VISION - 2020

CISH
PERSPECTIVE PLAN

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH
CENTRAL INSTITUTE FOR SUBTROPICAL HORTICULTURE, LUCKNOW

CISH, LUCKNOW

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FOREWORD

Over the years, the Indian Agricultural Research System under the aegis of the Indian Council of Agricultural Research has served a very useful purpose. Nevertheless, in the fast changing global context, managing the change on a time scale, by converting weaknesses, if any, into opportunities to become internationally competitive is considered important. We need to be forward looking and visible with appropriate agricultural research policies in place supported by the cutting edge technologies in order to attain and sustain global advantages. It is in this background that the formulation of a perspective plan with a visionary approach for the next 25 years, is quite necessary. The clearly spelt out options and likely changes would enable the system to capitalize on our strength so that the threats, if any, are converted into opportunities.

For diversification of agriculture, role of horticulture is of paramount importance. In this endeavour to realise enhanced productivity and production, tree nutrition is quite important. There is a need to develop integrated nutrient management programme for subtropical fruits. Use of biofertilizers, organic manures and organic coated fertilizers is the need of the hour. Organic farming, which excludes chemicals in any form will be a new approach to fruit production. Water management programmes for each fruit is required to be developed for judicious use of water. The Perspective Plan of Central Institute for Subtropical Horticulture, Lucknow, has taken care to highlight the issues in the fields of crop improvement, crop production, crop protection and crop utilization and the strategies to tackle these issues. Human resource development and transfer of technology are also important aspects which also form part of this plan.

In perspective plan formulation there was an overwhelming response to Council's initiative. The staff of the Policy and Planning Cell of the council deserves all appreciation for undertaking this onerous task right from designing of the necessary format and taking the plan formulation process to its logical conclusion. The various divisional heads at the ICAR Headquarters, Peer Review and RAC members made valuable contributions to the process of Plan formulation. The Director and scientists of the Institute have put in their collective wisdom in bringing out the document in its present form. It is hoped that the framework prepared would continue to be reviewed to accommodate changes in future so that the perceived vision continues to be close to the expected target. In the years to come, based on the long term perspective, it would be relevant to put implementable plan to action on five yearly basis to match with the ongoing planning system of the country.

(R.S. PARODA)
Secretary, DARE and
Director General, ICAR

March 5, 1997

PREFACE

Productivity of subtropical fruits grown in some of the states and union territories of the country is lower than the national average. Moreover, the average national productivity of these fruits is low compared to their potential productivity. Low productivity has resulted in low production. Increase in productivity and production is the present day need not only to meet the demand of domestic market but also for foreign market which will bring much needed foreign exchange to the country. Increase in productivity and production of fruits is bound to have a positive effect on the upliftment of the socioeconomic status of fruit growers.

Since our planners have laid more emphasis on export, it has become all the more necessary to produce not only more, but also quality fruits so that we can compete with other fruit producing countries in the international market. Hitherto, a myopic approach has been a drawback in planning research in area of fruit production. It is in this background that the Director General, Indian Council of Agricultural Research, suggested to prepare a perspective plan on mandate fruits of the Institute for the next 25 years in a prescribed format. This perspective plan *inter alia* includes issues and strategies, programme identification, setting of objectives and goals on a time scale, programme activities and priorities and expected end of the programme. Areas which have been targetted for research are crop improvement, crop production, crop protection, postharvest technology, biotechnology and transfer of technology.

I am grateful to Dr. R.S. Paroda, Director General, I.C.A.R., for his direction and valuable guidance in preparing this perspective plan. I express my sincere thanks to Dr. K.L. Chadha, Deputy Director General (Hort.) (retd.), Dr. S.P. Ghosh, Deputy Director General (Hort.), Peer Review Members and the Chairman and Members of Research Advisory Committee for their valuable and critical comments, which guided us in bringing the document to present form.

I am thankful to Shri M.S. Rajput, Senior Scientist of this Institute for rendering his help in the preparation of this perspective plan. Thanks are also due to Dr. R.P. Shukla, Principal Scientist, Dr. Ram Kishun, Senior Scientist, Dr. Ajay Verma, Senior Scientist, and Shri B.P. Kapoor, Technical Officer for providing necessary help in preparation and editing this plan. I am also thankful to all the Heads of Sections and other scientists of this Institute for furnishing necessary input for this document.

Lucknow
March 31, 1997

(S.S. NEGI)
DIRECTOR

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EXECUTIVE SUMMARY

Central Institute for Subtropical Horticulture has mandate to undertake basic and applied research on subtropical fruits, namely, mango, guava, papaya, litchi and grape with special emphasis on mango. The research programme of the Institute aims at increasing the productivity, quality and utilization of the mandate fruits by developing strategies and applying them for solving problems of these fruit crops.

India is the largest mango producing country in the world with an annual production of 10.99 million tonnes from an area of 1.23 million hectares. However, the productivity of mango in the country is low. Brazil is the largest producer of papaya in the world contributing 34.29 per cent of total production of 5.25 million tonnes followed by Nigeria, Cyprus, Indonesia and Mexico contributing 9.52, 9.33 and 8.76 per cent, respectively. India ranks fifth by contributing 6.86 per cent.

Malformation and alternate bearing are the important problems adversely affecting the production of mango. Perfect control of fruitfly is not available which restricts the export of mango from India. Guava varieties/rootstocks resistant to wilt, papaya varieties tolerant to frost and resistant to ringspot virus, litchi varieties having good colour, high yield and cracking resistance and early ripening good quality varieties of grape suitable for north Indian climate are not available. Varieties with high yield having long shelf life and good processing quality are yet to be developed. Micropropagation techniques for mango, guava and litchi are yet to be standardized. Integrated pest management programmes for major pests of mandate fruits are yet to be developed. While a lot of work in the field of molecular biology of mango and papaya is being conducted in some advanced countries of the world, no such work has yet been initiated in India.

There are tremendous opportunities to increase productivity and production of mandate fruits. The export of these fruits which is very less, can be increased by doing export oriented research. IPM, integrated nutrient and water management, biotechnology, breeding high yielding, red coloured, pests and diseases resistant varieties, postharvest management and fruit waste utilization are important areas where a vast scope exists for achieving the goals of the plan.

Malformation and irregular bearing in mango, guava wilt, frost and PRV in papaya, fruit cracking and discolouration of fruits in litchi constitute threats to the programme. Growing competition with other fruit producing and fruit exporting countries is a challenge to be faced in export market.

The institute will have the world germplasm of mango, guava, papaya, litchi and early ripening varieties of grape. Genetic resource information database of mandate fruits will be available with the Institute on national and international levels. The Institute would have developed high yielding, superior quality, red coloured, disease and pest resistant varieties of these fruits. Varieties suitable for export and processing will be developed. *In vitro* propagation techniques in mango, guava and litchi would be standardized for mass multiplication.

Integrated nutrient, water and pest management programmes would be developed. Dwarfing rootstocks for mango, guava and litchi and wilt resistant rootstocks for guava would be developed. High density planting system will be developed in mango, guava and litchi. Technology for integrated postharvest management of these fruits will be available at this institute.

The Institute will be in a position to produce plant material having desired genes through genetic engineering.

The Institute has drawn the following programmes to work upon to achieve the goals of the plan:

1. World collection of germplasm, its characterization, cataloguing and evaluation.
2. Developing varieties with desired traits.
3. Developing integrated nutrient, water and pest management programmes.
4. Developing high density planting system.
5. Standardizing *in vitro* techniques for mass multiplication.
6. Developing integrated postharvest management programme.
7. Genetic engineering to transfer desired genes.
8. Finding causes and control of mango malformation, guava wilt and alternate bearing in mango.
9. Transfer of technology.

The main objectives of the perspective plan are to enhance productivity, quality and improve postharvest management of mango, guava, papaya, litchi and grape. These objectives will be achieved by developing high yielding, disease resistant and red coloured varieties of mango, guava and litchi, developing early ripening high quality varieties of grape and PRV resistant and cold tolerant varieties of papaya. A complete production technology will be developed for these fruits. Integrated postharvest management programme will be developed for better utilization of these fruits and promoting their export. Development of red coloured varieties form a part of export oriented research which will increase export of fruits of these varieties. Mass multiplication of plants will be made through tissue culture. Genetic engineering will be used for transferring genes of desired traits into desired varieties. Molecular marker analysis will be used for selecting suitable parents based on QTL analysis. AFLP technology will be used for characterization of parents involved in the breeding programme.

With the development of high yielding, superior quality, disease and pest resistant varieties and production technology of mandate fruits, the productivity of these fruits will be increased. Development of red coloured varieties of mango, guava and litchi will increase their export and fetch much required foreign exchange. Development of integrated post-harvest management will lead to better utilization of fruits after harvest and also help in boosting export.

