberry, Strawberry, cashew, lemon.

Typical changes that occur during ripening

Ripening leads to several biochemical and physiological changes in the fruits and vegetable;

1. Changes in colour.
2. Softening and associated alteration in texture.
3. Production of volatiles and flavour compounds.
4. Altered sugar and organic acid metabolism.
5. Increase in pathogen susceptibility.
6. Increase in membrane permeability which releases compartmentalized enzymes.
7. Increase in protein (enzyme) synthesis.

8. Carbohydrate Changes- *Conversion of starch to sugar*; not desirable in potato but very desirable in apple, banana. *Conversion of sugar to starch*; not desirable in sweet corn but very desirable in potato. *Conversion of starch and sugars to CO2 and water during respiration*; not desirable because it leads to a reduction in quality.
9. Pigment Changes- *Chlorophyll*; a loss of chlorophyll in tomatoes is desirable but a loss in chlorophyll in broccoli is undesirable. *Carotenoids (yellow, orange and red colour)*; are desirable in fruits such as apricots, peaches and citrus giving them their yellow and orange colour. In tomatoes and pink grapefruit, a specific carotenoid, lycopene gives them their red colour. *Anthocyanins (red and blue colour)*; give red and blue colour to apples, berries, cherries and other fruits. *Phenolic compounds*; are responsible for tissue browning.
10. Other Changes- *Organic acids* (affects sweetness)*; Proteins* (affects texture)*; Amino acids* (affects flavour)*; Lipids* (affects flavour).

Ethylene

Ethylene is a natural plant hormone associated with the growth, development, ripening and aging of many plants. It is produced in varying quantities depending on the type of fruit. But when the concentration of ethylene reaches 0.1-1.0 ppm (parts per million), the ripening process in climacteric fruits is considered irreversible. Level of ethylene may be increased by physical injury (wounding), infection by pathogens such as bacteria, fungi, etc., high or low temperature, and water stress. Ethylene production managed by:

1. Reducing the storage temperature
2. Treating with silver thiosulphate (commonly used in flowers)
3. Reducing O2 levels to less than 8%
4. Treating with enzyme inhibitors of ACC synthase and ACC oxidase
5. Genetic engineering (for example, use of antisense technology) to prevent enzyme expression and in turn slowing the processes involved in ripening resulting in increased shelf-life.

Genetic engineering to prevent enzyme expression and in turn slowing the processes of ripening

Altering ethylene levels in plants

Modifying the amount of ethylene produced under ripening or stress conditions is the goal of a wide array of transgenic strategies. Study of the ethylene biosynthesis pathway in plants made it possible to modify and insert genes that alter the level of this hormone produced in response to various stimuli (Fig.1). Enzymes that degrade SAM or ACC, the precursors of ethylene, have been shown to effectively reduce ethylene levels without drastically altering the physiology of the plant.

SAM decarboxylase

1. The enzyme SAM decarboxylase, converts SAM to decarboxylated SAM that is then used in the polyamine biosynthetic pathway.
2. SAM decarboxylase is an essential gene that is present in bacterial, plant and mammalian systems, and has been isolated from many sources.

Expression of SAM decarboxylase following the insertion of the gene under control of either the cauliflower mosaic virus (CaMV) 35S constitutive promoter or the tet promoter.

3. It was thought that overexpression of SAM decarboxylase might enhance the flux of SAM through the polyamine pathway, thus reducing the amount available for ethylene biosynthesis.

SAM hydrolase

1. Another SAM degrading enzyme is SAM hydrolase. It is found only in bacteriophage T3, and converts SAM to 5'-methylthioadenosine (MTA) and homoserine both of which re-enter the methionine cycle.
2. The gene coding for the enzyme is obtained from *E. coli* T3 bacteriophage.
3. In this way, SAM is diverted away from the ethylene pathway and no foreign metabolites accumulate.
4. SAM hydrolase has been used to control ethylene levels in both ripening fruit and ornamental crops.

ACC synthase

1. ACC synthase is one of the rate-limiting enzymes in ethylene biosynthesis and many strategies aimed at reducing ethylene have targeted this step.
2. ACC (1-aminocyclopropane-1-carboxylic acid) synthase is the enzyme responsible for the conversion of S-adenosylmethionine (SAM) to ACC; the second to the last step in ethylene biosynthesis.
3. Enzyme expression is hindered when an antisense ("mirror-image") or truncated copy of the synthase gene is inserted into the plant's genome.

ACC deaminase

1. The enzyme ACC deaminase was first discovered in soil microorganisms and shown to convert ACC to ammonia and a-ketobutyrate, both of which may be further metabolized by the microorganism.
2. By inserting the gene for ACC deaminase into tomato plants under the control of the CaMV 35S promoter, fruit with delayed ripening were produced.
3. The gene coding for the enzyme is obtained from *Pseudomonas chlororaphis*, a common nonpathogenic soil bacterium. It converts ACC to a different compound thereby reducing the amount of ACC available for ethylene production.

ACC oxidase

1. ACC oxidase is the enzyme which catalyzes the oxidation of ACC to ethylene, the last step in the ethylene biosynthetic pathway.
2. ACC oxidase is present in low levels in most plant tissues, and may be modified post-translationally into some of the many isoforms that can be seen in plant tissues.
3. One strategy for reducing ethylene involved insertion of an antisense version of ACC oxidase into tomato; the effect of this strategy was studied on ripening fruit and wounded leaves.

4. Down regulation of the ACC oxidase gene results in the suppression of ethylene production, thereby delaying fruit ripening.

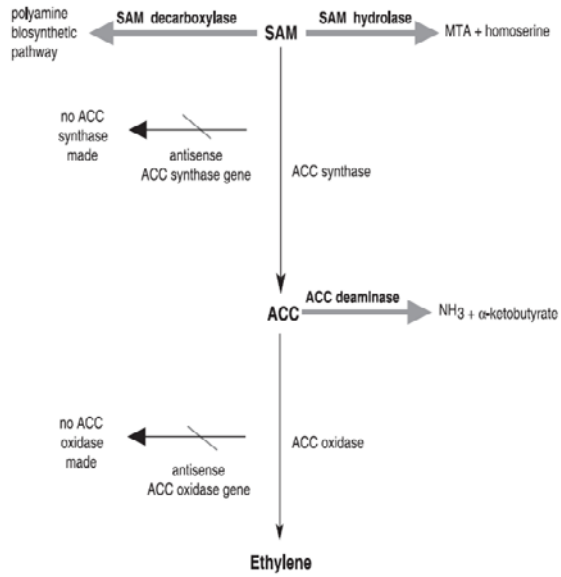


Fig 1. An overview of added or altered genes in the ethylene biosynthesis pathway

Abbreviations: ACC; 1- aminocyclopropane-1-carboxylic acid; MTA; 5V methylthioadenosine; SAM; S-adenosylmethionine

Mainly two strategies have been employed by the scientist to alter the ethylene in food and vegetables, which is;

1. Genetic engineering through insertion of foreign gene

Agrobacterium tumefaciens is an α-proteobacterium with the exceptional ability to transfer and integrate foreign genes into the genome of a host plant called genetic transformation. The transformation process requires the tumour-inducing (Ti) plasmid of *A. tumefaciens*. The Ti plasmid includes two regions: an oncogenic region (T-DNA) that encodes proteins involved in crown gall formation through auxin and cytokine synthesis after integration into the host plant genome and the vir gene region, which encodes the proteins that actually transfer the T-DNA into plant cells and integrate it into the host genome. Their unique ability to transfer genes into the plant genome has been widely utilized for plant genetic engineering. However, several studies revealed that ethylene decreases the efficiency of transformation. It is also found that *A. tumefaciens* does not possess an ACC deaminase gene in its genome, but it is a certain plant growth-promoting rhizobacteria (PGPR) having ACC deaminase activity. When ACC deaminase gene from the PGPR strain is integrated into the *A. tumefaciens*genome, the latter is termed as super-Agrobacterium could suppress the ethylene evolution and also increase the gene transfer efficiency. Widely three major gene has been targeted in gene insertion mechanism;

I. Insertion of the ACC deaminase gene (Gene taken from *Pseudomonas chlororaphis*).
II. Insertion of the SAM decarboxylase gene.
III. Insertion of the SAM hydrolase gene (Gene taken from *E.coli* T3 bacteriophage).

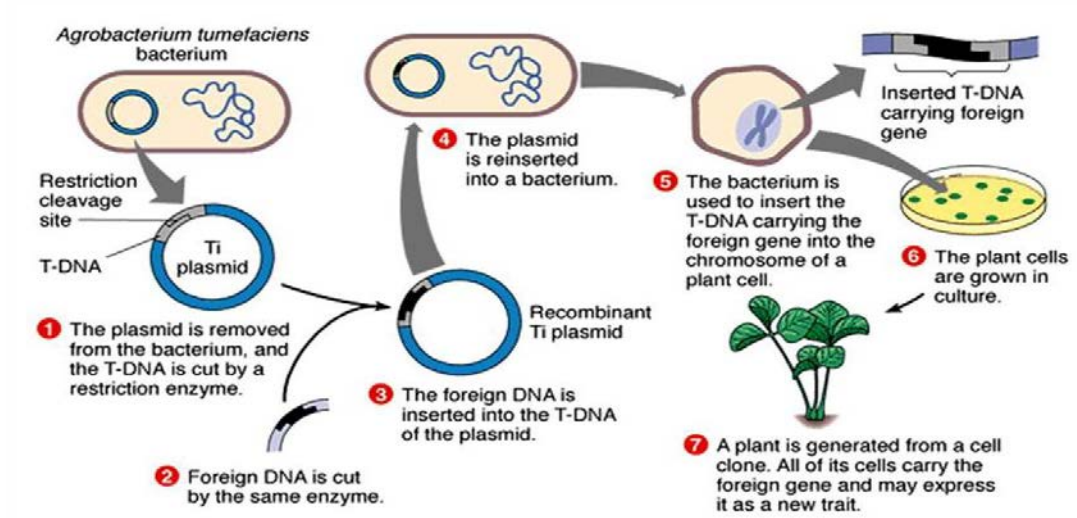


Fig. 2: Diagrammatical presentation of insertion of foreign gene inside the plant cell to obtain delayed ripening traits

2. Genetic engineering through Suppression (Antisense RNA)

Antisense RNA (asRNA) is a single-stranded RNA that is complementary to a messenger RNA (mRNA) strand transcribed within a cell. Originally, the term 'antisense' was used to describe inhibition of mRNA translation by hybridization of an oligonucleotide to a selected region of the mRNA. Since mRNA represents the 'sense' sequence, the oligonucleotide complementary to the mRNA was called 'antisense' oligonucleotide.

In any gene, the DNA strand oriented as 3′ → 5′ in relation to its promoter is transcribed; this strand is called the antisense strand. The mRNA base sequence, therefore, is complementary to that of the antisense strand. The remaining DNA strand of the gene, called sense strand, is naturally complementary to the antisense strand of the gene. Therefore, the base sequence of sense strand of a gene is the same as that of the mRNA produced by it (except for T in the place of U). Hence, the hnRNA/mRNA produced by a gene in normal orientation is also known as sense RNA.

An antisense gene is produced by inverting, i.e., reversing the orientation of, the protein-encoding region of a gene in relation to its promoter. As a result, the natural sense strand of the gene becomes oriented in the 3'→5′ direction with reference to its promoter, and is transcribed. (The normal antisense strand is not transcribed since now its orientation is 5'→3′). The RNA produced by this gene has the same sequence as the antisense strand of the normal gene (except for T in DNA in the place of U in RNA), and is, therefore, known as antisense RNA or, sometimes, asRNA. When an antisense gene is present in the same nucleus as the normal endogenous gene, transcription of the two gene yields antisense and sense RNA transcripts, respectively. Since the sense and the antisense RNAs are complementary to each other, they would pair to produce double- stranded RNA molecules.

This event makes (1) the mRNA unavailable for translation. At the same time, (2) the double-stranded RNA molecules are attacked and degraded by double-stranded RNA specific RNases. Finally, (3) these events

somehow lead to the methylation of the promoter and coding regions of the normal gene resulting in silencing of the endogenous gene. The application of antisense RNA technology is explained using the following examples.

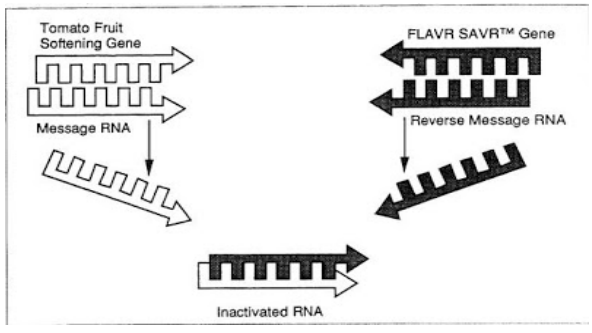
I. Suppression of ACC oxidase gene expression
II. Suppression of ACC synthase gene expression
III. Supression of polygalacturonase activity

Suppression of Polygalacturonase Activity

Polygalacturonase (PG) is the enzyme responsible for the breakdown of pectin, the substance that maintains the integrity of plant cell walls. Pectin breakdown occurs at the start of the ripening process resulting in the softening of the fruit. To produce a fruit with DR trait using this method, scientists insert an anti-sense or a truncated copy of the PG gene into the plant's genome resulting in a dramatic reduction of the amount of PG enzyme produced thereby delaying pectin degradation.

FlavrSavr Tomato

1. FlavrSavr, a genetically modified tomato, was the first commercially grown genetically engineered food to be granted a license for human consumption.
2. It was produced by Calgene, and submitted to the U.S. Food and Drug Administration (FDA) in 1992. Licensed in 1994
3. The tomato was made more resistant to rotting by adding an antisense gene which interferes with the production of the enzyme polygalacturonase. The enzyme normally degrades pectin in the cell walls and results in the softening of fruit which makes them more susceptible to being damaged by fungal infections.
4. The modified tomatoes are picked before fully ripened and are then artificially ripened using ethylene gas which acts as a plant hormone. Picking the fruit while unripe allows for easier handling and extended shelf-life.



Conclusion

- The use of antisense technology and over expression of metabolizing enzymes such as ACC deaminase control fruit ripening.
- The development of gene transplacement technology by homologous recombination should allow the creation of non-leaky ripening mutants with long-term storage potential.
- The prospect arises that inhibition of ethylene production using reverse genetics may be a general method for preventing senescence in a variety of fruits and vegetables.

TAPPING THE INDIGENOUS SKILL AND BRINGING AWARENESS AMONG THE TRIBAL GROWERS OF NEH REGION

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Introduction

North eastern region of India constitutes about 8% of the total geographical area of the country with a population of about 40 million, which represents 3.1% of the total Indian population. The region is rich in natural resources, covered with dense forest and has the highest rainfall in the country. Agriculture is the mainstay of the economies of the region and is a major source of employment and livelihood for around 80% of the population. Farmers grow only one crop in a year and farming is basically at a subsistence level. A large number of people inhabiting in the region follow the traditional practice of jhum or shifting cultivation.

Over the years, farmers have accumulated intimate knowledge of their environment comprising land, water, trees, plants and animals etc. and found solutions to management of problems by taking series of decisions and implementing them by allocating resources in a manner they considered to be the most effective or efficient. This knowledge consists of many facts and helped them evolve many practices which have been tested over long periods of time and proved beneficial. Appropriateness of these practices lies in efficient use of local resources. They depend entirely on locally available resources and knowledge base for maintaining productivity of crops and livestock. However, with changing time and in the face of rapidly increasing population pressure, they may also have some weakness, problems and constraints to be addressed in context of modern farming practices. Nevertheless, a greater appreciation of indigenous knowledge is necessary to improve the ability of development agencies and extension services to provide relevant support for the sustainable development and management of natural resources. Often farmers know more than many qualified professionals about the local resource dynamics within their interdependent, complex and flexible systems. In the modern development efforts, knowledge of such indigenous practices provides valuable inputs to make efficient use of natural resources. They should be properly understood and incorporated for the development of sustainable farming systems and practices.

Agriculture has been a way of life and continues to be single most important source of livelihood for farmers of NEH region. Farmers over centuries, have learnt to grow food and to survive in difficult environments, where the rich tradition of ITK has been interwoven with the agricultural practices followed by them. Indigenous knowledge is the information base for a society, which facilitates communication and decision-making. Indigenous information systems are dynamic, and are continually influenced by internal creativity and experimentation as well as by contact with external systems. The term indigenous technical knowledge is often

camouflaged with the belief that is associated with forthcoming happenings and the innovations made by the farmers to solve specific problems. The indigenous Technical Knowledge (ITK) system has been developed by the people based on their experiences and continuous improvement through informal experimentation over centuries. These ITKs are interwoven and assimilated in the cultural life of the people.

ITKs are based on experience, often tested over a long period of use, adapted to local culture and environment, dynamic and changing, and lays emphasis on minimizing the risks rather than maximizing the profits. ITK covers a wide range of subjects such as crop production, livestock rearing, natural resource management, food preparation, health care and many other related topics. Various aspects of agriculture and allied activities have been included in ITKs such as soil, water and nutrient management; crop cultivation; plant protection; farm equipment, farm power, post-harvest preservation and management; pasture and fodder management; agro-forestry; bio-diversity conservation and exploitation; animal rearing and health care; animal products preservation and management; fisheries and fish preservation; and ethnic foods and homestead management.

Capacity building on ITK

Capacity building programmes on indigenous knowledge systems are inevitable for bringing a desirable change in the attitudes of researchers and extension workers. The need for conducting training programs for extension workers on the role of indigenous knowledge in agricultural development is:

a. If the extension personnel including village extension workers and agricultural extension officers are provided training on scientific technological innovations, but have not learned to regard farmers as their colleagues, their potential to support farmers' local research efforts will be comparatively lower;

b. Training programmes on the role of ITKs in agricultural development help to remove the impression among the extension workers that research scientists are the only generators of technological innovations and their (extension workers) job is to merely transmit those innovations;

c. Information provided in these training programmes regarding local farmer organizations and their functions can stimulate ideas among extension workers for a number of viable action-programs; and

d. Extension workers can help local farmers' organizations establish and strengthen links with agencies such as government services, private organizations, commercial farms, and other farmer organizations for information and other inputs.

Capacity building on indigenous knowledge systems should be conducted in two stages:

1. Training/workshop for the State level trainers of TTCs, ICAR Institutes and Agricultural universities.
2. The trainers will then provide similar training for district-level extension workers, subject matter specialists of KVKs, ATMAs etc.

Evaluating Available Technological Options

Validation of ITK is a logical step to qualify and quantity effectiveness of the practices. Suitable modifications of the local practices, through research and development will help to develop appropriate and

acceptable technologies that are more suited to our farming situations.

Evaluating the technological options is an essential component while conducting On-Farm Farmer-Oriented Research**(**OFFOR). The extension scientist should evaluate the performance of technological options with respect to:

a. Compatibility with agro-ecological situations.
b. Compatibility with socio-cultural environments.
c. Usage of labour.
d. Usage of cash.
e. Profitability.
f. Need for institutional support.
g. Contribution to reducing risk.

Extension scientists with input from farmers should evaluate the technologies that have been tested during the OFFOR in terms of their contribution to:

a. Productivity of crops and associated livestock.
b. Sustainability of the agricultural system.
c. Complexity (e.g., ease of experimentation),
d. Labour intensity.

Extension scientists are expected to arrive at any one of the following decisions:

a. Drop the technological option that has been tested.
b. Technological options need long-term research.
c. Technological option is ready for further dissemination.

The technological options found viable after the on-farm research should be disseminated to farmers using Front Line Demonstration programme by collaborating with research, extension and NGOs.

Various ITKs in agriculture, animal husbandry, fisheries and other and based activities have been in use since the human civilization by the farmers, animal owners and other practitioners. In spite of advancement in scientific knowledge in agriculture, ITK-based practices still remain in use by the vast majority of the farming community particularly in resource poor farming situations, without the knowledge of its scientific rationality. In this context, blending of indigenous knowledge with modern scientific technologies is the need of the day to support sustainable development of agriculture and allied sector in the region.

Common indigenous traditional pest management practices prevalent under Horticultural crops in NEH region are briefly presented below with the purpose of identifying the inherent characteristics of sustainability embedded in them and exploring ways to replicate them elsewhere.

Table 1:Common indigenous traditional pest management practices found in NEH Region

Sl. No.	Target pests	ITK practices	Reference
1.	Vegetables Sucking pests	Sprinkling wood ash on vegetable crops.	Barooah and Pathak, 2009
2.	Citrus trunk borer	Application of fish cleaned water at the base of plant. Introducing predacious red tree ants nest into the fruit orchard. Application of kerosene oil to the fruit tree trunks.	Barooah and Pathak, 2009

3.	Banana Snails and slugs	Common salt is applied to the base of plants.	Barooah and Pathak, 2009
4.	Fruit moth Jack fruit, Mango	Smoke is generated at the base of fruit trees.	Barooah and Pathak, 2009
5.	Birds and monkeys Fruit orchard	Catapults and drum beating.	Barooah and Pathak, 2009
6.	Vegetables Many pests	Growing border mixed crops (broad leaf types) such as pumpkin, cucumber, lady's finger, banana and other horticultural crops like guava, pineapple, etc.	Chanu, 2010
7.	Fruit fly Pumpkin	Smoking in the pumpkin field.	Deka*et al*., 2006
8.	Potato Tuber moth	Sand cover (2-5cm depth) over the stored potato.	Deka*et al*., 2006
9.	Citrus Defoliators	Placing of red tree ant (*Oecophyllasmaragdina*) nest on the citrus plant.	Deka*et al*., 2006
10.	Citrus trunk borer	Application of fish cleaned water at the base of plant.	Deka*et al*., 2006
11.	Rhinoceros beetle Coconut	Placing of long hair of women in the crown portion of coconut tree. Placing of a dead frog at the base of the coconut plant @ 1 trap/m^2.	Deka*et al*., 2006
12.	Squirrel Coconut	The fragmented human hair and dry fish mixture are kept in the crown.	Deka*et al*., 2006
13.	Fruit trees Many pests	Fruit trees (*Brideliaretusa*) and animal bone tied with horticultural plants.	Saravanan, 2010
14.	Ginger Many pests	Planting of *Calotropis*in the field of ginger.	Shrivastava*et al*.,2009
15.	Vegetables (Kitchen garden) Bugs and beetles	Local crabs are smashed and put on the top of a pointed stick and is placed in crop fields.	Sinha*et al*., 2004
16.	Vegetables (Kitchen garden) Defoliators	Spraying of mixture of Cowdung, Cowurine, Chilli& Garlic @ 2:1:0.5:0.25Ratio. Spraying of dissolved silkworm excreta.	Sinha*et al*., 2004
17.	Vegetables Lepidopteron larvae	Spraying of "Re'not-bol" plant extract.	Sinha*et al*., 2004
18.	Kitchen garden and fruit trees Lepidopteron pests	Use of 'Changsim' (*Sapiumbaccatum* Roxb.) or 'Tuthekme' [*Dendropthoe falcate* (L.) Elting.] or 'Rakseng' (*Morusmacroura*Mig.) or 'Khasi-bol' (*Brideliaretusa*Spreng.) fruits to attract insect predators (birds).	Sinha*et al*., 2004

19.	Ginger Many pests	Bhang leaves and soil is mixed in the ratio 1:1 and kept for 12-24 hours for proper intermingling.	Sinha*et al*., 2004
20.	Red palm weevil Arecanut	*'PeitKsainKwai'* (Checking the grubs in nuts), killing the larva by inserting wire hook in the bored hole and also form soil below the tree.	Umdor, 2004

Conclusion

The documented ITKs serve as a ready reference for the agricultural scientists for further study to determine their scientific rationality and effectiveness. This will also be helpful in technology blending programme to generate eco-friendly, location specific, economically viable and socially acceptable technologies. Some locally available plants and plant parts were used by the farmers in traditional plant protection measures. This will lead to production of new bio-pesticides in near future. Since ITKs are organic in nature the documented ITKs may be useful for extension personnel in planning and executing various IPM, IDM and INM programmes through their judicious integration to these systems. Proper documentation, validation and refinement of ITKs at different stage will help mankind for easy access of ITKs or ITK based blended technology for their farming.

CLIMATE CHANGE AND CARBON SEQUESTRATION

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Introduction

About 2200 BC a shift in the Mediterranean westerly winds occurred, and it results in a reduction in the Indian Monsoon leading to three centuries of low rainfall and cold temperature. This phenomenon hit agriculture from the Aegean Sea to the Indus river. This change brought down Egypt's pyramid building old kingdom and Sargon the Great's empire in Mesopotamia. After only a few decades of low rainfall, cities lining the northern reaches of Euphrates – the breadbasket for the Akkadians, were deserted. At the city of Tell Leilan on the northern Euphrates, a monument was halted half built. A thick layer of wind-blown dirt covered the ruins of ensuring exciting job for the future archeologist. Even intensively irrigated southern Mesopotamia, which boasted of one of the most sophisticated bureaucracies of its time, could not react fast enough to the new conditions. Without the shipment of rainfed grains from the north, and faced with parched irrigation ditches and migration from the devastated northern cities, the empire collapsed.

Societies have always depends on the climate but are only now coming to terms with the fact that the climate depends on their actions. Evidences from the past have fully established that significant changes in the climate are taking place worldwide as a result of enhanced anthropogenic activities. The fast pace of development and industrialization and indiscriminate destruction of natural environment, more so in the last century have altered the concentration of atmospheric gases that leads to global warming. This global warming is the major cause of climate change. Climate change refers to the long term change in the state of climate that can be identified by changes in the means and/or changes in the variability. It also includes gradual and/or abrupt changes in the frequencies and intensities of extreme events.

The steep increase in GHGs since the industrial revolution has transformed the relationship between people and environment. The fact that climate affects development and development affects climate has come to be known widely during recent time. Climate change will reverse development progress and compromise the well-being of present and upcoming generations. Climate change is a complex phenomenon with a wide range of impact on the environment. Climate change, the greatest global challenge, is already a realty for the farmers of NE region. Enough is already known to start the action against climate change. Given the fragility of the resource base in NE region, agriculture is a high risk activity. Climate change poses formidable challenge to livelihoods.

Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide (CO_2).Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. It has been proposed as a way to slow the

atmospheric and marine accumulation of greenhouse, which are released by burning fossil fuels.

Carbon dioxide is naturally captured from the atmosphere through biological, chemical, or physical processes. Artificial processes have been devised to produce similar effects, including large-scale, artificial capture and sequestration of industrially producedCO_2 using subsurface saline aquifers, reservoirs, ocean water, aging oil fields, or other carbon sinks. Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide (CO_2) and may refer specifically to:

- "The process of removing carbon from the atmosphere and depositing it in a reservoir." When carried out deliberately, this may also be referred to as carbon dioxide removal, which is a form of geoengineering.
- Carbon capture and storage, where carbon dioxide is removed from flue gases (e.g., at power stations) before being stored in underground reservoirs.
- Natural biogeochemical cycling of carbon between the atmosphere and reservoirs, such as by chemical weathering of rocks.

Biological processes

An oceanic phytoplankton bloom in the South Atlantic Ocean, off the coast of Argentina. Encouraging such blooms with iron fertilization could lock up carbon on the seabed. Biosequestration or carbon sequestration through biological processes affects the global carbon cycle. Examples include major climatic fluctuations, such as the Azolla event, which created the current Arctic climate. Such processes created fossil fuels, as well as clathrate and limestone. By manipulating such processes, geoengineers seek to enhance sequestration.

Peat production

Peat bogs are a very important carbon store. By creating new bogs, or enhancing existing ones, carbon can be sequestered.