1. PREAMBLE

The Central Institute for Subtropical Horticulture, Lucknow, was initially set up as Central Mango Research Station on 4th September, 1972 under the aegis of Indian Institute of Horticultural Research, Bangalore by the Indian Council of Agricultural Research to conduct research on various aspects of mango cultivation. It was upgraded to the level of a full-fledged Institute on 1st June, 1984 and was named as Central Institute of Horticulture for Northern Plains. On 14th June, 1995, it was renamed as Central Institute for Subtropical Horticulture with modified mandate. The Institute has two farms, one is located at Rehmankhera about 30 km from Lucknow in the vicinity of Malihabad, the famous mango belt of Uttar Pradesh and home of Dashehari and other choicest varieties of mango. The farm at Rehmankhera spreads over an area of 132.5 ha. The other farm, comprising an area of 13.2 ha, is situated at Lucknow on Lucknow-Raebareli road. The Institute has the world's largest collection of mango germplasm with 650 accessions. Crop improvement, crop production, crop protection, postharvest management, biotechnology and transfer of technology of subtropical fruits are the major areas of research.

The headquarters of All India Co-ordinated Research Project on Subtropical Fruits are also located at this Institute.

2. MANDATE

i) To undertake basic and applied research for developing strategies to enhance productivity and utilization of subtropical fruits with special emphasis on mango.

ii) To act as a national repository of mango germplasm.

iii) To act as a centre for training and for upgradation of scientific manpower in fruit crops.

iv) To collaborate with national and international agencies for achieving the above objectives.

v) To provide consultancy.

3. GROWTH

3.1 Infrastructure

3.1.1 Laboratories

Earlier, the laboratories were housed in private buildings at Lucknow, whereas the experimental orchards existed at Rehmankhera 30 km away from the city. Later, all laboratories were shifted to the experiment station for smooth functioning of the research programmes. While most of the laboratories were housed in vacant residential quarters at block I, some of them were housed in field labs at block II of the orchard. All the laboratories have been provided space and these labs will continue to function in the existing buildings

until the administrative-cum-laboratory building, which is under construction, is completed. Besides research labs, a field lab has also been constructed at block III of the orchard. All the laboratories are equipped with the equipments almost sufficient in number to carry out the present research programmes.

3.1.2 Library

Institute has a library at the experimental orchard. It has 2152 collections of scientific and technical books and 1194 references on subtropical fruits. The Institute subscribes to 45 foreign and 50 Indian journals.

3.1.3 Field

The experimental farm of the Institute spreads over an area of 132.5 ha at Rehmankhera and 13.2 ha at Raebareli Road, Lucknow. The Institute has plantations of mango, guava and papaya for conducting experiments. Collection of litchi and grape germplasm has also been started. Mango germplasm collection has 650 accessions collected from indigenous and exotic sources. Mango germplasm collection of the Institute is the world's largest repository.

3.1.4 Buildings

At present, the Institute has 47 residential quarters – 21 at Raebareli Road campus and 26 at Rehmankhera and a training hostel. A laboratory-cum-administrative building including museum, auditorium, lecture hall, processing hall and library is under construction at block II at Rehmankhera.

3.1.5 Any other

The Institute has irrigation and drinking water facilities, 24 hr electric supply, telephone and E-Mail and transport facilities. A metalled road runs across the blocks II and III at Rehmankhera.

3.2 Budget

(Rs. in lakhs)

Plan period	Plan	Non-Plan	Others	Total
1 VI (1.6.1984 to 31.3.85)	25.07	18.00	–	43.07 *
2 VII	141.35	187.87	–	329.22
8 VIII	700.00	797.85	32.95	1530.80
% increase (8 over 2)	395.22	324.68	–	364.98

* Met out of IIHR VI Plan Budget since CISH was its Regional Station before upgradation as Institute on 1.6.1984. Hence, % increase calculated as 8 over 2.

3.3 Manpower

Plan period	Scientific	Technical	Administrative	Auxiliary
1 VI	23	33	21	4
2 VII	48	41	23	53
8 VIII	43	48	2663	63
%increase (8 over 1)	87	45	24	43

4. SALIENT RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

a) *Mango:* The Institute has a large germplasm collection of mango numbering 650 accessions collected from indigenous and exotic sources.

A mango hybrid, 'CISH-M-1', from a cross of Amrapali x Janardhan Pasand was found to be very promising. Fruits of this hybrid are large, bright yellow with dark red blush, highly attractive and of good quality. It has good export potential.

Tree No. 3 of 'Dashehari' has been bearing regularly for 14 years giving good yield. It has been named as 'Dashehari-51.'

'Saheb Pasand', a collection from east India, has been found to have a potential for processed products, especially beverages and slices.

b) *Guava:* The Institute has 54 cultivars of guava and 7 species of *Psidium.*

A guava selection, 'CISH-G-1', was found to be promising. It has deep red coloured fruits of uniform size with high T.S.S., few soft seeds and long shelf life. It also has good yield and export potential.

c) *Papaya:* Forty cultivars of papaya and 5 species of *Carica* have been collected from indigenous and exotic sources.

d) *Grape:* The Institute has collected 15 varieties of grape.

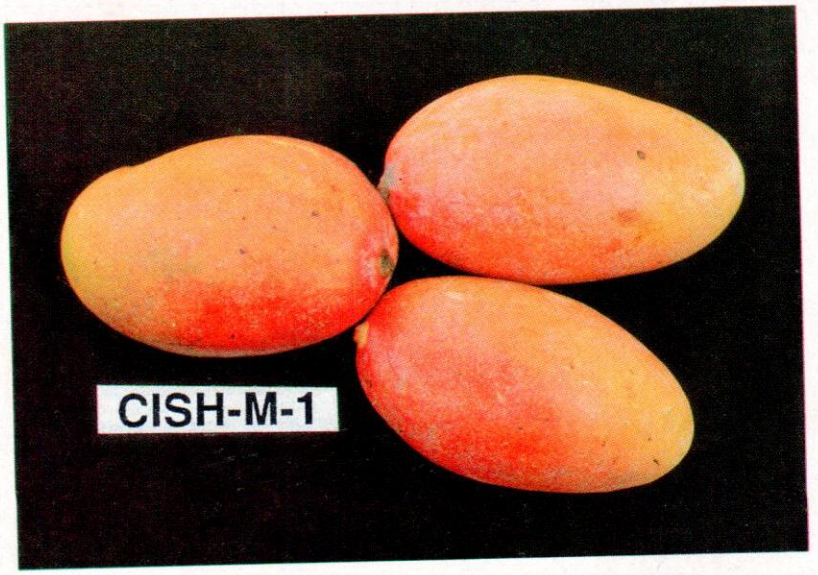
e) *Litchi:* Eight varieties of litchi have been collected.

f) *Lime and lemon:* Two varieties of lime and 6 of lemon have been collected.

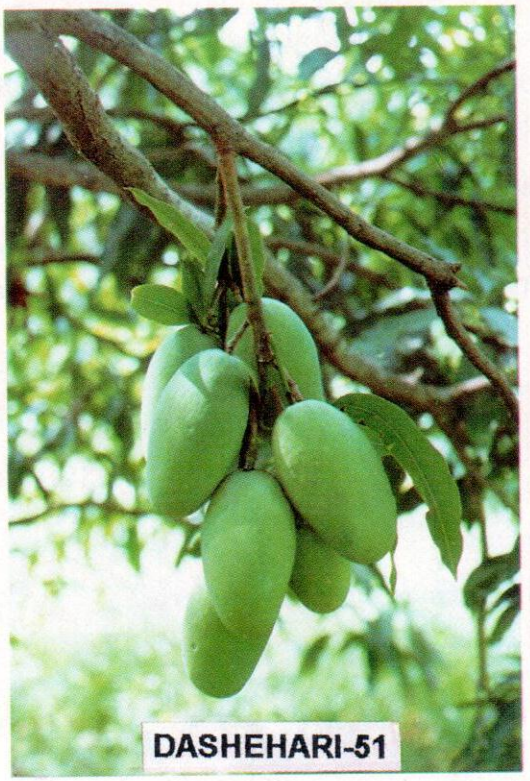
2. CROP PRODUCTION

a) Mango

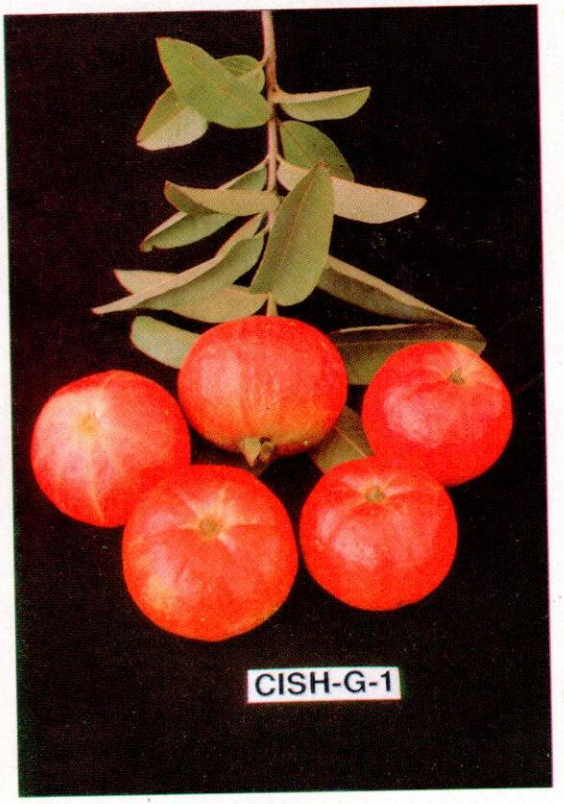
i) *Propagation:* Veneer grafting and soft wood grafting were found to give up to 90 per cent success when grafting was done in the months of July and August.