Reforestation

Reforestation is the replanting of trees on marginal crop and pasture lands to incorporate carbon from atmospheric CO_2 into biomass. For this process to succeed the carbon must not return to the atmosphere from mass burning or rotting when the trees die. To this end, land allotted to the trees must not be converted to other uses and management of the frequency of disturbances might be necessary in other to avoid extreme events. Alternatively, the wood from them must itself be sequestered, e.g., via biochar, bio-energy with carbon storage (BECS), landfill or 'stored' by use in e.g. construction. Short of growth in perpetuity, however, reforestation with long-lived trees (>100 years) will sequester carbon for a more graduated release, minimizing impact during the expected carbon crisis of the 21st century.

Urban Forestry

Urban Forestry adds carbon with new tree sites and the sequestration of carbon over the lifetime of the tree. There are several methods of accounting for carbon storage, one of which, I-Tree is easy to use.

Wetland restoration

Wetland soil is an important carbon sink; 14.5% of the world's soil carbon is found in wetlands, while only 6% of the world's land is composed of wetlands.

Agriculture

Globally, soils are estimated to contain approximately 1,500 gigatons of organic carbon to 1 m depth, more than the amount in vegetation and the atmosphere. Modification of agricultural practices is a recognized

method of carbon sequestration as soil can act as an effective carbon sink offsetting as much as 20% of 2010 carbon dioxide emissions annually.Carbon emission reduction methods in agriculture can be grouped into two categories: reducing and/or displacing emissions and enhancing carbon removal. Some of these reductions involve increasing the efficiency of farm operations (e.g. more fuel-efficient equipment) while some involve interruptions in the natural carbon cycle. Also, some effective techniques (such as the elimination of stubble burning) can negatively impact other environmental concerns (increased herbicide use to control weeds not destroyed by burning).

Reducing emissions Increasing yields and efficiency generally reduces emissions as well, since more food results from the same or less effort. Techniques include more accurate use of fertilizers, less soil disturbance, better irrigation, and crop strains bred for locally beneficial traits and increased yields.
Replacing more energy intensive farming operations can also reduce emissions. Reduced or no-till farming requires less machine use and burns correspondingly less fuel per acre. However, no-till usually increases use of weed-control chemicals and the residue now left on the soil surface is more likely to release its CO_2 to the atmosphere as it decays, reducing the net carbon reduction.

In practice, most farming operations that incorporate post-harvest crop residues, wastes and byproducts back into the soil provide a carbon storage benefit. This is particularly the case for practices such as field burning of stubble - rather than releasing almost all of the stored CO_2 to the atmosphere, tillage incorporates the biomass back into the soil.

Enhancing carbon removal

All crops absorb CO_2 during growth and release it after harvest. The goal of agricultural carbon removal is to use the crop and its relation to the carbon cycle to permanently sequester carbon within the soil. This is done by selecting farming methods that return biomass to the soil and enhance the conditions in which the carbon within the plants will be reduced to its elemental nature and stored in a stable state. Methods for accomplishing this include:

- Use cover crops such as grasses and weeds as temporary cover between planting seasons
- Concentrate livestock in small paddocks for days at a time so they graze lightly but evenly. This encourages roots to grow deeper into the soil. Stock also till the soil with their hooves, grinding old grass and manures into the soil.
- Cover bare paddocks with hay or dead vegetation. This protects soil from the sun and allows the soil to hold more water and be more attractive to carbon-capturing microbes.
- Restore degraded land, which slows carbon release while returning the land to agriculture or other use.

Agricultural sequestration practices may have positive effects on soil, air, and water quality, be beneficial to wildlife, and expand food production. On degraded croplands, an increase of 1 ton of soil carbon pool may increase crop yield by 20 to 40 kilograms per hectare of wheat, 10 to 20 kg/ ha for maize, and 0.5 to 1 kg/ha for cowpeas.

The effects of soil sequestration can be reversed. If the soil is disrupted or tillage practices are abandoned, the soil becomes a net source of greenhouse gases. Typically after 15 to 30 years of sequestration, soil becomes saturated and ceases to absorb carbon. This implies that there is a global limit to the amount of carbon that soil can hold.

Many factors affect the costs of carbon sequestration including soil quality, transaction costs and various externalities such as leakage and unforeseen environmental damage. Because reduction of atmospheric CO_2 is a long-term concern, farmers can be reluctant to adopt more expensive agricultural techniques when there is not a clear crop, soil, or economic benefit. Governments such as Australia and New Zealand are considering allowing farmers to sell carbon credits once they document that they have sufficiently increased soil carbon content.

Ocean-related

Iron fertilization

Ocean iron fertilization is an example of such a geo-engineering technique. Iron fertilization attempts to encourage phytoplankton growth, which removes carbon from the atmosphere for at least a period of time. This technique is controversial due to limited understanding of its complete effects on the marine ecosystem, including side effects and possibly large deviations from expected behaviour. Such effects potentially include release of nitrogen oxides, and disruption of the ocean's nutrient balance.

Natural iron fertilisation events (e.g., deposition of iron-rich dust into ocean waters) can enhance carbon sequestration. Sperm whales act as agents of iron fertilisation when they transport iron from the deep ocean to the surface during prey consumption and defecation. Sperm whales have been shown to increase the levels of primary production and carbon export to the deep ocean by depositing iron rich feces into surface waters of the Southern Ocean. The iron rich fecescauses phytoplankton to grow and take up more carbon from the atmosphere. When the phytoplankton dies, some of it sinks to the deep ocean and takes the atmospheric carbon with it. By reducing the abundance of sperm whales in the Southern Ocean, whaling has resulted in an extra 2 million tonnes of carbon remaining in the atmosphere each year.

Urea fertilization

Ian Jones proposes fertilizing the ocean with urea, a nitrogen rich substance, to encourage phytoplankton growth.Australian company Ocean Nourishment Corporation (ONC) plans to sink hundreds of tonnes of urea into the ocean to boost CO_2-absorbing phytoplankton growth as a way to combat climate change. In 2007, Sydney-based ONC completed an experiment involving 1 tonne of nitrogen in the Sulu Sea off the Philippines.

Mixing layers

Encouraging various ocean layers to mix can move nutrients and dissolved gases around, offering avenues for geo-engineering. Mixing may be achieved by placing large vertical pipes in the oceans to pump nutrient rich water to the surface, triggering blooms of algae, which store carbon when they grow and export carbon when they die. This produces results somewhat similar to iron fertilization. One side-effect is a short-term rise in CO_2, which limits its attractiveness.

Seaweed

Seaweeds grow very fast and can theoretically be harvested and processed to generate biomethane, via anaerobic digestion to generate electricity, via Cogeneration/CHP or as a replacement for natural gas. One study suggested that if seaweed farms covered 9% of the ocean they could produce enough biomethane to supply Earth's equivalent demand for fossil fuel energy, remove 53 gigatonnes of CO_2 per year from the atmosphere and sustainably produce 200 kg per year of fish, per person, for 10

billion people. Ideal species for such farming and conversion include *Laminariadigitata, Fucusserratus* and *Saccharinalatissima*.

Physical processes

Bio-energy with carbon capture and storage (BECCS)

BECCS refers to biomass in power stations and boilers that use carbon capture and storage. The carbon sequestered by the biomass would be captured and stored, thus removing carbon dioxide from the atmosphere.This technology is sometimes referred to as bio-energy with carbon storage, BECS, though this term can also refer to the carbon sequestration potential in other technologies, such as biochar.

Burial

Burying biomass (such as trees) directly mimics the natural processes that created fossil fuels. Landfills also represent a physical method of sequestration.

Biochar burial

Biochar is charcoal created bypyrolysis of biomass waste. The resulting material is added to a landfill or used as a soil improver to create terra preta. Biogenic carbon is recycled naturally in the carbon cycle. Pyrolysing it to biochar renders the carbon relatively inert so that it remains sequestered in soil. Further, the soil encourages bulking with new organic matter, which gives additional sequestration benefit.

In the soil, the carbon is unavailable for oxidation to CO_2 and consequential atmospheric release. This is one technique advocated by scientist James Lovelock, creator of the Gaia hypothesis. According to Simon Shackley, "people are talking more about something in the range of one to two billion tonnes a year." The mechanisms related to biochar are referred to as bio-energy with carbon storage, BECS.

Ocean storage

River mouths bring large quantities of nutrients and dead material from upriver into the ocean as part of the process that eventually produces fossil fuels. Transporting material such as crop waste out to sea and allowing it to sink exploits this idea to increase carbon storage. International regulations on marine dumping may restrict or prevent use of this technique.

Subterranean injection

Carbon dioxide can be injected into depleted oil and gas reservoirs and other geological features, or can be injected into the deep ocean. The first large-scale CO_2 sequestration project which began in 1996 is called Sleipner, and is located in the North Sea where Norway's Statoil Hydro strips carbon dioxide from natural gas with amine solvents and disposed of this carbon dioxide in a deep saline aquifer. In 2000, a coal-fueled synthetic natural gas plant in Beulah, North Dakota, became the world's first coal-using plant to capture and store carbon dioxide, at the Weyburn-Midale Carbon Dioxide Project.

CO_2 has been used extensively in enhanced crude oil recovery operations in the United States beginning in 1972. There are in excess of 10,000 wells that inject CO_2 in the state of Texas alone. The gas comes in part from anthropogenic sources, but is principally from large naturally occurring geologic formations of CO_2. It is transported to the oil-producing fields through a large network of over 5,000 kilometres of CO_2 pipelines. The use of CO_2 for enhanced oil recovery (EOR) methods in heavy oil reservoirs in the Western Canadian Sedimentary Basin (WCSB) has also

been proposed. However, transport cost remains an important hurdle. An extensive CO_2 pipeline system does not yet exist in the WCSB. Athabasca oil sands mining that produces CO_2 is hundreds of kilometers north of the subsurface heavy crude oil reservoirs that could most benefit from CO_2 injection.

Chemical processes

Developed in the Netherlands, an electro catalysis by a copper complex helps reduce carbon dioxide to oxalic acid; This conversion uses carbon dioxide as a feedstock to generate oxalic acid.

Mineral Carbonation

Carbon, in the form of CO_2 can be removed from the atmosphere by chemical processes, and stored in stable carbonate mineral forms. This process is known as 'carbon sequestration by mineral carbonation' or mineral sequestration. The process involves reacting carbon dioxide with abundantly available metal oxides–either magnesium oxide (MgO) or calcium oxide (CaO)–to form stable carbonates. These reactions are exothermic and occur naturally (e.g., the weathering of rock overgeologic time periods).

$CaO + CO_2 \rightarrow CaCO_3$

$MgO + CO_2 \rightarrow MgCO_3$

Calcium and magnesium are found in nature typically as calcium and magnesium silicates (such as forsterite and serpentinite) and not as binary oxides. For forsterite and serpentine the reactions are:

$Mg_2SiO_4 + 2\ CO_2 = 2\ MgCO_3 + SiO_2$

$Mg_3Si_2O_5(OH)4 + 3\ CO_2 = 3\ MgCO_3 + 2\ SiO_2 + 2\ H_2O$

Theoretically up to 22% of mineral mass is able to form carbonates.These reactions are slightly more favorable at low temperatures. This process occurs naturally over geologic time frames and is responsible for much of the Earth's surface limestone. The reaction rate can be made faster, for example by reacting at higher temperatures and/or pressures, or by pre-treatment, although this method requires additional energy. One experiment suggests this process is reasonably quick (one year) given porous basaltic rocks. CO_2 naturally reacts with peridotite rock in surface exposures of ophiolites, notably in Oman. It has been suggested that this process can be enhanced to carry out natural mineralisation of CO_2.

Industrial use

Traditional cement manufacture releases large amounts of carbon dioxide, but newly developed cement types from Novacem can absorb CO_2 from ambient air during hardening. A similar technique was pioneered by TecEco, which has been producing "EcoCement" since 2002. In Estonia, oil shale ash, generated by power stations could be used as sorbents for CO_2 mineral sequestration. The amount of CO_2 captured averaged 60 to 65% of the carbonaceous CO_2 and 10 to 11% of the total CO_2 emissions.

Chemical scrubbers

Various carbon dioxide scrubbing processes have been proposed to remove CO_2 from the air, usually using a variant of the Kraft process. Carbon dioxide scrubbing variants exist based on potassium carbonate, which can be used to create liquid fuels, or on sodium hydroxide. These notably include artificial trees proposed by Klaus Lackner to remove carbon dioxide from the atmosphere using chemical scrubbers.

Ocean-related

Basalt storage

Carbon dioxide sequestration in basalt involves the injecting of CO_2 into deep-sea formations. The CO_2 first mixes with seawater and then reacts with the basalt, both of which are alkaline-rich elements. This reaction results in the release of Ca^{2+} and Mg^{2+} ions forming stable carbonate minerals. Underwater basalt offers a good alternative to other forms of oceanic carbon storage because it has a number of trapping measures to ensure added protection against leakage. These measures include "geothermal, sediment, gravitational and hydrate formation." Because CO_2 hydrate is denser than CO_2 in seawater, the risk of leakage is minimal. Injecting the CO_2 at depths greater than 2,700 meters (8,900 ft) ensures that the CO_2 has a greater density than seawater, causing it to sink. One possible injection site is Juan de Fuca plate. Researchers at the Lamont-Doherty Earth Observatory found that this plate at the western coast of the United States has a possible storage capacity of 208 gigatons. This could cover the entire current U.S. carbon emissions for over 100 years. This process is undergoing tests as part of the CarbFix project.

Acid neutralization

Carbon dioxide forms carbonic acid when dissolved in water, so ocean acidification is a significant consequence of elevated carbon dioxide levels, and limits the rate at which it can be absorbed into the ocean (the solubility pump). A variety of different bases have been suggested that could neutralize the acid and thus increase CO_2 absorption. For example, adding crushed limestone to oceans enhances the absorption of carbon dioxide. Another approach is to add sodium hydroxide to oceans which is produced by electrolysis of salt water or brine, while eliminating the waste hydrochloric acid by reaction with a volcanic silicate rock such as enstatite, effectively increasing the rate of natural weathering of these rocks to restore ocean pH.