Promising mango hybrid CISH-M-1



Regular bearing and high yielding clone Dashehari -51



Promising guava selection CISH-G-1

ii) *Rootstocks*: 'Rumani', 'Ambalvi' and 'Pahutan' rootstocks imparted dwarfing effect on the scion variety 'Dashehari', while 'ST-9' rootstock produced most vigorous trees and 'Kurukkan' and 'Taimuria' rootstocks produced semi-vigorous trees. Significantly higher yields were obtained with 'Kurukkan' and 'Taimuria' rootstocks.

A long-term interstock trial planted with 'Chandrakaran' and 'ST-9' rootstocks and 12 interstocks showed that interstock-rootstock combination significantly influenced canopy growth of 'Dashehari' variety of mango. 'Willard' and 'Ambalvi' interstocks produced dwarfer trees on ST-9 rootstock, whereas 'Kurukkan' interstock produced vigorous trees with 'Chandrakaran' rootstock.

iii) *Nutrition:* Ten-year study on nutritional requirement of mango cv. 'Dashehari' showed that soil application of 400 g N, 200 g P_2O_5 and 400 g K_2O per plant of 10 year in 40 cm deep circular trench dug 2 m away from tree trunk boosted the yield.

It was found that in general, 6-7 months old 40-45 leaves collected from the middle of nonfruiting terminals from all directions representing all heights are ideal for assessing nutritional status of mango trees. The critical limits of leaf nutrients worked out for N, P and K were 1.10, 0.08 and 0.52 per cent, respectively. The critical soil nutrient levels determined were: organic carbon 0.58 per cent, Olsens' P 34.6 ppm and ammonium acetate K 49.5 ppm for surface soil and Olsen's P 3.55 ppm and ammonium acetate K 45.0 ppm for subsurface soil.

iv) *Salt tolerance:* Salt tolerance studies made on seven rootstocks of mango revealed that 'Moovandan' and 'Nekkare' rootstocks were more tolerant to salt.

v) *Intercropping:* Intercropping in young mango orchards was found remunerative up to 10th year. Cowpea-potato-mango system gave the highest monetary return.

vi) *Overcoming irregular bearing:* Effect of paclobutrazol (PP_{333}) on the control of irregular bearing in mango revealed that soil application of paclobutrazol (4 g/tree) produced higher number of hermaphroditic flowers, improved fruit set and produced higher yield (91.3 kg/plant) in Dashehari.

vii) *Control of mango malformation:* Foliar application of 200 ppm NAA in the month of October followed by deblossoming at bud burst stage or deblossoming alone controlled mango malformation up to certain extent. Morphactin (500 ppm) produced the malformation like symptoms in mango with increased IAA-Oxidase activity. A higher activity of enzyme was also obtained in naturally occurring malformed panicles.

viii) *Internal necrosis*: Three foliar sprays, one at pea stage and the other two at 15 days interval of 1 per cent borax reduced the incidence of internal necrosis.

ix) *Black tip*: Intensity of black tip was found to be comparatively very low in the orchards which were 5-6 km away from the brick-kilns and located in the north and south directions.

x) *Fruit drop:* Fruit drop in 'Dashehari' was minimised with foliar sprays of Alar (100 ppm) followed by NAA (20 ppm) at pea stage.

b) **Guava**

i) *Crop regulation*: Guava fruits produced in rainy season are attacked by many pests and are inferior in quality. Crop regulation studies revealed that the rainy season crop can be eliminated by double spraying of 10 per cent fertilizer grade urea in 'Allahabad Safeda' and 20 per cent urea at bloom stage in the cv. 'Sardar'. These treatments also increased the yield of winter season crop manifold.

Withholding irrigation from February to June also controlled the rainy season crop in guava and increased the yield of winter season crop.

c) **Papaya**

While maximum yield of papaya was obtained when planted in September, minimum infestation of papaya ring spot virus was observed in February planted plants.

3. CROP PROTECTION

Chemicals for the control of mango hoppers, mealy bugs, inflorescence midge, shoot gall psylla have been standardized. In a biocontrol programme, entomogenus fungus, *Verticillium lecanii*, egg parasites *Agrostocetus* sp., *Gomatocerus* sp. and *Polynema* sp. and the predators *Chrysopa lacciperda* and *Mallada boninensis* have been identified as potential bioagents for control of mango hoppers. *Tetrastichus* sp. and *Eupelmus* sp. have been found potential bioagents for controlling inflorescence midge. Neem and other plant products and an insect growth regulator were found effective killers of mealy bugs and mango hoppers. Integrated Pest Management (IPM) for mango mealy bug, leaf webber and fruitfly has been developed.

Chemicals for control of powdery mildew, anthracnose, die-back, sooty mould, phoma blight and red rust of mango have been standardized.

4. POSTHARVEST TECHNOLOGY

a) **Mango**

i) *Maturity index*: 'Dashehari' and 'Langra' varieties reached physiological maturity after 85 days, while 'Mallika' and 'Chausa' took 100 days to mature after fruit set.

Fruits of 'Dashehari' with specific gravity less than 1.0 ripened slowly (in 8 days) and had extended marketability period by 2-3 days, while fruits having specific gravity more than 1.02 ripened within 5 days of storage with less marketing period.

Mango fruits harvested with 8-10 mm stalks could be stored for 21 days at 12°C and then for 6 days at room temperature.

Corrugated fibre board boxes (CFB) with tissue paper wrapping (unipack) system were found most suitable for mango packaging.

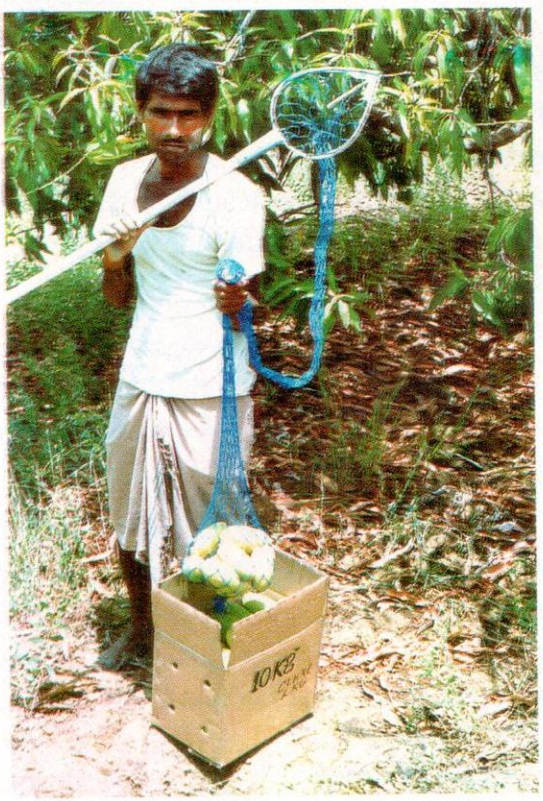
ii) *Processing*: The thermal processing at 75-78°C was assessed as sufficient for preserving flavour and colour of 'Dashehari' pulp. The sterilized pulp stored well in glass jars up to 12 months at low temperature (0-5°C) without preservative. The sterilized pulp could also be preserved by adding 1000 ppm of SO_2 as potassium metabisulphite in sealed glass jars up to 1 year under ambient conditions.

The blend of pulp of mango cvs 'Totapuri', 'Banganapalli', 'Dashehari' and 'Chausa' with papaya pulp showed good commercial potential. Nectar prepared from most of the blends (mango containing up to 33 per cent papaya) could be preserved for a year in glass bottles and was organoleptically acceptable. The nectar prepared from 'Saheb Pasand' variety of mango and pineapple (1:1 pulp) was rated the best. Pear-mango blended drinks were also found acceptable.

iii) *Harvesting device:* A simple, low cost and portable mango harvester has been designed. A man can harvest 700-1000 fruits per hour under experimental conditions.

b) **Guava**

Handling and storage: Guava fruits having specific gravity between 1.0 and 1.02 had longer shelf-life due to delayed onset of senescence. Guava cv. Sardar could be stored for 3-4 weeks in 0.5 per cent ventilated LDPE bags at 5°C and 85-95 per cent relative humidity.



Portable low cost mango harvester along with CFB box

5. BASIC RESEARCH/BIOTECHNOLOGY

Work on this aspect has been initiated recently as Section of Biotechnology came into existence during 1995.