Obstruction for carbon sequestration

Danger of leaks

Carbon dioxide may be stored deep underground. At depth, hydrostatic pressure acts to keep it in a liquid state. Reservoir design faults, rock fissures and tectonic processes may act to release the gas stored into the ocean or atmosphere.

Financial costs

Some argue that the cost of carbon sequestration would actually increase over time. The use of the technology would add an additional 1-5 cents of cost per kilowatt hour, according to estimate made by the Intergovernmental Panel on Climate Change. The financial costs of modern coal technology would nearly double if use of CCS technology were to be implemented.

Energy requirements

The energy requirements of sequestration processes may be significant. It was reported that, sequestration consumed 25 % of the plant's rated 600 megawatt output capacity.

Conclusion

The debate on atmospheric build-up of GHGs and their role in global warming by conference of the parties to the United Nations Framework Convention on Climate Change (UNFCC) in 1997, Kyoto protocol Japan culminated in urging the participating countries to find ways of reducing GHGs concentration in the
atmosphere. Carbon reduction target could be achieved through two major processes:

1. Reducing atmospheric emissions of CO_2 and 2. Creating and/or enhancing carbon sink in the biosphere. Current terrestrial (plant and soil) carbon is estimated at 2000±500Pg, which represents 25% of global carbon stocks. The sink option for CO_2 mitigation is based on the assumption that this figure can be significantly increased if various biomes i.e croplands, forestland, deserts and degraded lands are judiciously managed and/or manipulated. The primary method to increase carbon sequestration in cropland biome has been advocated as high level management whereas for other biomes high level manipulation. Therefore based on the earth's area that is suitable for practice a large amount of carbon could be stored in the terrestrial ecosystems.

MULCHING FOR WEED MANAGEMENT IN ORGANIC VEGETABLE PRODUCTION IN NORTH - EAST REGION

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Mulches contribute to weed management in organic crops by reducing weed seed germination, blocking weed growth, and favoring the crop by conserving soil moisture and sometimes by moderating soil temperature. Organic mulches like straw suppress annual weed seedlings, conserve moisture, and add organic matter as they break down, but they are more labor-intensive to apply. This article examines uses, advantages, and limitations of organic mulching systems for weed control in organic vegetable production.

Introduction

Mulching can reduce weed competition against vegetable crops, and save fuel and labor costs for weed control. Covering the soil surface with suitable mulch which can:

- Reduce weed seed germination.
- Shade and physically hinder emerging weeds.
- Enhance crop growth and competitiveness by conserving soil moisture and sometimes by modifying soil temperature.

Organic mulches such as hay, straw, leaves and legumes are usually applied when the vegetable crop is well established and the soil has warmed to near-optimum temperatures. They are most effective on weeds emerging from seed, and least effective on aggressive perennial weeds emerging from rootstocks, rhizomes, or tubers. Organic mulch applied immediately after a final cultivation often suppresses later-emerging weeds until the crop has passed through its minimum weed-free period. Organic mulches generally lower soil temperatures and conserve soil moisture by slowing evaporation while allowing rainfall to penetrate. Normally, organic mulch is left in the field after harvest and, as it breaks down, it helps build soil organic matter.
Manual application of hay and other organic mulches is labor intensive, and is practical only on a small scale.

Many vegetable farmers apply straw or other organic mulches in alleys between beds, either at planting or after cultivation. In addition to suppressing alley weeds, this system adds organic matter, helps conserve soil moisture and soil quality, and prevents excessive soil heating during summer, thereby realizing many of the benefits of organic and mulch. The organic mulch can also improve fruit quality in pumpkin and other vine crops by preventing fruit-soil contact in alleys.

Weed Seed Germination and Emergence

Light promotes seed germination in many agricultural weeds (Egley, 1996), including common lambsquarters (*Chenopodium album*), hairy galinsoga (*Galinsoga ciliata*), common chickweed (*Stellaria media*), common ragweed (*Ambrosia artemesiifolia*), common purslane (*Portulaca oleracea*), some pigweeds (*Amaranthus* spp.), black nightshade (*Solanum nigrum*), and annual bluegrass (*Poa annua*) (Mohler and DiTommaso, unpublished). Any opaque mulch, such as black plastic or several inches of hay, straw, or leaves, blocks the light

stimulus, thereby reducing seed germination in these weeds after mulch application.

Seeds of an even wider range of common weeds respond to wide daily soil temperature fluctuations, including some that do not respond to light, such as horsenettle (*Solanum carolinense*), common cocklebur (*Xanthium strumarium*), and foxtails (*Setaria* spp.). Many summer annuals, including pigweeds, galinsoga, and purslane, germinate in response to high soil temperatures (85–100°F). Organic mulches and white or reflective plastic films lower soil temperature and dampen daily fluctuations, thereby deterring weed seed germination.

Even with light and temperature stimuli blocked, a percentage of the weed seed population will germinate. However, the mulch intercepts light essential for photosynthesis and physically hinders seedling emergence. Dicot (broadleaf) seedlings are fairly delicate and easily suppressed by this mulch effect. Hay, straw, or cover crop residues at 3–5 tons per acre (2–4 inches, loosely packed) can prevent emergence of small-seeded broadleaf weed seedlings for at least several weeks, whereas a heavier mulch (7–10 tons per acre) may be required to block larger seeded species like common cocklebur or velvetleaf (*Abutilon theophrasti*), and some grasses, whose shoots are protected by a pointed sheath (coleoptile). Perennial weed shoots emerging from rootstocks, tubers, rhizomes, or bulbs can penetrate most organic mulches, and a few weeds, such as nuts edges, can puncture plastic film.

Effects of Mulch on Crop and Weed Growth

In addition to reducing weed seed germination and emergence, mulch can improve the growth and competitiveness of established crops by conserving soil moisture and modifying soil temperatures (Schonbeck and Evanylo, 1998; Swaider et al., 1992). Some organic mulch, such as hay, provides slow-release nutrients, or reduces certain pests by harboring their natural enemies. (Orzolek and Lamont, 2000).

It is important to note that, once a weed manages to emerge through the mulch, or emerges through a planting hole in plastic film, it enjoys the same soil moisture conservation and other mulch benefits as does the established crop. Conversely, any crop seedlings emerging beneath mulch will be suppressed. Thus, it is common practice to spread straw or other organic mulches only after the crop is well established, and immediately after cultivation or manual removal of existing weeds.

Integrating Mulch with Other Weed Management Practices

Mulching cannot alone provide sufficient weed control, and works most effectively in conjunction with other practices. For example, market gardeners often spread hay or straw after cultivating one or more times during crop establishment. Because organic mulches rarely block 100% of weed emergence, they give best results when used in conjunction with good crop rotation and measures to prevent or limit weed propagation.

ARUNACHAL PRADESH: POTENTIAL SOURCE OF RHIZOBACTERIA FOR ENHANCING SEED QUALITY OF MAJOR VEGETABLES AND CITRUS SAPLINGS

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Introduction

Arunachal Pradesh, the land of rising sun is the homeland of some 25 indigenous tribes and sub tribes or groups. The total schedule tribal population is 63.66%. Each tribe and sub tribe has distinctive culture, custom, tradition and dialect of their own. This particular state is unique and fragile with richness in natural resource and biodiversity. Though India is the second largest producer (9.7%) of vegetables (100.5 MT of tomato, 930 MT of banal, 5992 MT of cabbage and 5260 MT of cauliflower) next to China, productivity and quality is poor in remote state like Arunachal Pradesh. About 17.6% of people are below in poverty line and most of them are deprived from balanced food diets and under the clutch of malnutrition. Out of various vegetables, tomato, chilli, cabbage and cauliflower are importantly grown in different parts of Pasigaht and Siang region. Among fruit crops, citrus is the major crop widely grown. Citrus canker incidence varies 14-47% during May to August months and sooty mould incidence 60-100% during August to December every year Vegetables (chilli, brinjal, tomato, cabbage and cauliflower are being cultivated during winter season (Nov-Feb) of every year.

Frequent surveys conducted in the vegetable growing region revealed that some of the seed borne fungal diseases also contribute major yield losses. In tomato, damping off and bacterial wilt are the major diseases under nursery conditions and the incidence recorded upto 80% and 25% respectively. The next problematic disease on tomato is spotted wilt virus (10-80%). In brinjal, mosaic was recorded up to 40% followed by damping off (10-15%). In chilli, cercospora leaf spot and die back diseases are the major diseases (up to 30%). Similarly, in cabbage and cauliflower damping off is problematic at nursery stage and alternaria leaf spot incidence recorded up to 18%. Overall survey results indicated that the bacterial wilt and damping off are major diseases of Solanaceous crops In Pasighat region of Arunachal Pradesh. Therefore any kind of research proposal with discouraging use of agro-chemicals will have great impact in this region in addition to rapid spread of the technologies to the tribal population in this region. There is much scope for the production of organic vegetables in North Eastern states as compared to other parts of the country.

Purification and characterization of PGPR

PGPR strains were isolated from soil sample by using KB *selective* medium. Ten gram of soil sample was taken, and suspended in 100 ml of sterile distilled water and stirred well to get 10^{-1} dilution. One ml was transferred from this to 9 ml of sterile water in a test tube to get 10^{-2} dilutions. Serial dilutions were made by transferring one ml of suspension to subsequent tubes to get dilution of 10^{-6}. One ml of the 10^{-5} soil suspension was transferred to sterile Petri plates containing KB selective medium. The plates were rotated gently, allowed to

solidify and incubated at 22°C temperature for 1-2 days and observed for the development of bacterial colonies. *Pseudomonas fluorescence* colonies are showed fluorescence under UV light. Individual colonies were transferred to KB agar slants with labels. Details of PGPR strains and other data pertaining to isolates are given presented.

Purification and characterization of seed-borne pathogens

Seeds of tomato, chilli, cabbage, and cauliflower are collected from the market, vendors and farmers and tested for the presence of seed borne pathogens by following methods. The pathogen was isolated and preserved in PDA slants at 5°C. The infected portion of plants leaves bearing lesions/spots were collected) and herbarium was prepared for further reference. Infected leaves showing lesion along with healthy portion was removed and then washed in distilled water. The lesions were surface-sterilized with 0.01 % mercuric chloride for 3 min and washed in sterile distilled water thrice then layered onto PDA agar plate. After incubation for 24-48 hr at 22°C $\pm$ 2°C, conidia was collected from conidiophores emerging from the infected tissue and transferred to fresh PDA tube. Mycelia tip or single spore was isolated from the colonies bearing the micro conidiophores and maintained on PDA.

Bio-priming of vegetable seeds with PGPR

Tomato seeds were surface sterilized with 1% sodium hypochlorite and then rinsed in sterile distilled water and dried under shade. The bacterial inoculum (3×10^8cfu mL−1) along with carboxymethylcellulose (100 mg/10ml) was added to this seed (10g) and allowed to imbibe for 12 h. Then, seeds will be dried overnight under sterile conditions after draining off the excess cells. Different methods of priming including osmo-priming were tested and only suitable priming was selected for further studies. The moisture content and the seed quality parameters at different durations of storage were tested by oven method.

Different priming components were amended in liquid and solid medium to evaluate PGPR strains in presence of test pathogens. The growth rate and colonization of PGPR isolates were assessed in different periods of intervals by following the test tube method. In another experiment, the seed-borne fungal and bacterial pathogens were cultured in solid medium. Their compatibility with priming materials was evaluated by poison food technique.

Seed quality assessment

The germination percentage and other quality parameters of primed seeds were evaluated as per the ISTA guidelines. The notified seed-borne pathogens except tomato mosaic virus maintained in their respective medium were inoculated in bio-primed seeds. These parameters have been also studied in presence of test pathogens. Normal seeds available in the markets were used for comparison. Association of PGPR and other microbial populations were assessed. Tomato seeds primed PGPR and were studied for their susceptibility to seed-borne pathogens Primed seeds will be challenge inoculated with these test pathogens having different inoculum levels and the proliferation of seed-borne pathogens were identified by isolation in their respective medium as per the standard procedures for confirmation. The fungal pathogens were tested by blotter method and the bacterial pathogens will be assessed by agar plate method.

Direct sowing on pot

The collected seeds are sown directly on pot to check the seed borne pathogens. Overall results depicted the incidence of *Rhizoctonia solani, Pythium sp and Fusarium sp* with disease index rainging from 4.4 to 8.3 PDI in cabbage. In case of cauliflower, the PDI recorded was 20.2 with *Rhizoctonia solani, Pythium sp and Fusarium sp. In tomato, it was* 8.57 PDI and in chilli, there was no incidence of diseases under pot culture.

Detection of pathogens and PGPR strains in bio-primed seeds

The colonization of seed-borne pathogens and PGPR strains will be detected in bio-primed seeds and their respective seedlings by using histological, immunological and nucleic acid based techniques. Seed and seedlings tissues cut with ultra-thin sections will be and the cell reactions of bio-primed seed of tomato to test pathogens and PGPR will be studied by to root infection by light and fluorescence microscope. Rate of auto-fluorescence, reactions under UV excitation and the ultra structural modifications will be analyzed to correlate with the efficiency of seed priming.

Induction of resistance in seedlings

The bio-primed seeds and seedlings will be assessed for the induction of systemic resistance. The standard procedures used in some of the foliar soil borne pathogens will be followed to study defense reactions. The primed seeds will be challenge inoculated with test pathogens and incubated at different periods of time intervals. Defense responses such as variation in phenol oxidizing enzymes (peroxidase, polyphenol oxidase and phenyl ammonia lyase and accumulation of phenolics) and pathogenesis related proteins will be analyzed by using molecular techniques. These defense responses will also be studied in tomato seedlings from bio-primed seeds challenge inoculated with test pathogens Plant growth-promoting efficacy if PGPR will be was assessed based on the seedling vigour index by the standard roll towel method as per ISTA guidelines and the vigour index will be worked out as per the standard formula.

Green/Net house and field evaluation

The pot culture experiments were carried out under glass house to find out the efficacy of the PGPR priming. The per cent of control of pre and post emergence damping off, root rot or wilt and seedlings blights (early blight) was calculated. In this case, foliar sprays and soil application of PGPR strains prepared in powder formulation in addition seed priming was tested an integrated method of PGPR application. Suitable design of experiment was followed for each treatment. Plant samples have been analyzed for induced systemic resistance as per the standard procedures when there the diseases intensity (PDI) reaches to the category of highly susceptible. The best treatment combinations were evaluated under for conditions. Under field conditions, a set of highly susceptible varieties were used in field experiments. One set of seeds pre-inoculated with seed-borne pathogens and normal seeds from markets were compared under field conditions using suitable design of experiment. The yield and quality of tomato fruits and seeds in addition to suppression of diseases were analyzed and suitable treatment combinations are highlighted herein.

Result

Rhizosphere soil from different crops plants and places were also collected for the isolation of beneficial bacteria. Pure cultures of seed-borne fungal pathogens are under maintenance in respective medium for further studies. A total of 97 isolates of bacteria were isolated and purified from the rhizosphere soil samples from different locations including the existing strains

Screening of PGPR isolates against seed borne pathogens

Chilli die-back (*Colletortrichum capsici*)

The chilli-die back pathogen *Colletortrichum capsici* was isolated from fruit and seed samples collected from various locations. There was variation in *in vitro* control efficacy of the PGPR strains which have been evaluated against this pathogen. Mycelia growth was significantly reduced by the PGPR strain TRB-2 (PEDC 73) followed by CHF-2011 32a (60 PEDC) and CHF-OS-1 (59 PEDC). Though the PGRP strain CfS 1 and CfS 2 did not show much inhibitory effect, inhibition zone formation was comparatively better with these strains. Other strains line 3-b-W1 and WNC also showed moderate efficacy against the test pathogen. However, more than 50 per cent of the strains tested were not effective against chilli die-back pathogen

Identification of suitable riming/coating materials

Initially, to find out suitable priming material compatible with PGPR, isolate CHF-18 was amended with different clay based components such as bentonite, Fuller's earth, guar gum, kaolin and silicon at three different concentrations like 50, 100 and 250 ppm w/w of the seeds were tried. Cauliflower seeds were blended with these components separately and sown in plastic trays filled with pre-sterilized soil mixture. Before sowing, PGPR isolate was blended @ 3 x 10^{-6} cfu per ml. Germination percentage and seedling vigour index were worked out as per the standard procedures of ISTA. Out of these priming components, performance of kaolin was superior at all concentrations (Plate 8). However, rate of germination and vigour index were proportionately reduced with increase in concentrations. Compatibility of bentonite was also better in terms of seeds germination with vigour index and similar trend was recorded in guar gum as well. Therefore, this particular experiment demonstrated the usefulness of kaolin which could be exploited for seed priming with PGPR

Screening of PGPR isolates under pot culture

Bacterial isolates from Pasighat region were primed on cabbage and cauliflower seeds. rimed seeds sown in earthen pots as per ISTA standards. Germination percentage, rate of germination and seedling growth parameters including vigour index were observed periodically. Data presented in table 11 and Plate 13 indicated that PGPR strain 6aW and CHF-53 significantly enhanced the growth being 625 and 605 followed by CHF-43 (379), CHF-OS-1 (424). Interestingly, hydropriming also enhanced vigour index (587) as compared to unprimed seeds. However, germination and rate of germination were rapid and high in PGPR treatment

Seedling priming of vegetable with PGPR strains under field conditions

Filed experiments

Bio-priming was carried out with selective PGPR isolates received from IARI to assess the seed germination and seed borne infection in the nursery. Isolate CHF 2011 32a have shown 28.00 per cent increase over control in germination followed by CHF 2011 43 (Table 1). The above germinated seedlings are planted in main field in RBD design. The experiments are in progress.

Table 1. Biopriming and germination percentage of target vegetable crops

	No. of seeds germinated					Per cent increase over control
PGPR strains	**Tomato**	**Chilli**	**Cabbage**	**Cauliflower**	**Brinjal**	
CHF 2011 32a	68	81	59	69	71	28.0
TRB-2	69	78	59	63	65	22.9
OS-1	69	68	52	61	68	17.0
CHF 2011 43	59	71	59	79	73	25.4
Kings B Broth	49	68	64	70	70	18.1
Water (control)	61	67	59	81	61	0

Conclusion

Rhizosphere soils were collected from root zone of 40 different places and bacterial strains were isolated. A set of cultures were sent to IARI and University of Mysore for collaborative works. Assessment of diseases intensity in target crops indicated the *Alternaria* leaf spot (5-15%) and bacterial wilts (1%) in tomato. In chilli,

cercospora leaf spot (1%), Colletotrichum leaf spot (up to 15%), die back (5-10%), bacterial leaf spot (30%) and fruit rot (10%) were observed. In citrus, bacterial canker ranging from 5-15% was recorded. Seeds of tomato, chilli, cabbage, and cauliflower are collected from the market, vendors and farmers. Seed-borne pathogens viz., *Alternaria brasicicola, Rhizoctonia solani* and *Alternaria alternata* were isolated by follwing differnt methods of isolation such as blotter method, paper roll towel method and Agar plate method. Seeds collected from different sources were directly on pot to check the seed borne pathogens. Overall results depicted the incidence of *Rhizoctonia solani, Pythium sp and Fusarium sp* with disease index rainging from 4.4 to 8.3 PDI in cabbage. In case of cauliflower, the PDI recorded was 20.2 with *Rhizoctonia solani, Pythium sp and Fusarium sp. In tomato, it was* 8.57 PDI and in chilli, there was no incidence of diseases under pot culture. Kaoline is the best priming material and recommended for the seed priming @50ppm. Isolate CHF 2011 32a is recommended for biopriming of vegetable seeds @0/5%.

CONSERVATION CONCERNS AND SUSTAINABLE UTILIZATION OF ENDANGERED TEMPERATE MEDICINAL PLANTS

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Introduction

The place of non-wood forest products, especially medicinal plants, in society is changing. As the common property resource, these products are central to the lives of many people for domestic use. The agriculture revolution especially in the last sixty years has however, sidelined these forest products labeling them of 'minor' importance. However, considering the International trade (~ US $ 60 billion annually), their use in disease amelioration, extent of usage in home/traditional/allopathic remedies and the current thinking of going back to the nature, there is a paradigm shift. Now we are more vigorously discussing about their sustainable utilization and the steps required for bringing about their transition from common property resource to crop.

In India, of the 960 traded medicinal plant species, 178 species are consumed in volumes exceeding 100 MT per year, with their consolidated consumption accounting for about 80% of the total industrial demand of all botanicals in the country. Analysis of these 178 species by their major sources of supply reveals that 21 species (12%) are obtained from temperate forests (table 1), 70 species (40%) from tropical forests, 36 species (20%) largely or wholly from cultivations/plantations, 46 species (25%) largely from road sides and other degraded land use elements and the remaining 5 species (3%) are imported from other countries (Ved and Goraya, 2007).

Table1. Medicinal Plant Species in High Trade sourced from Temperate Forests (Ved and Goraya, 2007)

S. No	Species	S. No	Species	S. No	Species
1	*Abies spectabilis*	8	*Ephedra gerardiana*	15	*Pistacia integerrima*
2	*Aconitum ferox*	9	*Juniperus communis*	16	*Rheum australe*
3	*Aconitum heterophyllum*	10	*Jurinea macrocephala*	17	*Rhododendron anthopogon*
4	*Berberis aristata*	11	*Nardostachys grandiflora*	18	*Swertia chirayita*
5	*Bergenia ciliata*	12	*Onosma hispidum*	19	*Taxus wallichiana*
6	*Cedrus deodara*	13	*Parmelia perlata*	20	*Valeriana jatamansi*
7	*Cinnamomum tamala*	14	*Picrorhiza kurroa*	21	*Viola pilosa*

CONCERN & CHALLENGES OF TEMPERATE MEDICINAL PLANTS:

The Indian himalayan region has been recognized as one of the best habitats for medicinal plants. It is the home of 1748 medicinal plants, of which 25.8% species are native to the Himalayan region, 5.66% species native to the Himalayan region and neighbouring biogeographic domains, together: 3.55% species endemic and 11.9% species near endemic to the IHR. The tropical and sub-tropical zones ie <1800m has maximum diversity of medicinal plants that decreases with the increasing altitude. Sikkim and North Bengal (Darjeeling distr.) (707 species) Uttarakhand (701 species) and Himachal Pradesh (643) respectively support the maximum medicinal plant diversity in the IHR (Samant et al 1998, 2007). Medicinal plants form an integral part of the daily activity of most of the hill communities and inhabitants are known to collect these plants from natural habitats mainly for their own use or for trade (Samant et al 1998, 2007). Majority of these are used in Ayurvedic, Unani and other Traditional systems of Medicines. The Tibetan System of Medicine is exclusively dependant on medicinal plants of the Himalayan region.

Of the total medicinal plants traded in India, about 90% are wild collected in which 70% collections involve destructive harvesting (Ved et al 2003; Natesh, 2000). The ruthless in situ harvesting, high grazing pressure, land use changes, lack of cultivation and other pressures on the commercially viable medicinal plants have caused rapid depletion of their populations in the wild. If all these factors continue to operate and necessary steps are not taken, these species might become extinct. The estimates indicate that between 4000 and 10000 medicinal plants might now be endangered at global level (Edwards, 2004). The high incidence of threat is due to destructive mode of harvesting accompanied by the restricted distribution of the medicinal plants (Dhar et al 2000). Due to above reasons, about 120 species of medicinal. plants of IHR have been categorized as Critically Endangered, Endangered, Vulnerable, Near Threatened and Data Deficient as per IUCN parameters(Samant *et al* 1998, 2007; Ved *et al* 2003). The options available to us for their conservation and sustainable use are i) conservation by cultivation, ii) protecting wild habitat and iii) regulated extractions

Conservation by cultivation

Cultivation of high priority medicinal plant species outside the forest areas is considered as one of the ways to off-load some of the pressure from the fast depleting wild resources and to provide good alternative cropping options to the farming community. Cultivation of medicinal plants in the temperate region has failed to pick up due to non-availability of certified planting material, information gaps on agro-techniques, exploitative market mechanisms and non-clarity related to the regulatory mechanisms. The work on agrotechniques on many high priority species has been carried out by many research institutes, however, most of this work is based on limited trials, is scattered and is in scientific language. Such trials for many priority species are yet to be undertaken. Some of the important medicinal plant species suitable for cultivation are listed in Table 2.

Table 2: Medicinal plant species suitable for cultivation in temperate regions

S. No	Species	S. No	Species
1	*Aconitum heterophyllum*	10	*Crocus sativus*
2	*Aconitum ferox / Aconitum balfouri*	11	*Saussurea costus*
3	*Hedychium spicatum*	12	*Picrorhiza kurroa*

4	*Swertia chirayita*	13	*Valeriana jatamansi*
5	*Bunium persicum*	14	*Boerhaavia diffusa*
6	*Berberis aristata*	15	*Dactylozhiza hategri*
7	*Ferula foetida*	16	*Hippophae rhamnoides*
8	*Nardostachys jatamansi*	17	*Asparagus racemosus*
9	*Podophyllum hexandrum*	18	*Taxus wallichii*

Many Himalayan medicinal plant species command a very high price in trade. Attempts to domesticate some of these species have already been made. However, suitability of the germplasm sourced from the wild for different zones has not been assessed on a concerted scale. Selection and breeding of species for cultivation suitability in different areas and for high alkaloid contents is considered an important step in the direction of making cultivation of such species remunerative. The strategic planning, for the success in the breeding of medicinal and aromatic plants, should be species specific since the breeding behavior of each species is very complex and highly variable (Raina et al., 2004). Every plant has great deal of variability in the mode of reproduction. Apart from these, there is wide variety of genetic and environmental factors (male sterility, self-sterility, self incompatibility etc.) which influence the breeding structure. In addition, certain changes due to chance of historical events further influence the population. (Purohit and Vyas, 2004). Genetic improvement in medicinal and aromatic plants should ensure the development of following type of species:

- Synchronous flowering and maturity
- Resistant to abiotic stress (drought, temperature, salinity etc.)
- Resistant to biotic stress (disease and insect)
- Higher biomass and/or active content yield
- Short gestation period
- Less dependent on inorganic fertilization for higher productivity.

Although significant success has been achieved in some important medicinal species in developing better strains, yet a perusal of literature reveals that most of the breeding work undertaken in them is restricted to selection breeding only. On the basis of literature survey conducted by Raina et al. (2004), 63.5% of the varieties developed are through selections only, with 22.35% varieties developed through mutations, 9.41% through hybridization and 4.70% through polyploidy. Considering the advances made in vegetables, cereal and other crops, by hybridization, such effort has been minimal in medicinal and aromatic plants. The reasons are not far off to understand. From time immemorial upto recent times, herbs have been sourced from wilds only with scant attention given to their domestication and cultivation. It is only in the recent times that significant attention is being given to their cultivation. This calls for meaningful breeding studies for developing elite strains of important medicinal and aromatic plants in future. The first step should be to understand the reproductive biology of the species under study (Kaufman, 1972). This is the most important and crucial stage of the plant life and may be highly susceptible to environmental stresses (Larcher, 2002; Leopold and Kriedemann, 1975). The pollination behavior (self or cross) of plant plays significant role for the application of appropriate breeding system. Similarly, knowledge regarding the flowering pattern is equally important like synchronous versus

staggered flowering, dichogamous versus monogamous flowers, cleistogamy versus chasmogamy, herkogamous versus normal flowers etc which to a large extent determine the breeding system prevalent (Procter *et al.* 1996). Concerted efforts made by the authors in the last several years have to a large extant determined the breeding system of some of the commercially important temperate/sub temperate medicinal plants (Table 3).