6. TRANSFER OF TECHNOLOGY/ TRAINING

The Institute organised 14 training programmes on Production, Protection and Postharvest Technology of Horticultural Crops under National Agricultural Research Project in which 260 scientists from State Agricultural Universities,

ICAR Institutes and State Horticulture Departments have been trained. The Institute adopted 600 farm families under 'Lab to Land' programme. Technologies generated by the Institute on plant protection in mango were transferred to the farmers. Radio and T.V. talks, replies to postal queries of farmers, *Gosthis*, etc. have been regular features of extension activities of the Institute.

5. IMPACT ASSESSMENT

5.1 Growth

1. Crop Improvement

Germplasm collection is a continuous process. Germplasm of mango, guava, papaya litchi and grape collected will be utilized for selection and breeding for varieties of desired traits such as high yield, good quality and disease and pest resistance. Plants of Dashehari clone No. 51, a regular bearing clone, will be used for field trials to confirm its bearing behaviour. Promising mango hybrid, CISH-M-1, will be evaluated further.

2. Crop Production

Results of fertilizer and crop regulation trials in mango and guava and use of chemicals in guava will increase productivity and ultimately add to the economy. Growing suitable and profitable intercrops identified in mango orchards will not only increase food production per unit area but also increase income from mango orchards in the less productive phase. Work on dwarfing rootstocks will continue. In the meantime, the results obtained so far will be further tested. Time of planting has shown encouraging results. Standardization of time of planting papaya will be used for higher yield and escaping virus infection.

Control measures developed for mango malformation, black tip and fruit drop will increase production. Standardization of doses of PP_{333} for application in mango will increase yield as the plants will produce crop every year. Further work on this aspect will continue.

Development of leaf sampling technique in mango will help in further research on plant nutrient status. Identification of phosphorus solubilizing microbes in mango and guava rhizosphere soils will help in increasing availability of phosphorus to plants which is otherwise fixed in the soil and remain inaccessible to roots. This will increase production of mango and guava. Further work on this aspect will be intensified.

3. Crop Protection

Standardization of doses of various insecticides for controlling important pests of mango has helped in protecting the crop from damage caused by these pests. This has

indirectly increased production of crop and has added to the economy. Since chemicals are hazardous to health, development of biocontrol methods and use of plant products for controlling insects will prevent environmental pollution and eliminate the danger of pesticide residual effect on human health.

Chemical control measures of major diseases of mango have been worked out. This will help in protecting the crop from damage caused by various diseases and indirectly increase production of crop. Detection of toxins in a few strains of mango bacterial canker disease (MBCD) and identification of antagonistic microflora to MBCD will further help in research for finding out suitable control of MBCD. Further research will continue on these aspects.

4. Postharvest Technology

Setting maturity standards for mango and guava will help to prevent spoilage, ensure proper ripening and the fruits will fetch higher price. Mango harvested with 8-10 mm stalks and packed in CFB boxes with tissue paper lining will cause less spoilage and increase their shelf-life.

Guava harvested with foliage and packed in ventilated polythene bags show better appearance which can fetch more price. As maturity standards are important for market, work on this aspect will continue. Optimum temperature and relative humidity, identified for storage of mango has increased the shelf-life of fruits. The fruits can be transported to distant markets and even foreign markets thereby fetching foreign exchange. Results obtained in mango and guava pulp storage can help in preparation of processed products any time of the year. Beverages developed from fruit juice blends will be put to pilot testing. Processes and products such as pickles and beverages, etc. can be patented and the products will be exported to earn foreign exchange. The technology developed for production of citric acid, vinegar, pectin and fibre from mango wastes may add to the economy. The work will continue on this aspect for testing economic viability.

Extent of postharvest losses worked out in mango and guava during transportation, handling and packaging will help in further research on how to manage such postharvest losses of fruits. Further research in this area will be intensified to minimize postharvest losses.

Mango harvester developed will prevent damage to fruits during harvesting. The quality of marketable fruits harvested with this harvester will increase and it will fetch more money adding to economy. Regular slot container corrugated fibre board boxes have been designed. Mango fruits can be packed in these boxes and transported without loss caused by dynamic and static pressures. This will increase the quantity of healthy marketable fruits fetching higher price and thereby adding to economy. However, further research on these aspects will be intensified.

5. Transfer of Technology

Technologies developed in respect of control of insect pests and diseases, plant nutrition, intercropping, etc. have been transferred to end users. It will increase production of mango and add to the economy. Further work on refinement of technology will be done.

5.2 Input/Output Assessment

The gross domestic product of the country at 1980-81 prices stood at Rs 233.04 thousand crores during 1992-93 of which, agriculture sector accounted for about 30 per cent. The share of agriculture in the gross domestic product has been going up over the years. While it was 27.8 per cent during 1990-91, it increased to 28.1 per cent in 1991-92 and reached the present level. An observation into the value of output from agriculture at 1980-81 prices indicated that fruits and vegetables, including nuts, accounted for about 10.93 per cent of total output during 1990-91, which increased to 11.02 per cent in the following year. While the proportional contribution from fruits and vegetables increased over the years, the absolute value of output actually decreased from Rs. 6929 crores in 1990-91 to Rs. 6785 crores in 1991-92. The major item in the group, i.e. fruits and vegetables was potato, which contributed about 2 per cent towards total agricultural output. Amongst the fruits, for which data were available, banana was the single largest item contributing 1.07 per cent. The other items, which comprised major fruits like mango, grape, citrus, guava, papaya, litchi and some vegetables accounted for 6.85 per cent of total agricultural output. An observation into the private final consumption indicated that the total expenditure on food, beverages and tobacco in 1993-94 was Rs. 86988 crores at 1980-81 prices which was 52.1 per cent of total private final consumption expenditure of Rs. 166833 crores. The food items were the single largest group comprising 47.8 per cent of total expenditure in the year 1992-93. The highest expenditure of Rs. 27230 crores was on cereals accounting for 16.3 per cent of total consumption expenditure. This was followed by milk and milk products (8.2 per cent) and sugar/gur (5.2 per cent). The expenditure on fruits and vegetables was Rs. 8269 crores accounting for 5.0 per cent of the total private consumption expenditure. Although precise estimates are not available for the coefficients of input-output tables for the horticulture sector in general and fruits in particular, it is estimated that about 1.0 per cent of the fruits produced in the country are used in the processing sector. On the other hand, 70 to 80 per cent fruit produced is utilized for processing in the developed countries. About 0.1 per cent of this production is exported. The seed industry also utilizes some of the fruits produced. As per the estimates, 20 to 30 per cent of the fruit production is lost at different stages during the postharvest system. Therefore, about 70 per cent of the fruit production gets available for fresh consumption of the consumers engaged in the agricultural, industrial and allied sectors of the economy. In the developing economy like ours, the need for changing this scenario cannot be overemphasized. Besides increasing the production of all the fruit crops in general and mango, guava, papaya, grape and litchi in particular, there is an urgent need to manage the postharvest system in an efficient manner to reduce the losses at each and every stage

the postharvest system in an efficient manner to reduce the losses at each and every stage of handling including packaging and transportation. There is ample scope to increase consumption of fruits in the processing and export sectors. However, efficient infrastructural facilities and favourable freight structure would have to be created for the purpose.

5.3 Shortcomings

Although the progress has been proportionate to available facilities for research in almost all areas, infrastructural facilities like construction of laboratories, cold storages, glasshouses, etc. are urgently required. Provision of these basic facilities will accelerate the pace of research. Lack of trained/specialised manpower in state-of-the-art techniques of conducting advance research and basic research and lack of sophisticated lab facilities have been handicap in keeping pace with fast advancing science. There are some problems which cannot be solved by applied research alone. Absence of a regular Director for nearly seven years has also been a handicap for progress in research and development of infrastructural facilities.

5.4 Lessons Learnt, Suggestions and Options for Future

Number of crosses made in mango for producing hybrids have been inadequate. A large number of crosses should be made in mango, guava, papaya and other fruits to produce sufficient number of hybrids for selection. Highly coloured varieties should be included in the breeding programme to produce coloured hybrids for export purpose. Interspecific hybridization should be done in guava to produce dwarfing and wilt resistant rootstocks. Growing of healthy papaya germplasm is difficult because of 98 per cent incidence of papaya ringspot virus (PRV). *Carica candamarcencis* is difficult to cross with *C. papaya*. It is, therefore, necessary to go in for embryo rescue technique to raise interspecific hybrids resistant to frost and PRV. Work on identification, isolation and transfer of genes responsible for desired traits should be undertaken. Basic information on doses of fertilizer and chemicals in mango has been generated. Studies on uptake, translocation and metabolisation of the nutrients in mango and guava need to be studied. Carryover of fertilizers in orchard soil and their use by plants in subsequent years need to be studied. Further experiments on dwarfing rootstocks should be conducted.

Infrastructural facilities for study of postharvest technology of subtropical fruits should be developed. Regular interface with the processing industry needs to be arranged for promotion of processed products. Pilot testing of processed products developed should be done. Feasibility of extraction of value added products from mango wastes on commercial scale needs to be explored. Non-conventional processed products are also required to be developed.