These studies, conducted here in about two decades, have been helpful in i) significantly increasing seed yield in *Gloriosa superba*, ii) seed production in *Stevia rabaudiana*, iii) pure line maintenance in *Hypericum perforatum* and *Valeriana jatamansi* iv) understanding the use of gynodioecism in *Valeriana jatamansi* for hybrid development v) selection of a high

Table 3 : Breeding system attributes of some medicinal plants.

Species	Breeding System	Diploid chromo. no.	Ploidy status	Reproduction	Flower
Gloriosa superba	Autogamy Xenogamy; Gnetenogamy	22	Diploid	Vegetative; Seeds	Bisexual; Hercogamous
Picrorhiza kurroa	Xenogamy	34	Genomic allotetraploid	Vegetative; Seeds	Bisexual
Gentiana kurroo	Xenogamy	26	Genomic allotetraploid	Vegetative; Seeds	Bisexual
Swertia chirayita	Autogamy Xenogamy; Gnetenogamy	26	Genomic allotetraploid	Seeds only	Bisexual
Hypericum perforatum	Autogamy	32	Genomic allotetraploid	Seeds only	Bisexual
Valeriana jatamansi	Autogamy Xenogamy; Gnetenogamy	32	Genomic allotetraploid	Vegetative; Seeds	Pistillate; Bisexual
Stevia rabaudiana	Xenogamy; Sporophytic, self-incompatible	22	Diploid	Vegetative; Seeds	Bisexual
Podophyllum hexandrum	Autogamy Xenogamy;	12	Diploid	Vegetative; Seeds	Bisexual; Solitary on a plant
Nardostachys grandiflora	Xenogamy	78	Hexaploid	Vegetative; Seeds	Bisexual

valepotriate yielding strain in *Valeriana jatamansi* and vii) selection of three different strains in *Hypericum perforatum* with varying biomass & hypericin yield.

Protecting wild habitats

Conservation by field cultivation cannot be the only option because of various reasons. Cost of domestication and bringing new species into cultivation is enormous and time required is generally many years as the environment conditions on the farm will undoubtedly differ from those in nature. That would require suitable adaptive methods to be taken like development of suitable strains as well as specific agro-techniques. Further, as the commercial demand is horizontal; every species may not be amenable for open cultivation but needs increased productivity in their natural habitat regions. Only high value high volume species are amenable for cultivation eg. Isabgol, Senna, Ashwagandha etc. In addition, however, attractive the new crop appears; it will have to find a place in existing or modified cropping systems. It must be shown to be sufficiently commercially attractive.

There is thus need about taking risks for the domestication of a new species and the expansion of medicinal species in the farming environment. There are few people or organizations prepared to take risks of this nature and even fewer who also have the resources required to make the necessary investment.

So, what therefore, are the alternatives and additional options?

Where the driving force is better land use or better exploitation of under utilized environmental resources, bearing in mind the need for conservation; reduction or prevention of environmental degradation or the reversal of degradation process and the potential value of medicinal species in times of need, Governments should take the lead. Using the forest floor, which are under the control of state forest departments, for medicinal plants' sustainable cultivation can be an effective strategy. These areas are optimally suited for following reasons:

- These regions offer the most natural habitat of specific medicinal plants.
- An environment broadly similar to the natural one regarding rainfall, temperature, day length and soil conditions.
- Minimal problems encountered with regard to establishment, growth and yield.
- No major inputs required and the produce can be truly organic.
- Many species are only required in small quantities that do not make cultivation economically viable.
- Successful cultivation techniques do not exist eg. for slow-growing, habitat specific taxa.
- Saves on land costs.
- It is often believed that wild harvests are more powerful.
- It provides access to cash income without prior investment.

Suggested approach

Cultivation of medicinal plants should be sub-divided into two heads viz. Cultivation for profit and Cultivation for sustainable harvest. While the former focuses on cash medicinal crops like Isabgol, Mulethi, Chirata, Atish, Rose, Jangli gainda etc amenable for field cultivation, it is the latter kind of cultivation that needs special attention. As the demand is horizontal, every species may not be amenable for open cultivation but needs increased productivity in their natural habitat regions

Step-I

- Most threatened and high value medicinal plants be identified for focused attention. The prioritized species for temperate/subtemperate regions should invariably include *Picrorhiza kurroa,Gentiana kurroo,Valeriana jatamansi, Podophyllum hexandrum, Aconitum heterophyllum,Swertia chirayita, Gloriosa superba, Rauvolfia serpentina, Mucuna* sp. etc.

Step-II

- Identify the forest niches suitable for their re-incorporation, strategic re-planting and multiplication.

- Initially a small area (say approximately 10 ha) in a forest area can be selected and enclosed. This area should be seeded by appropriate propagules of the selected species with a view to increase productivity. Superior genotypes, if available should be incorporated.

Step-III

These selected areas should be enclosed for outside interference for a period not less than two growing cycles of the selected species so that the introduced plants are able to produce, set and disperse seed. Once that is achieved, later on the normal natural regeneration process shall take over and consequently the stock of the species shall spread beyond the restricted areas

Step-IV

To begin with, no extraction activity should be permitted for the period till a stage is reached when the stocks can be labelled as ABUNDANT.

Some potential medicinal plants for reincorporating in forest ecosystems

Picrorhiza kurroa: The species is useful in treating abdominal pain, jaundice, fever, liver and stomach disorders. The species is threatened and has very high demand. It is natural in sub-alpine to alpine zone and demand supply shortfall in 2004-05 was about 144.2 tonnes. The species can be planted as ground crop on forest floor as it produces better in forest litter. Propagation done through stolen cuttings dipped in water for 24 hrs. and planted at 45x30 cm spacing is most economical method of cultivation(Mehra et al 2007a&b).

Gentiana kurroo: With a North-west temperate distribution, the species is valued as bitter tonic, antiperiodic, expectorant, astringent, stomachic, anthelmintic, blood purifier. Excessive extraction coupled with nil cultivation has depleted its resources and its stocks are difficult to locate in nature. It is very slow growing, difficult to establish cross pollinated species (Raina et al 2003). Projected shortfall in 2004-05 was of the order of 501.7 tonnes. It Can be reintroduced on hill slopes between 1500-3000 m altitude. Seedlings raised in polybags for about one year and then can be planted in small pits along suitable sites/slopes at a distance of 30x30 cm.

***Valeriana jatamansi* :** Source of valepotraites' and essential oil, rhizome and roots are used to relieve hysteria, cough and as stimulant and tonic. Has depressant action on central nervous system and is used in hypochondriasis, nervous unrest, emotional troubles, epilepsy etc. The species is widely distributed in temperate regions under deodar and oak forests but natural productivity is low and extensively wild harvested. The species tolerates moderate shade and is

suitable for sloppy terrain. The projected supply shortfall in 2004-05 was about 144.5 tonnes. Nursery raised seedlings can be introduced in suitable forest niches during rainy season at a spacing of 30x45 cm ideal and better genotypes need to be incorporated for higher productivity. Two years old plantation gives commercial harvest. (Raina and Srivastava 1992: Gupta *et al* 2004)

Gloriosa superba: Colchicine present in its seeds (~0.7%) and roots (~ 0.2%) is used for treating gout and for inducing polyploidy in plants. Naturally occurs in tropical and sub-tropical regions but is characterized by low seed set in nature. Seed harvest avoids destructive harvest. Due to the projected shortfall of 51.4 tonnes in 2004-05 this species has been shortlisted by NMPB for intensive cultivation. The species is suitable for incorporation in tropical and sub-tropical forest ecosystem hilly regions. It can be raised both by seed as well as tubers. Seed raised tubers should be initially raised in nursery beds and maintained as such for one year. Such small tubers then should be transplanted in field at a spacing of 45x30 cm. As the plants of this species require support appropriate niches that can provide support to the growing vines need to be selected. Controlled pollination technique developed here ensures high seed yield (~ 400 kg/ha) in one season. (Gupta and Raina 2001; Raina and Gupta 1999; Mehra *et al* 2008)

Aconitum heterophyllum : Tubers of this species are used as anti-inflammatory, analgesic and febrifuge. The species is highly endangered and very low population density is encountered in nature and the projected shortfall in 2004-05 was 255.7 tonnes. It can be restocked in its natural distribution regions by planting seed raised tubers (one year old). Seed should be sown in November-December in nursery beds and allowed to remain as such for one growing season. One-year-old tubers then can be transplanted in forest floors at a spacing of 30x30 cm. This would ensure high establishment rate and productivity.

Hypericum perforatum : Commonly occurs in orchard floors in sub-temperate and temperate regions and is much valued for its anti depressant action. It is one of the major herbal resources of USA, Europe etc. In India the projected shortfall was about 36.3 tonnes in 2004-05. It can be propagated both by seeds as well as vegetatively but the former method is easier. Seeds should be sown in nursery beds in November-December or February-March and seedlings be transplanted when about 6 cm tall at a spacing of 30x45 cm. Being a low return crop, forest floor especially orchard floor in temperate regions is the most suitable area for its regeneration, multiplication and cultivation activity (Raina *et al* 2005; Singh *et al* 2008).

***Podophyllum hexandrum*:** The rhizomes of this species are important source of drug (podophyllotoxin & its derivatives) for treating various types of cancers. It is native to Himalayas between 2000-3600 m., commonly found in sub alpine and alpine forest region under Kharsu oak, birch, fir etc. Initial propagation can be done under nursery conditions. Seeds sown in November-December result in sporadic emergence of seedlings, which develop into small rhizomes. These seed raised rhizomes can be transplanted on forest floor maintaining a spacing of 45x60 cm.The establishment rate of such rhizomes is high. Rhizome cuttings with at least one sprouting bud can also be used to propagate this species.

***Swertia chirayita*:** A critically endangered species and highly prized in the Indian system of medicine, is valued as a bitter tonic, blood purifier, hepatic stimulant etc. It can be

propagated by seeds. Seedling growth is slow hence 4-6 leaved seedlings are pricked into polybags for further growth. After about 8-10 months in polybags, the seedlings are field transplanted at a spacing of 30 X 45cm. In second or third year, plants develop aerial shoots which bear flowers. After seed set the entire plant dies and the whole plant is harvested. Periodically some radicle leaves should also be harvested

***Mucuna* sp.** Seeds of this species are source of L-DOPA useful in treating Parkinson disease and the projected shortfall in 2004-05 was about 670.8 tonnes. Distributed in tropical and subtropical regions, plants of this species are weak stemmed & need support. Hence growing in association with trees is suitable. White seeded strain with non-stinging pods is suitable for cultivation. It can be raised through seeds sown alongside trees in small pits. Growing vine climbs trees and bears pods. It doesn't need much care and in turn fertilizes soil due to nitrogen fixing ability. Seedlings raised in polybags and transplanted alongside trees ensures higher success rate. Single vine produces approximately 700 g to one kg dry seed.

Regulated extraction

The principle of harvest from the wild being followed as at present seems to be making wild collections 'somehow', 'anyhow' and 'before others'. The indiscriminate harvesting practice has led many a high value medicinal plant species to the risk of extinction. In recent times, *Trillidium govanianum* commonly known as "*Nag Chhatri*" has got the attention of policy makers of the Himachal Pradesh because of its large scale illegal smuggling during past 2-3 years from the high ranges of Kinnaur, Shimla, Chamba and Kullu districts of Himachal Pradesh wherefrom about more than 80 quintal of its roots have been seized by the government agencies. The species is reported to have aphrodisiac/tonic properties and is facing threat of extinction if its illegal harvesting continues. For its better utilization, Himachal Pradesh government has decided to take help of relevant experts to formulate its export policy (Anonymous, 2013).

Whereas the need for harvest from the wild, being linked to livelihood security of rural populations is recognized, the wild populations can still be conserved by i) developing and disseminating sustainable harvest methods through field agencies and research institutes, ii) by effectively regulating the wild harvests of high risk species through formulating comprehensive participatory resource management plans, harvesting guidelines and enabling legislation. With the ownership of minor forest produce now endowed to the Panchayats especially in Himachal Pradesh, these have to be oriented to take greater responsibility towards ensuring that the harvesting of medicinal plants is carried out in sustainable manner and unscruplous collections and trade is kept under check. Table 4 summarizes some information about the harvesting schedule of some important medicinal plants developed/fine tuned by the authors here. This information can be used for optimizing wild harvests, if need be, in accordance to biodiversity concerns.

Table 4: Harvesting schedule of some medicinal plants based upon active content.

S.No	Species	Plant part to be harvested	Harvesting Stage	%age Content
1	*Hypericum perforatum*	1/3rd of the plant	Full flowering	0.075% Hypericin

		from top		
2	*Swertia chirayita*	Whole Plant	Full flowering	0.227% amarogentin; 0.071% amaroswerin
3	*Solanum laciniatum*	• Berries • Leaves	Dark Green Coloured Mature	≥4.0% solasodine ~1.0% solasodine
4.	*Andrographis paniculata*	Aerial biomass	Flowering Stage	~2.0% andrographolide
5.	*Valeriana jatamansi*	• Rhizome • Roots	>Two years old in autumn season >Two years old in autumn season	~4% Valepotriates; ~4% Valepotriates ~2.0% E. Oil
6.	*Gloriosa superba*	• Seeds • Tubers	Ripened Dormant stage	0.70% colchicine 0.25% colchicine
7.	• *Mucuna sp (white seeded)* • *Mucuna pruriens (black seeded)*	Seeds	Ripened	• 5.5% L-Dopa • 6.0-7.0% L-Dopa
8.	*Picrorhiza kurroa*	Rootstock	> 3 yr old in autumn season	Picroside-I: 0.26- 3.7 % (rhizomes) & 0.10 to 1.12 % (roots). Picroside- II: 2.60 to 7.08 % (rhizomes) and 2.34 to 6.71 % (roots)
9.	*Podophyllum hexandrum*	Rhizome	Three leaved plants in autumn season	4.3% podophyllotoxin

Conclusion

The conclusion is a challenge. Our approach to conserve biodiversity for sustainable development should be targeted at different levels, from improving living standards to changing the attitude of people. MAPs of hilly regions have so far lagged behind in commercialization efforts. Special emphasis should be laid on *insitu* cultivation using the forest floor. Herbal culture should form an integral part of any forestry operations. Since forests are govt. controlled and about 2/3rd of the geographical area of hilly states has to be under forests, there is urgent need of modifying the forestry laws to integrate herbal cultivation. From the concept of *In-situ* conservation we need to move to In-*situ* cultivation. Medicinal plants having well commercial /business potential should be prioritized at state/regional/national level. In order to avoid duplication, these should be allotted to specific institutions/organizations (having proven expertise) for developing/providing leadership in research and development issues. Efforts in Human Resource development, in broad areas of MAPs, needs to be strengthened to produce trained personal to take care from cultivation to post harvesting stages. Organizations/Universities need to be suitably supported and in turn such institutions should develop specialty course curriculum packages keeping in view the industry/market demand.

FLORICULTURE IN NORTH EASTERN STATES OF INDIA: PROSPECTS AND CHALLENGES

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Introduction

The north eastern region of India include eight states i.e. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. This region lies between 21°57' and 29°28' north latitude and 89°40' to 97°50' east longitude. This region has 2.55 lakh km^2 which is about 8% of the total geographical area of the country. The physiographically this region is divided into three divisions namely Meghalaya plateau, the northeastern hills and the Brahmaputra valley. The NE hills alone accounts for 65% of the total land area whereas the Brahmaputra valley and the Meghalaya Plateau constitute 22% and 13% of the area respectively. More than 64 percent of total area in north-eastern states is covered by thick and deciduous forests. Dr. M. S. Swaminathan, renowned Indian scientist described the region as cultural and genetic paradise and granary of megadiversity in terms flora and fauna. Despite of richness natural resources and climatic diversity, the economic development in north-eastern states of India is poorest from the rest of country. The change in climate, decreasing crop productivity, poverty and unemployment are creating pressure on natural resources. In result, the natural resources in the region are jeopardising very fast. Floriculture is an very important sector of horticulture industry which is labour intensive and gives highest per unit profitability. It also creates job opportunities ranging from cultivation to post harvest handling, marketing, value addition and sale of products by retailers. Among floriculture crops, high value and low volume crops hold good promise for these areas. The orchids are one of them. The region has abundant orchid genetic diversity resource and nearly 900 species of orchids are concentrated in this region. Orchids in this region can be grown on unused/wastelands since these are grown in containers. A few success stories of commercialization of orchids have already been written in states like Sikkim, Arunachal Pradesh, Tripura, Assam and Meghalaya. However, the concerted efforts are required in planning, promotion and mitigating the problems of orchid growers for sustainable development of orchid industry in the region.

Indian floriculture –past present and future

India has a long tradition of growing ornamental plants. The history of gardening in India is as old as civilization. The evidence found in the excavation of Indus and Mohan jo daro civilization (2400 B.C. and 1750 B.C.) indicates the importance of ornamental plants. Aryans (1600 B.C.) called India as Aryavrta meaning the country of Lotus and abundant sunshine. They saw the lakes were studded with lotus flowers and there were wide-open spaces. They appreciated the beauty of ornamental plants, mountains, lakes and flowers. The association of Lord Buddha with the trees is well known. He was born under the Ashoka (*Saraca indica*) tree, attained his enlightenment under Pipal (*Ficus religiosa*), spread his new teachings under Banyan (*Ficus benghalenlesis*) and Mango (*Mangifera indica*)tree and breadth last in Sal (*Shorea robusta*) grove. The Aryan Epics Ramayana and Mahabharata (500 B.C.) mention trees and creepers like

Anthocephalus cadamba, Ficus bengalensis, F. religiosa, Saraca indica, Michelia champaca, Terminalia arjuna, Butea monosperma etc. The great Emperor Ashoka (264-227 BC) adopted arboriculture as one of his state policies. The sculptures of Kushan period (70-200 AD) have been inscribed with *Saraca indica, Anthocephalus cadamba,* and *Ixora parviflora*. The writings of Sudraka (100 BC), Asvaghosha, and Kalidasa have mentioned several trees and climbers. Vatsayana (300-400 AD) mentioned four types of gardens, Promodyan, Udyan, Brikshvatika and Nandavana in his book Kamsutra. Feroz Shah Tughlaq (1351-1388 AD) developed 1300 garden in Delhi. The mughals had great love for flowers and gardens they established several gardens in their capitals and other places as well. The Nawabs and Rajputs also established several garden during their rule. The Sikandar Bagh developed by Nawab Wajid Ali (1847-1856) Shah is now National Botanical Research Institute. During the British rule in India there were many activities related gardening by British and Indian kings. King Hyder Ali established most famous Lal Bag Garden at Bangalore. In North India, Maharaja Ranjit Singh made the garden at Amritsar. The British introduced annual flowers that were not known in gardening of India. They also introduced several trees and flowering plants in India. They established Royal Agri-Horticulture Societies and Botanical Gardens in India. Among them Royal Agri-Horticultural Society Garden, Calcutta, Lloyd Botanical Garden, Darjeeling, Botanical Garden, Saharanpur, National Botanical Garden, Lucknow, Botanical Garden, Ootacmund etc.

Floriculture gained the status of farming much late, and the recognition as an industry is only after the liberalization of economy in 1991-92 and modified EXIM policies of 1995-96 and 1999-2002. After liberalization, the Government of India identified floriculture industry as a sunrise industry and accorded 100% export-oriented status. Opening of the world market has encouraged Indian entrepreneurs for establishing world class export oriented floriculture units. The boost in export oriented floriculture in India was triggered by the access to contemporary exotic genetic materials along with world class technology. The Indian floriculture industry is mostly characterized by sale of loose flowers (rose, chrysanthemum, jasmine, marigold, crossandra, tuberose etc.) cut flowers (Rose, Carnation, Chrysanthemum, Gladiolus, Gerbera, Orchids, Anthuriums, Liliums, Alstroemeria, Tulip etc.), Cut greens and nursery materials (seeds of annuals, propagating materials of foliage and landscaping plants). In the recent year (2013-14) the country has produced 543,000 MT of cut flowers and 1754000MT of loose flowers. Traditional loose flowers form a major section of the internal flower market. In current years India has occupied the top position in terms of area under floriculture crops but modern cultivation under greenhouses and export from the country is still in its nascent stage. According to a study conducted by ASSOCHAM, The Associated Chamber of Commerce and Industry of India Indian floriculture sector values at Rs. 3,700 crore (US $ 68.6million), expanding at a compounded annual growth rate (CAGR) of about 30 per cent. At this growth rate, the industry is likely to cross the Rs. 8,000 crore (US $ 148.4 million) mark by 2015. The study further says that Floriculture sector in India has meagre share (0.61%) in the global floriculture industry which is likely to reach 0.89% by 2015. Floriculture as an industry has a tremendous potential in our country for generation of employment and earning of valuable foreign exchange, through achieving consistent growth in production and export. The hills of India has greater potential for exploiting this increasing demand of ornamental crops with the virtue of its wide climatic variation, unique niche areas and traditional resources management practices.

In order to harness the opportunities and overcoming the hurdles of setting up

floriculture in the north east India one has to understand the composition of the silvi-horti-pastural farming system of the hills and integrate modern technologies and infrastructure in the existing frame work. To achieve this, specialized policies are required for developing floriculture and horticulture in the hills. The implementation Horticulture Mission for the North East and Himalayan States (HMNEH) as a part of the Mission for Integrated Development of Horticulture (MIDH) scheme is such an initiative by the Government of India. The Mission looks forward in developing technologies suitable for the hilly terrain and also addresses the entire spectrum of horticulture from production to consumption through forward and backward linkages. The Mission covers all the North Eastern States including Sikkim and three Himalayan states of Himachal Pradesh, Uttarakhand and Jammu and Kashmir and has given a fillip in development of floriculture through area expansion, supply of planting material and financial support to the growers. Emphasis should also be given to conservation of the rich genetic wealth and sustainable exploitation of the same in developing improved cultivars and introduction of new species in the world of ornamentals. These hills also offer several niche commodities and there is ample scope to reap this uncommon opportunities. But the linkage between the market and the producers is missing. Hence, to develop floriculture industry in the north east India devolution of appropriate strategies is required.

Floriculture research and development in India

There are 10 ICAR institutes (with 24 regional stations) 6 Directorates and 7 National Research Centres (on major crops) engaged in horticulture research in the country. Several of these institutes carry out research in floriculture. Area specific, multi-disciplinary research is also being conducted under All India Co-ordinated Research Projects each on Floriculture located at various research institutes and State Agricultural Universities. Research and education on floriculture is also undertaken in multi-disciplinary institutes, departments of horticulture in 35 Agricultural Universities, two Deemed Universities and 3 Universities of Horticulture and Forestry. Horticulture Division of ICAR plans and promotes major research programs in relation to horticultural crops including floriculture. The main focus of program is to safeguard the genetic resources, develop suitable cultivar of different crops, augment the production and protection technologies and also technologies for enhanced shelf-life. The systematic research in floriculture began with the establishment All India Coordinated Research Project (AICRP) on Floriculture during 1970-71. AICRP on floriculture was an effort to link ICAR Institutes with the State Agricultural Universities (SAU's) to carry out nation-wide interdisciplinary research in floriculture crops. The AICRP on Floriculture is mandated to coordinate research on genetic resource management and utilization, standardization of production technology, resource utilization such as efficient use of water, repository of data bank, etc. Currently, AICRP on Floriculture has 22 coordinated centres (16 Budgetary, four institutional and two voluntary) working on 13 ornamental crops. Realizing the importance of the floriculture sector, the AICRP on floriculture has been upgraded to a full-fledged Directorate of Floriculture to cater the research needs of the sector. The floriculture research in the country now is carried out at Directorate of Floriculture Research, Pune, Maharashtra and National Research Centre for Orchids, Sikkim. Area specific, multi-disciplinary research is also being conducted under All India Co-ordinated Research Projects on Floriculture at centres located in various agroclimatic conditions with major work on orchids at NRC Orchids, IIHR, Bangalore, Kerala Agricultural University, Thrissur, TNAU, Coimbatore. Several other institutions engaged in various aspects of research development of orchids in the country are Orchid Laboratory, Chandigarh, IHBT,

Palampur, Botanical Survey of India, SFRI, Arunachal Pradesh, Departments of Botany in several universities, TBGRI, Trivandrum.

Floriculture as Industry – the global scenario

Floriculture is established as a dynamic and fast-growing global industry, today. In 2013, the global exports of cut flowers and ornamental plants accounted for US$ 20.6 billion (World Floriculture Map 2015). Floriculture gained the status of industry only in 1800s when large-scale plantings were set up in the United Kingdom. Presently, more than 140 countries are involved in the flower business with a total area of 3, 05,105 ha under production (Current Status of Floriculture, www. farmrest.com). Europe has always remained the centre of floral industry producing and consuming nearly half of World's cut flower production. The Netherlands is the dominant player in world flower trade with 52% share (2015). The other European flower producing countries are the Germany, Italy, UK, Spain and France. In recent years, however, there is a paradigm shift from the conventional production areas to the other parts of the world endowed with more suitable environment. Now, entrepreneurs are more interested in investing in developing countries because of the huge cost of production in the traditional European countries, where considerable amount is spent on energy cost for heating of greenhouses and labour, and stringent environmental consciousness. On the contrary, the tropical developing countries have more congenial natural condition, cheap labor and lax environmental laws. This is the reason behind the speedy growth of flower industry in the Latin American, African and Asian countries like Columbia, Kenya, Israel, Ecuador, Ethiopia, Brazil, South Africa, Australia, Thailand and Malaysia. India is sure to reap the benefit of this shifting trend with its climatic and other advantages.

Floriculture as Industry – national scenario

Area and production of flowers under both green house and open field cultivation have shown increasing trends in India. It is interesting to look at the figures of area and production in India over the period of time. The area under flower crops has increased from 106 thousand hectares to 255 thousand hectares over a period of last fifteen years. Similarly the production of loose flowers increased from 735 thousand MT in 2001-02 to 1754 thousand to 1754 MT in 2013-14. The cut flower production has risen from 8040 lakhs to 76732 lakhs in 2012-2013. The value of export of flowers reached from Rs. 105.2 crores to Rs. 460.75 crores in 2014-15. The production of loose and cut flowers showed increasing trends over a period of time. However, as compare to loose flowers, it shows that, cut flower production increasing more rapidly. In last few years, there can be seen changes in area and production in various states of India. During 2012-13, Tamil Nadu held first place in production of loose flowers (312.97 thousand MT) accounting for 18.10% of total cut flower production. It is followed by Andhra Pradesh (224.41 thousand MT) and Karnataka (207.50 thousand MT). During the same year the cut flower production was highest in West Bengal (25429 lakhs) followed by Karnataka (9441.8 Lakhs) and Maharashtra (7914 lakhs). It can be seen that there would be increasing trends in production of both the loose and cut flowers in India. The Government of India has identified floriculture as high export potential. It was proposed that export of floriculture should be increased Rs.100 crore per annum in eighth plan period. For this purpose, National Commission on Agriculture had set a target to bring five lakh hectares of land should be under floriculture up to 2000 A.D. With the help of supporting agencies, export of floriculture has been increasing year by year. At the beginning of current decade, India's flower export to world market was of about $ 50 billion crore

per annum which less than 0.1 per cent, it was definitely negligible.