During the past several years, the disadvantages of intensive and extensive use of chemicals have come to light with the result that many problems such as environmental pollution, residue hazards, developing resistance in insects to pesticides, upsetting of pest balance in nature and carry over of the chemicals in food chains have been noticed. Keeping the above problems in view, it is suggested that research work in future may be intensified to develop integrated pest management (IPM) of major insect pests and diseases of mango, guava, papaya and litchi.

Diseases of mango, guava and papaya cause heavy crop loss. Although spray chemicals have been identified and concentrations have been worked out, but sometimes total control is not achieved. This may be due to attack by new strain. It is, therefore, necessary to work out the strains/ pathotypes of different fungal and bacterial pathogens of fruit crops. Critical period and peak infestation in relation to different factors need to be worked out. Epidemiological aspect of different diseases needs to be studied to evolve effective control measures. Ringspot and leaf curl of papaya which are important viral diseases need greater attention. Its virus-vector relationship, suitable control measures, resistant lines need to be investigated. Work on guava diseases especially wilt and mango malformation need to be intensified. Status of various diseases (fungal, viral and bacterial) of fruit crops in fruit growing zones need to be worked out to develop detailed disease map. Integrated disease management with chemical, biological and cultural components need greater attention.

Work on mango malformation has, so far, been done in isolation with the result, perfect control measure(s) could not be worked out. It is, therefore, necessary to follow a multidisciplinary approach involving the disciplines of horticulture, plant physiology, plant pathology and entomology. More work is required on causes and control of alternate/ irregular bearing in mango. Photosynthetic efficiency of commercial cultivars of mango and its relationship with productivity needs to be studied further.

Water requirement of mango, papaya and litchi at vegetative and reproductive phases needs to be studied. Soil moisture probe is required for studying rapid and precise movement of soil moisture *in situ*. A vast mango germplasm is available at the Institute. A large area of land is salt affected in our country. A systematic work on screening of mango rootstocks for salt tolerance is needed.

Database with respect to area, production and productivity of subtropical fruits is limited which is a must for framing a policy for horticulture development. Horticultural census/ large scale meaningful sample surveys are required to be undertaken to generate information on the above aspects.

Mango harvester developed at the Institute needs to be improved and popularised among mango growers. Mango graders suitable for different varieties need to be developed. Guava harvester is also required to be developed.

Demonstration of technologies developed should be laid out in the fruit growers' orchards. Instead of picking up a few farmers for this purpose a whole village should be adopted for such demonstrations. Information and communication technologies are quite advanced, but the Institute utterly lacks in sophisticated facilities. The Institute needs to be equipped with such facilities for better transfer of technologies to the farmers.

6. SCENARIO

6.1 Strength

After attaining self-sufficiency in foodgrain production, the emphasis has now shifted to enriching the human diets through increasing the availability of fruits to our growing population. Consequently, the country is embarking on the rapid expansion of area under fruits and increasing their productivity. As a result of concerted efforts, the area under fruits has risen from 1.22 million hectares in 1961 to 5.57 million hectares in the year 1994-95 recording an increase of 357 per cent. The production of fruits has increased from 20.4 to 47.93 million tonnes over the period 1981 to 1994-95 showing an increase of 135 per cent. The country, which accounts for about 9.8 per cent of total production of fruits in the world, has now become the second largest producer of fruits after China. While mango accounts for 22.93 per cent of total fruit production in the country, guava, papaya and litchi account for 2.90, 2.85 and 0.69 per cent, respectively.

India continues to be the largest mango producing country in the world with production of 10.99 million tonnes from an area of 1.23 million hectares during 1994-95. In fact, it accounts for 52.63 per cent of the total mango production of 19 million tonnes in the world. Andhra Pradesh is the largest producer of mango with a production of 3.07 million tonnes followed by Uttar Pradesh, Bihar and Karnataka which produce 2.39, 1.79 and 0.92 million tonnes, respectively. The country produces choicest varieties of mango, which have great potential for export to other countries. Due to diverse climate in different regions, mango is available from one or the other region of the country for almost six months in a year. The Institute has a very large collection of germplasm of mango numbering 650 accessions. These varieties are being used effectively for breeding suitable varieties with desirable traits, viz. dwarf trees for high density planting, red coloured fruits, long shelf life, better processing quality and resistance against diseases and pests for domestic as well as export markets.

Work on finding a solution to mango malformation has already been started with multidisciplinary approach. Various aspects of causes and control of mango malformation are being studied. 'Elaichi' a mango cultivar has been identified as almost free from floral malformation. This character of 'Elaichi' will be transferred to commercial varieties of mango. Breeding for regular bearing and red coloured varieties for export has been going on and a hybrid CISH-M-1 with red coloured fruits has been developed which holds promise

for export. Tree No. 3 of Dashehari has been identified as high yielding and regular bearing clone, which has been named as Dashehari-51. Some dwarfing rootstocks have been identified and the technology will be refined through further testing with different mango varieties. High density planting in mango using pruning, dwarf variety and use of chemicals is being standardized to give an ideal high density system for increasing productivity per unit area of land. The Institute has also planned to identify mango rootstocks/varieties suitable for waterlogged and sodic soils. Programme on development of integrated pest management to control fruitfly and other pests has been taken up. Fruitfly free zone is also being identified.

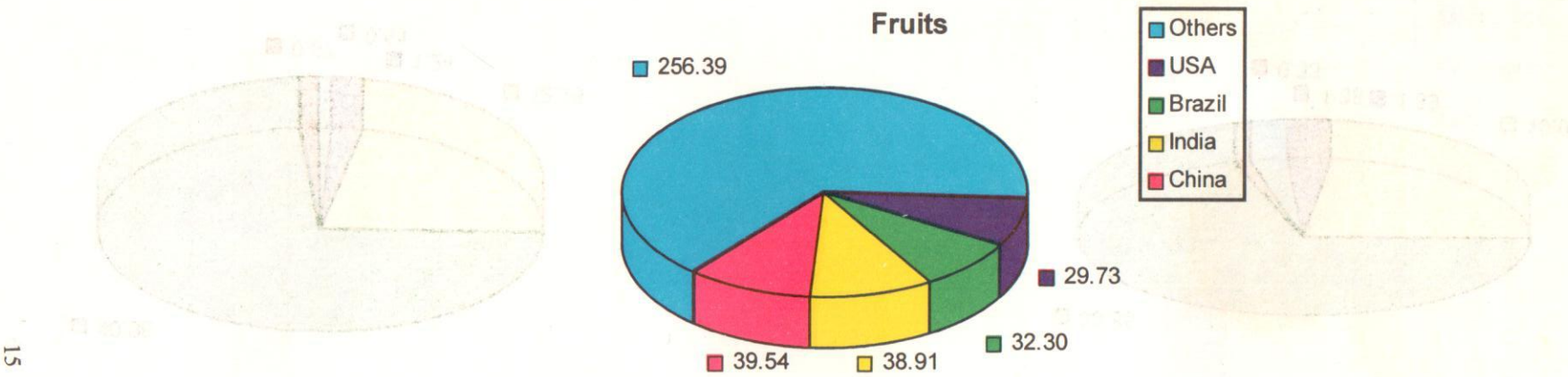
Guava is a very hardy fruit and can tolerate waterlogging. Moreover, it is suitable for problematic soils and marginal lands. It is cultivated in about 0.12 million hectares with production of 1.27 million tonnes during 1994-95. While Bihar is the largest producer of guava with production of 0.32 million tonnes, Uttar Pradesh, Karnataka and Andhra Pradesh produce 0.17, 0.15 and 0.10 million tonnes of guava, respectively. Due to considerable research efforts already put in, the cultivars Allahabad Safeda and Sardar have found wide adaptability at the farmers' fields. The Institute has good germplasm collection consisting of 54 varieties of guava and 7 species of *Psidium*. Concerted efforts are being made to evaluate, characterize and use them in breeding programme to produce varieties with desirable characteristics like attractive colour, high yield, less and soft seeds, long shelf life, wilt resistance, etc. The Institute has developed a selection, CISH-G- 1, which has deep red coloured uniform sized fruits and holds promise for export. *Gliocladium roseum* has been identified as a possible cause of guava wilt. Work on control/ management of guava wilt is in progress.

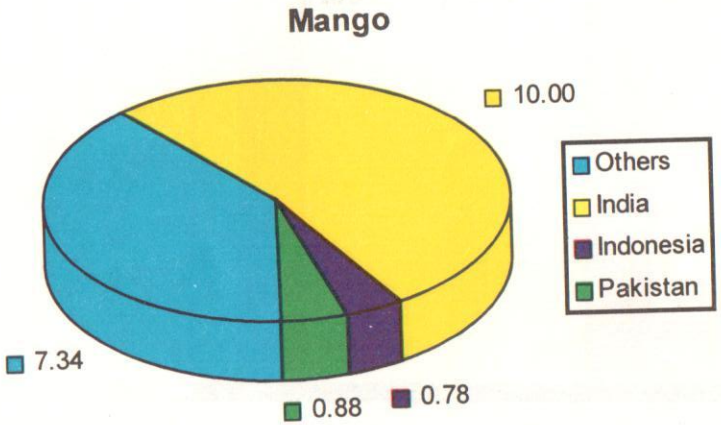
Brazil is the single largest producer of papaya in the world contributing 34.29 per cent of total production of 5.25 million tonnes followed by Nigeria, Cyprus and Mexico contributing 9.52, 9.33 and 8.76 per cent, respectively. India ranks fifth with 6.86 per cent of total world papaya production. The area under papaya has increased from 16.05 to 60.98 thousand hectares during the period 1965 to 1994-95 depicting a growth of 280 per cent. Similarly, the production has increased from 2.5 to 13.73 lakh tonnes during the period showing an increase of 449 per cent. While Karnataka is the largest producer of papaya with production of 0.43 million tonnes, Bihar, Andhra Pradesh and Uttar Pradesh produce 0.12, 0.06 and 0.02 million tonnes of papaya, respectively. Considerable advancement has been made all through the world towards the improvement of papaya. The fruit has adapted well in our country. Its demand is likely to increase tremendously owing to its therapeutic and nutritional qualities.

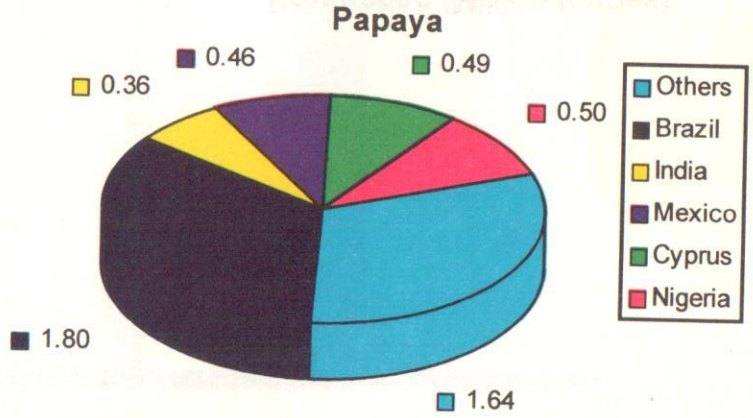
The Institute has made a good collection of papaya germplasm. Interspecific hybridization is being done to develop cold and ringspot virus resistant varieties. Embryo rescue technique will be used to get a large number of hybrids.

World fruit production during 1995

(Million tonnes)

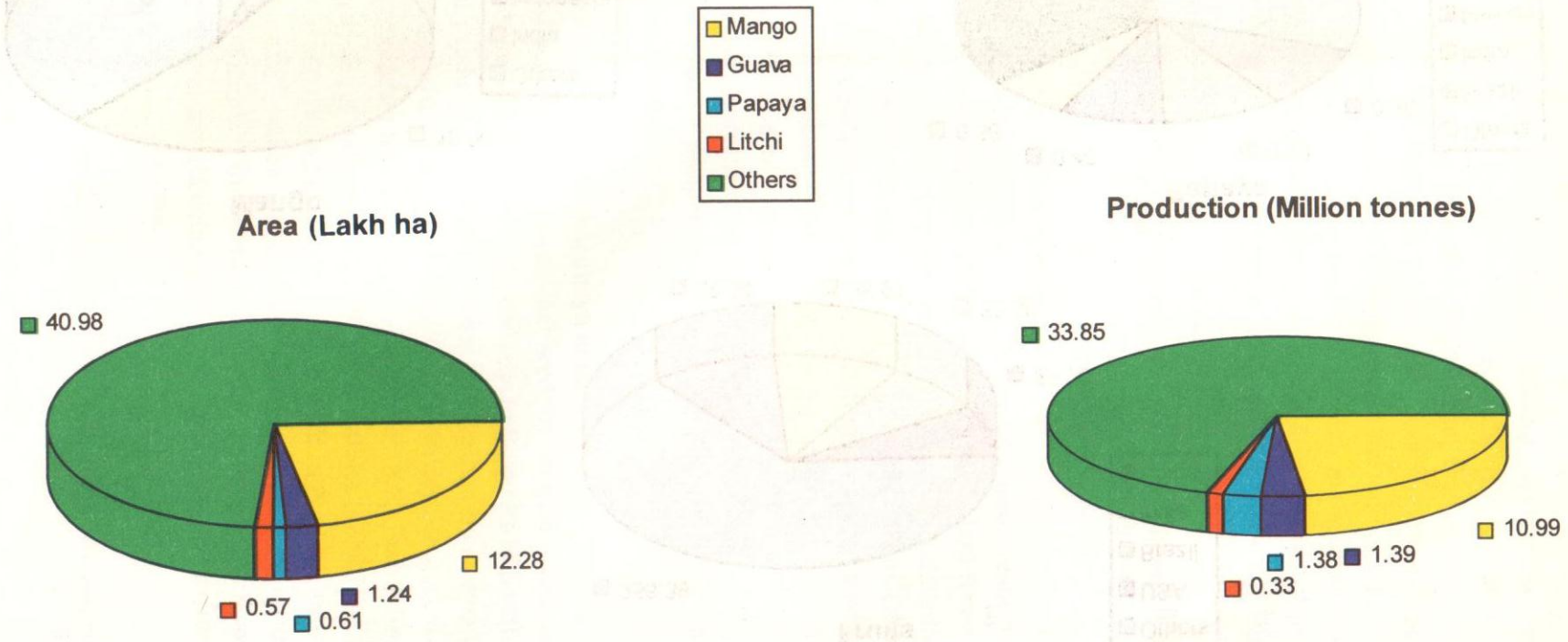






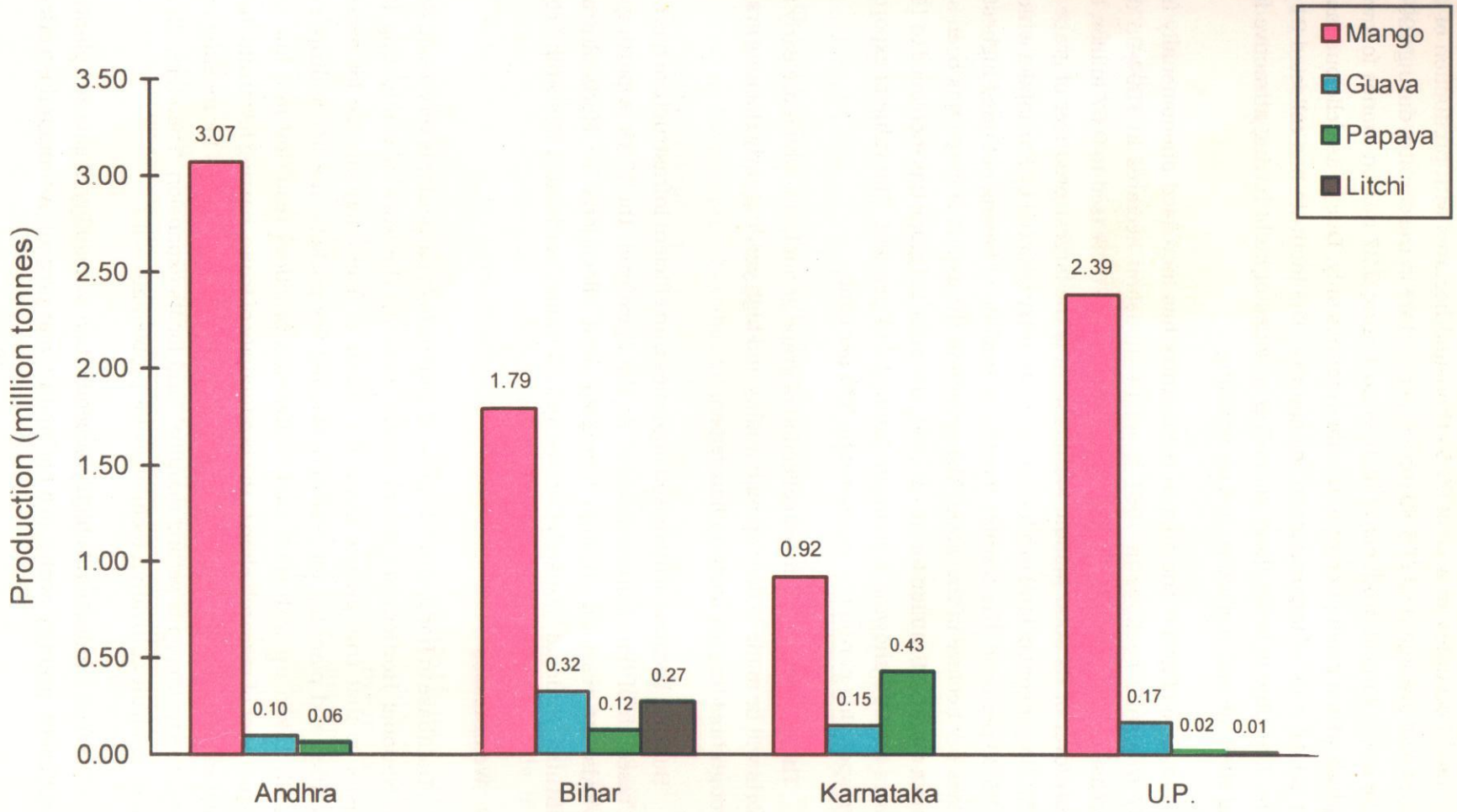
(Source : FAO Yearbook - Production, Vol. 49, 1995)

Area and production of fruits in India during 1994-95



(Source : National Horticulture Board)

Statewise production of different fruits in India during 1994-95



(Source : National Horticulture Board)

Litchi occupies an area of 56.54 thousand hectares with production of 0.33 million tonnes and average yield of 5.89 tonnes per hectare in the country during 1994-95. Bihar is the single largest producer of litchi contributing 0.27 million tonnes followed by Uttar Pradesh with a production of 0.01 million tonnes only. Due to its delicious taste, the fruit has gained a lot of importance in the country. The Institute has collected 21 varieties of litchi. Breeding is being done to develop varieties of litchi having attractive fruit colour, long shelf life and resistance to fruit cracking.