Policy changes for the development of floriculture

After liberalization of economy and announcement of National Seed Policy that paved the way for the import of planting material of elite, exotic varieties from different parts of the world. The liberalization of Indian economy also favoured Foreign Direct Investment (FDI) in floriculture, infrastructure and input supply industries. This helped access to technology for state of the art greenhouse production of flowers during early 90's. A large number of public and private companies were established for 100% EOUs in different parts of the country. Both public and private sector played a proactive role in development of infrastructure facilities and logistic network which are the backbone of Indian flower industry. The cold storage facilities at airports, fleet of refrigerated vans for effective transportation were developed. The state of the art international flower auction centres were commissioned at Bangalore and NOIDA. The floriculture sector in India is growing much above 7 per cent annually, in terms of value and creating job opportunities and livelihood. The sister organizations of Govt. Of India provide for setting up commercial horticulture units, development of post harvest infrastructure and development of technology for horticultural crops including floriculture. There are more than 300 export-oriented units in India. More than 50% of the floriculture units are based in Karnataka, Andhra Pradesh and Tamil Nadu. APEDA provides assistance for development of infrastructure facilities, quality development and transport assistant to floriculture industries engaged in production and export of floriculture products.

World flower growing environment – opportunities north east India

A review of the flower growing environment of the world reveals that the floriculture has developed in three different horizons in the world- i) The European countries which was the center of economy and knowledge. Here floriculture got a boost as a consequence of the acquired knowledge and genetic materials gathered from all over the world and backed by the strong economic uplift. ii) Latin America and Africa (Columbia, Kenya, Ecuador) - the upcoming countries where the industry was initialized in recognition of the comparative natural advantage and government policies to combat the high production cost of the Europe or North America. Most of the flower industry of these countries are owned by the investors of the developed countries and production is dependent on the technology, genetic materials and market of those countries iii) The South East Asian countries of (Thailand, Malaysia). Here the flower industry is mostly based on the indigenous genetic base and technology and specialized on specific crops, mostly orchids, of which the region is a niche area. Country like India has an advantage of both the second and the third group of countries, specially, in its hilly region. The other advantage of the country is the huge and growing internal market; this gives more stability to the market comparative to the other developing exporting countries.

However, if we take an account of Columbia, Kenya and Ecuador, the leading countries of the world flower export, we can see that the crops cultivated are mainly rose, carnation and chrysanthemum and foliage and filler ornamentals. The cultivation areas of Kenya and Columbia mostly lay at higher altitudes of 1500m msl. This offers greater diurnal variations and more bright sunshine hours which are congenial for rose, carnation (standard and spray) and chrysanthemums. Similar situations are available in the hills of India, mainly in the Himalayas. Exploitation of these areas with proper infrastructure development, technology support and strong marketing strategy can lead world class production of roses, carnations and chrysanthemums.

The roses require a light intensity of more than 8000 lux, temperature between 15°C – 21°C and wintering for its proper growth and flowering. Most of Ecuador's roses are found in the Pichincha in the Andes at an altitude between 2800 and 3000m msl which offers more natural light all through the year and cooler nights. Roses grown at this height has much longer growing cycle (15 weeks) than those cultivated at the sea level (8weeks) and is perfect for long stemmed varieties with big heads. The cold night encourages the bicolour varieties which are sought after in the international market. The average light intensity and the temperature regime of the hills in our country are optimum for rose cultivation. The crop can easily be grown in open condition if protection is given from harsh weather and disease pests. The carnations are more sensitive to diurnal variation and light intensity. The hilly region of northern India, due to its topography, shows a wider variation of day and night temperature than the plains. This can be exploited for the cultivation of carnations. On the other hand, chrysanthemum is more sensitive to day length. These plants can be tailored to flower by manipulating the night duration. Adaptation of simple technologies enables year round production of these flowers in the mid and low hills. Other crops like gladiolus, gerbera, orchids like Cymbidiums can also be cultivated in the middle and lower altitudes. The higher altitudes are suitable for temperate crops like liliums, alstromerias, tulips, narcissus, hyacinths etc. The western Himalayas are especially suitable for cultivation for lilies and tulips, which are difficult to grow in the warmer climate. The Jammu and Kashmir and Himachal Pradesh are endowed with the temperate climate with cold winter and bright cool summer which are required for the growing these crops. Apart from cut flowers the propagating materials of lilies and tulips are in high demand in the world market and can be exported to earn the foreign exchange.

The lower altitudes of Shiwalik range and Southern hills which are characterized by mild warm temperature and heavy rainfall can be effectively utilized for cultivation of high value crop like orchids, gerbera and anthuriums under shade and tuberose, marigold, rose and gladiolus in open. Orchids and anthuriums require a humid condition with mild temperatures. Crops like Dendrobium, Pahlaenopsis, Oncidium and Vanda and Mokara hybrids are very suitable for growing in the foot hills. Hills of Meghalaya, Manipur, Arunachal Pradesh, Mizoram, Sikkim and Darjeeling are very apt for growing these crops.

Potted plants and nursery stocks of Azalea, Hedera, Glaxonia, Cyclamen can be raised in the higher altitude over 1500m msl whereas, seed production of annuals can be better option in the mid hills. The foot hills are also favorable for growing of foliage plants like Dracaena, Cordyline, Palms, Cycads, Crotons, Aliums, Ferns, cacti & succulents, Juniperus etc.

Apart from the climatic suitability, India has a wealth of large genetic diversity of indigenous plants and flowers. The biodiversity hotspots of the country are mostly spread on the hills and mountainous regions, examples the Indo- Burma mega-diversity region covering the Himalayas and biodiversity hotspot of Western Ghats. These regions offer an amazing diversity of orchid flora along with the assortment of palms, cycads and flowering plants of other families. This genetic diversity can be improved and introduced to the international trade, the strategy adopted by the south-east Asian countries for orchids.

Challenges of floriculture industry in north east India

In spite high export potential, the export of India Floriculture has not been very encouraging. The export of floriculture remained stagnant since last few years. The Indian floriculture stands 0.19 % of total world floriculture exports.

The low export of flower products is attributed to high import tariff vis -a -vis African Countries. The high freight cost availability of logistics for export of perishables, the small size of farms, cold chain management are major constraints. The Indian floriculture industry is facing several challenges at production level like availability of quality seed and planting materials, farm inputs, quality irrigation water and skilled manpower. At marketing level product diversification, quality and environmental issues are of major concern.

In addition to above challenges floriculture in north east India, flower growing areas are to be affected by the large-scale deforestation, soil erosion, (46.0t/ha of top soils washes away annually), dry water bodies, soil acidity, high intensity of rainfall, snow and frost, lack of infrastructure and transportation facilities in hostile topography. The agriculture and horticulture are the dominant activity in the hill economy, but it faces multiple risks and challenges like-

1. The staggered land holding makes it challenging to use modern technologies and equipment.
2. The ethnic practice of *Jhum* or shifting cultivation is also a limiting factor for setting up of high-value floriculture units.
3. The single most limiting factor is the inaccessibility due to the fragile and difficult terrain of the regions.
4. Remoteness from the market as well as inputs.
5. Lack of availability of modern technologies customized for use in the hilly terrain.
6. Lack of access to genetic materials or planting materials.
7. The fast depletion of biodiversity is also a major concern for the area.

Strategies for Promotion of Floriculture in North East India

The domestic floriculture market is estimated to be about Rs. 5000 million and growing by 25 % annually. The preference of domestic market is shifting from traditional cut flowers to exotic flowers which is good sign for orchids and other exotic flowers. The shift from traditional to exotic flowers offers good scope for orchids due to their variety in colour and long shelf life. The Delhi market alone is estimated to be about of Rs. 1000 million.

(i) Determining product specific zones: India is endowed with diverse ecological zones, making it feasible to cultivate almost all kinds of orchids grown for commercial purpose. The modern cultivars are combination of several species and thus suitable climatic conditions needs to be ascertained before taking up large scale production. There is need to earmark the production zones for each product of cultivated genera like Cymbidium, Dendrobium, Oncidium, Paphiopedilum etc. The work done in past may be useful in assessing potential areas. There is need to find out nontraditional areas for growing orchids e.g there is possibility of producing good quality of Cymbidium and other exotic flowers in Uttaranchal and Himachal Pradesh with slight manipulation of green house conditions.

(ii) Human resource development: In India cheap skilled and non skilled manpower is the major advantage in floriculture and orchids in particular. The human resource could be developed through training of entrepreneurs in selected institutions of the country and a backward linkage with the institutes specializing in the region needs to be created for technical support and advice of entrepreneurs. However there is need to start a diploma course in cultivation of orchids as well as tissue culture so that these people may become future orchids entrepreneurs or contribute significantly by getting employed in companies engage in production of orchids.

(iii) Infrastructural support: The infrastructure is prime requirement for the development of commercial cultivation perishable meant shipping to distant places. Both, on farm or off farm infrastructure facilities would require to be created for safe delivery of quality products. The on farm facilities like pack house, refrigerated van, and cool store may be owned by individual or a group of growers. The off farm facilities are being created by APEDA. A substantial

progress has been made to develop off farm infrastructure facilities like construction of cool store at major airport of the country, development of flower auction centers, and an international flower auction centre at Bangalore. An Agri export zone for promotion of orchids is being setup in Sikkim with an investment of Rs. 32.21 crores.

(iv) Floriculture education and skill development: The floriculture is fast growing segment of Indian horticulture. A key challenge is to harness and sustain the strength and achievements made in this sector. The educated youth have inclination towards floriculture as it provides higher income and social status. The avenues of employment are expanding in the fields of farm/greenhouse managers, supervisors, consultants in landscape architecture, town and city planning, parks, public gardens, floral designers, and horticultural therapists etc. Apart from these employment opportunities one can have his own enterprise. The capacity building programme needs to reorient using modern information technology. The Indian floriculture sector moving towards Hi-tech horticulture the institutions and learning centres would be in actual fact required to serve as knowledge bank and grow as an interactive learning centres. These should be backed by complete research and reliable hands on training. These learning centres should provide superior learning opportunity along with perfect blend technical skill to demonstrate their ability at workplace. The manpower and technology development through education and research institutions should be as per demand of the market in both quality and quantity. The change in technology, preferences of consumers, national and international completions affect on the profitability and sustainability of the enterprise. Accordingly, the course curriculums for diploma, graduate and post-graduate courses have to be redesigned.

(v) Research and development for hill floriculture: To develop floriculture industry in the hilly terrains, strong R & D support is the most essential factor. Prioritization of research on developing and refinement of appropriate technologies and production of suitable genetic material is required. It is also essential to assess the impact of such technologies and address constrains of adaptation. Dedicated institutes for research and development of hill horticulture can serve the need. The National Research Centre for Orchids with its mandate to develop the orchid cultivation in the country is situated in the hilly terrain of Sikkim. The institute is devoted in addressing the various problems and issues associated to orchid cultivation, especially in the hilly regions and have provided location specific strategies and techniques for the hills of Sikkim and Darjeeling and other parts of the country. The centre is also involved in conserving the orchid wealth of the country, improvising the genetic stock and development of market driven cultivars. Similar institutes, with sole objective of developing floriculture in hills can manifold the efforts and lead to a bright floral future in the hills of India.

Strategies for Growth of Floriculture

Rapid technological agri-business, international economic integration, saturated markets and free market mechanism have provided opportunity, but also the challenges. Retailing on markets will be more complex. Service, quality and reliability would be an essential factor for securing position in international market. Producers have to organize the production so as to supply the necessary quantities according to the required quality standards. Any parties in the chain, which do not contribute to higher added value, will disappear. The advantages of large-scale market could be found for efficient purchasing process and also in terms of logistics and sue of information technologies. Accordingly, our efforts have to be directed to harness the potential through strategic promotion of market. Strategies could be for policy support,

infrastructural development, professionalism in market management, networking of markets and quality assurance.

All these developments provide opportunity for production and marketing. This would need strategic marketing approach having backward and forward linkages coupled with horizontal and vertical integration. By providing sufficient attention and support, attaining the goal of reliable production of high-quality product consistent in quantities could be attained. Resultantly, Asian flower sector would soon become a major player in the region as well as in European flower market. Moreover, given the rapidly increasing rate of spending among Asian consumers for cut flowers, it is also reasonable to expect that the Asian flower industry will soon surpass consumption rates for cut flowers compared to other regions.
Cooperation and commitment, in terms of education, research, funding and communication in Asia would be a driving force to become a leader of commercial floriculture worldwide, in years to come. The strategies have been chalked out to meet the challenges and to make floriculture a most viable activity in Asia to ensure employment with enhanced farm income. The challenges are to capture emerging trend in marketing through innovation and skilled professional management. Therefore, strategies to promote effective marketing should include, quality assurance, transportation, hub development for effective delivery, institutional support for information and training, specialty production, reducing cost and widening products, developing domestic market, promoting indigenous plants and flowers, developing professional skill and knowledge management, promoting uses of flowers and providing policy support product and delivery. Therefore, there is a need for quality products and delivery, and to develop quality certification system, as developed in Holland, which ensures the quality for the brand.

Conclusion

India has conducive climatic conditions, richness of genetic resources, basic infrastructure, favourable government policies, and large scientific and technical expertise in the field of orchids. A substantial progress has been made in basic and applied research on flower crops including orchids. Our genetic resources are depleting very fast, they need to be conserved and protected from biopiracy, at the same time they need to be judiciously utilized for commercial gains. In globalised economy easing of trade barriers, it is obvious that orchids and exotic flowers from other countries would dominate our markets and it is required to protect the interests of our growers. We must devise ways and means to hedge our markets with competitive countries and harness orchid potential for export markets. New consumption centres are also emerging in South-east Asia, Middle-East and Eastern Europe. The scenario provides opportunity to capitalize on the strength and convert weaknesses into opportunity However, in the consumer-driven market, quality of service and delivery system will play a significant role. Marketing is no more a meeting of buyers and sellers, but it is complex, which is driven by quantity of products and reliability of delivery. New distribution structure with the aid of IT is likely to be in place, which would be a virtual market, demanding, branding, cataloguing and quality assurance emphasizes.


NABARD