In case of grape, the area in the country has increased phenomenally from a mere 2.27 thousand hectares in 1961 to 42.14 thousand hectares in 1994-95 denoting an increase of 1756 per cent. The production has also increased to 0.67 million tonnes with a turn over of Rs 8000 million. Maharashtra is the largest producer of grape accounting for 52.08 per cent of total production in the country followed by Karnataka which accounts for 25.30 per cent. The country has the distinction of having obtained highest yield of 96 tonnes per hectare in the world. The growth in the export of grape has been spectacular. From a mere 5.35 million tonnes in 1991, the export of grape has increased to 16.81 million tonnes in 1995 showing a quantum jump of 214 per cent. The value of export during the corresponding period has increased by 374 per cent.

The Institute has started collection of grape germplasm, which are early in ripening. Efforts will be made to develop high quality and high yielding early ripening grape varieties through breeding for north Indian region.

Besides, because of increased awareness, an efficient infrastructure has been created for research of horticulture in India. At the apex level, the ICAR is putting extra effort towards the research through increased fund allocations for Horticultural Research Institutes, National Research Centres and All India Coordinated Research Projects.

6.2 Weaknesses

Database in horticulture in general and fruits in particular is very weak. Some agency like National Horticulture Board should take up the work of conducting Horticulture census so that true picture about the status of fruits may emerge for deciding on the priorities and planning for research. Barring few pockets, the horticulture enterprise is usually taken up with traditional cultivation practices resulting into low productivity. Despite a lot of research efforts, the productivity of fruits, barring few fruits, has remained stagnant. Since the prime land is usually put under food crops for meeting food requirement, the fruit crop is getting marginal land for its expansion. Therefore, there is a need to develop fruit cultivation technology for problematic soils.

The fruit production is highly dependent on availability of genuine planting material in sufficient quantity, which is a big limitation at present. Although the work is going on,

proper rootstocks for mango, litchi and guava are yet to be identified. Propagation of these fruits are still being done on assorted rootstocks.

Mango

Although a large number of germplasm is available in the Institute, there exists scope for collection of more germplasm including *Mangifera* species from indigenous and exotic sources.

One of the important objectives of mango research is to increase productivity. Mango malformation and irregular bearing are the main impediments in increasing productivity and production. Mango industry also needs off season bearing varieties to maintain supply of fruit almost throughout the year. Absence of dwarfing rootstocks and dwarf varieties in mango has not made it possible to practice high density orcharding in all mango growing regions of the country. Rootstoks/varieties have not yet been identified for waterlogged and sodic soils. Export markets demand attractive red coloured varieties of mango which we are lacking at present.

Fruitfly infestation of Dashehari and other commercial varieties of mango is an important bottleneck in export. Conventional method of mango breeding is a slow process and even a large number of crosses do not result in required number of hybrids.

Nutrient, water and pest management are important components of production technology. Work on these aspects have been done in isolation and no perfect answers are available to problems on these aspects.

Similarly, the new techniques of propagation like veneer and soft wood grafting are yet to reach the farmers or yet to be adopted. The need of the hour is to produce dwarf trees either through breeding efforts or through use of dwarfing rootstocks or through use of chemicals. Some sort of regulatory body to certify the planting material needs to be established so that right material may reach the farmers.

Since north Indian mango varieties do not have attractive red coloured fruits and have a short shelf life, they are not able to reach the export markets. There is an urgent need to broadbase the export basket through developing varieties with attractive red coloured fruits and increasing the shelf life of the fruits significantly. This will also increase the availability of mangoes over a longer period, thereby increasing the exports both in terms of quantity as well as value over the current exports which are virtually stagnating. Presently, the mangoes are available only for about 5 to 6 months from April to September. During this period, mango has to face stiff competition from the temperate fruits in the European market. The efforts may be made to increase the availability period of the mangoes. The freight structure for export of Indian mangoes is not favourable vis-a-vis competing countries. The fruit markets are not regulated and hence the farmers may not be getting sufficient price for their produce.

Guava

In guava, wilt is a major problem. Its causes and control measures are not yet known. Moreover, varieties with fruits having red coloured skin and pulp are not available. These characters are required for export of guava. Germplasm collection of guava needs to be enriched by introducing from exotic sources.

Papaya

In papaya, frost is a serious problem under north Indian conditions. Ringspot virus is also a problem which causes tremendous loss to crop. Non-availability of pure seeds is another problem in papaya. Germplasm needs to be collected from exotic sources.

Litchi

Non-availability of high yielding good quality litchi varieties with attractive red coloured fruits having long shelf life and resistant to cracking is an important weakness in litchi. Discolouration of fruit skin after harvest mars the quality of litchi fruits.

Grape

Northern India is a potential region of the country for growing grape. This part of the country needs high yielding, high quality varieties which ripen much before the onset of monsoon rains, which are not available at present.

The Institute at present does not have proper infrastructural facilities like laboratory building, cold storage, processing hall and state-of-the art equipments. Further expansion of the orchard is not getting possible at present because a lot of land at the experimental farm is still undeveloped.

Training of scientists in reputed national and international institutions in advanced areas of research to improve their skill is needed.

The fruits, in general, are highly perishable and their production is concentrated within a small period causing glut conditions in the market. This causes fruit loss to the extent of 20 to 40 per cent. This glut could be utilized towards processing. However, only about one per cent of the fruit production is processed. On the other hand, 70 to 90 per cent fruits are processed in the developed countries. This calls for development of efficient processing technologies and their dissemination to the end users. The mango processing industry is practically dependent on Totapuri variety. There is a need to identify other varieties for processing which are high yielding and are cheaper in comparison to commercial table varieties.

The farmers are also incurring loss in terms of quality and value as they do not resort to proper sorting and grading. Currently, conventional trucks are being used for movement of fruits. This results into considerable loss due to temperature build up and strain

sustained by the fruit during transportation. Similarly, the packing practices are traditional, which are not able to protect the fruit but use wood which is getting scarce and costly with the passage of time. Therefore, efforts should be made to develop alternate packages. The conditions need to be standardized for packing, cool chain and temperature controlled transportation so that the fruit reaches the consumer in prime condition.

When we attempt to increase productivity, production and quality of fruit, we must develop technology for postharvest management. An integrated postharvest management system needs to be developed.

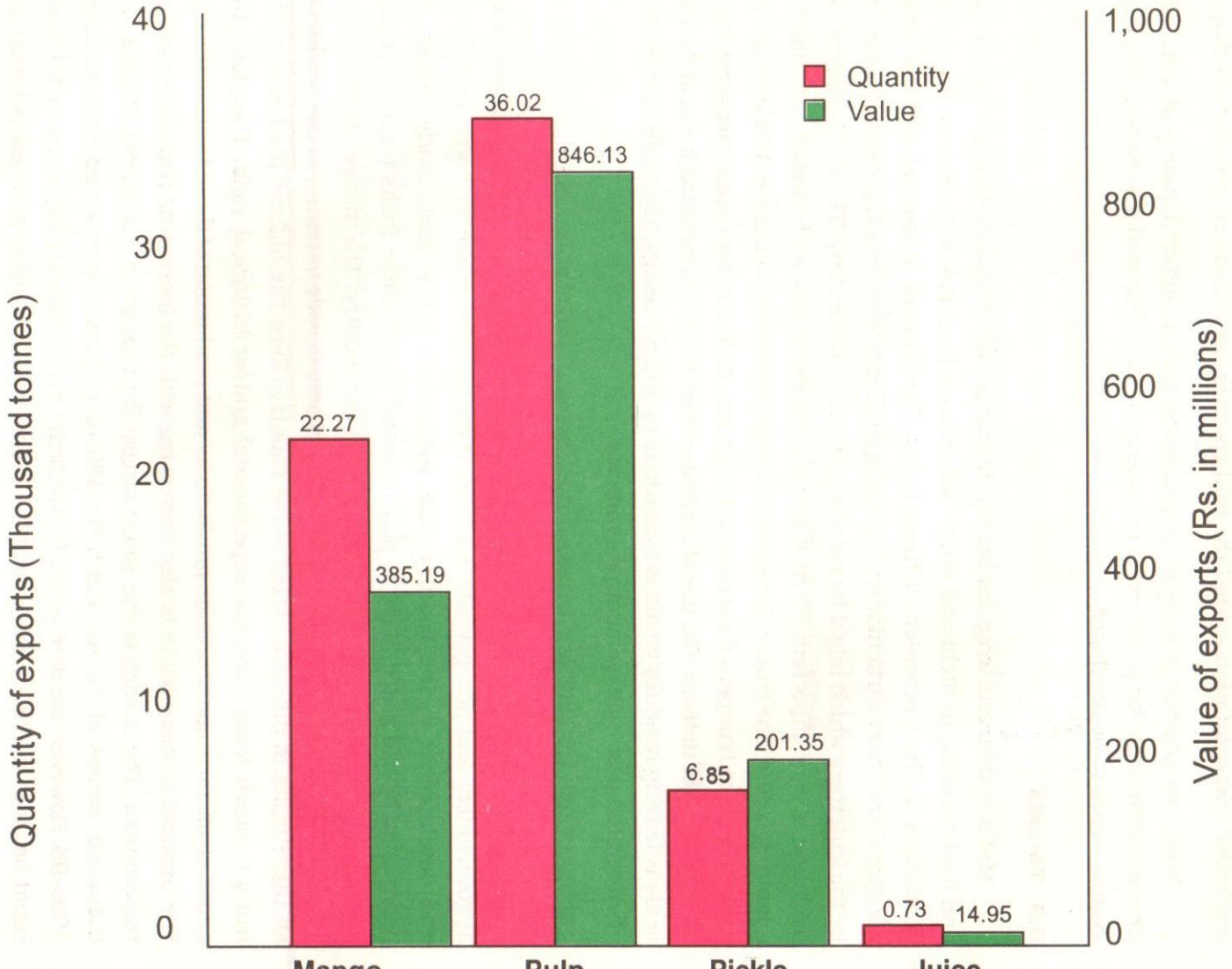
6.3 Threats

Malformation and irregular bearing in mango, wilt in guava, ringspot virus in papaya and fruit cracking in litchi and grape, which have been evading solution, are the biggest challenges in the cultivation of these fruits. The farmers in general and the small and marginal farmers in particular are not using fertilizers to replenish the nutrients exhausted by the fruit trees which might be resulting into low productivity. The availability of assured irrigation is very important for fruit growth and development. However, this has become a limiting factor. The fruit cultivation is highly dependent on nature. While wide variation in temperature hampers flowering and fruit set, dust storms cause excessive fruit drop and reduce productivity. The use of excessive chemicals for producing fruits at the farmers' fields is leaving residues which is hazardous to human beings. This calls for development of integrated pest management programmes.

6.4 Opportunities

With the increased awareness and importance being attached to horticulture, both at government and non-government level, there is a vast scope for horticultural research and development in the country. The subtropical fruits, particularly mango, guava, papaya, litchi and grape, have to play a pivotal role as these fruits together account for 30.77 per cent of the total fruit production in the country. The mango alone accounts for about 22.93 per cent of the fruit production. There is wide variation in the productivity of all these fruits in different states of the country. Even the highest productivity of these fruits is much lower than the experimental and/or biological yield. Therefore, there is ample scope for augmenting the productivity and production of these fruits in the country. The demand of these fruits is also increasing with the increasing population and export requirement. The mango is the single largest fruit exported from India. A total of 22.27 thousand tonnes of mango worth Rs 385.19 million was exported from India during 1995-96. However, the time series data indicate that it has virtually stagnated. The exports could be given a fillip by enhancing the export basket to other choicest cultivars besides Alphonso, increasing the period of availability and exploiting the hitherto unexploited international markets like Europe and America. This calls for development of export quality varieties and postharvest technologies. The export of papaya, guava and litchi are of recent

Export of mango and its products from India during 1995-96



(Source : Monthly statistics of the foreign trade of India, Vol. 1 - exports and re-exports, March, 1996)

origin and require concerted effort towards advertisement, market enhancement and development of suitable varieties and postharvest technologies. The export performance of grape has been spectacular as it increased from a mere 5.348 thousand tonnes worth Rs. 85.508 millions in 1990-91 to 16.813 thousand tonnes worth Rs. 404.899 millions in 1994-95. Thus, growth of 214 and 374 per cent in quantity and value of exports, respectively has taken place. The export of grape is likely to increase further due to its wider acceptability internationally.

Amongst the processed products, mango pulp is the most important. Its export has increased from 19.50 thousand tonnes worth Rs. 270.76 millions in 1990-91 to 36.02 thousand tonnes worth Rs. 846.13 millions in 1995-96 depicting an increase of 84.74 and 212.50 per cent, respectively. Mango pickle and Juice are other processed products exported from India. With the rapid pace of economic development taking place in the country the domestic demand for processed products is likely to increase rapidly. Since the Institute is embarking on the task of collecting world germplasm of these fruits, there are vast opportunities to develop suitable varieties for foreign and domestic markets. The development agencies' infrastructure network at macro and micro level has to live up to the expectations in transferring the technology to end users efficiently towards the balance development of this industry. The opening of the economy in the post GATT scenario has not only paved the way for introduction of technologies from developed world at a quicker pace but has thrown the challenges to researchers to do better and has provided them international exposure right at their door steps. The tissue culture techniques have opened up wide vistas by not only providing true to type multiplication of planting material rapidly, but also providing virus free plants to the farmers. This technique can also be used for conserving the genetic resources. Similarly, integrated pest management has tremendous potential as it discourages use of hazardous chemicals and lays more emphasis on natural control.

With the advent of drip irrigation systems for fruit trees, the farmers will be able to produce quality fruits with limited irrigation resources. The government is already providing heavy subsidy for its installation at farmers' fields. Therefore, there is tremendous scope of increasing productivity, its utilization and preventing postharvest losses resulting into increased availability of these fruits for domestic consumption and export as fresh and processed products through integrated approach in research and development.

The availability of mangoes is only for a short period in a year which limits export. Efforts are required to be made to increase the availability of mangoes round the year by developing suitable varieties and by exploiting climatic conditions in different regions of the country.

7. PERSPECTIVE

By the year 2006, the Institute will have all the available world germplasm of mango. Characterization, evaluation and cataloguing of the world germplasm will be completed by the year 2016. Collection of *Psidium* species and guava varieties will be completed by the year 2002 and their characterization, cataloguing and evaluation will be completed by 2011. Collection of papaya varieties and *Carica* species will be completed by 2011, and by 2016, the characterization, cataloguing and evaluation of germplasm will be completed. The Institute will have all the world germplasm of litchi by 2007. Characterization, cataloguing and evaluation of germplasm will be completed by 2011. The early ripening varieties of grape (*Vitis* sp.) will be collected by 2006 and their characterization, cataloguing and evaluation will be completed by 2011. Genetic resource information database of mandate fruits will be available with the Institute on national and international levels. Identity of genotypes of mandate fruits will be established by using molecular tagging technology.

High yielding, regular bearing varieties of mango having attractive red coloured fruits, longer shelf life, etc. suitable for export and processing will be available at the Institute. The Institute will be in a position to make available malformation free varieties of mango and hormonal and cultural control of malformation. Guava varieties resistant to wilt, with red fruit skin and pulp, soft and less seeds and having long shelf life will be available. Papaya varieties resistant to ringspot virus, *Phytophthora* and tolerant to frost will be available with the Institute for supplying to farmers.

In vitro propagation techniques will be standardized which will make possible the mass multiplication of mango, guava and litchi plants and conservation of germplasm.

Integrated nutrient and water management programmes which will give a complete information on leaf nutrient standards, plant nutrient requirement, source of nutrients, increasing fertilizer use efficiency and water requirement and judicious use of water will come up in mango for adoption. Rootstocks of mango, guava and litchi for dwarfing and suitable for waterlogged and sodic soils will be available. Rootstocks of guava having resistance to wilt will also be available for grafting commercial guava varieties on them.

High density planting system in mango, guava and litchi using dwarfing rootstocks and by canopy management by pruning and chemicals will emerge which will increase yield per unit area of land.

Integrated pest management programme in which biocontrol will be one of important components for the management of mango hopper, mealy bug, fruitfly, etc. will be available for adoption. By analysing pesticide residue in fruits, it would be possible to market fruits with minimum permissible limit of residues. Forecasting models for insect pests and diseases will be available for taking preventive measures against their occurrence.

Postharvest management of fruits is an important aspect. Through an integrated approach, i.e., working out maturity of fruits, optimum low temperature for long shelf life, methods of harvesting, handling, packaging and transportation, utilization of by-products for various purposes such as extraction of pectin, making alcohol, other products and animal feed, a complete postharvest management system will be available.

Export of fresh fruits and processed products will increase manifold by developing suitable varieties and postharvest management system.

Tools and implements such as harvester, grader, peeler, drier, etc. will be available for increasing efficiency of various processes.

The technologies developed by the Institute during perspective plan period will be transferred to end users and it is envisaged that the new technologies will be adopted by the farmers.

It is expected that the implementation of the plan will increase yield, quality of fruits, ensure better postharvest management of fruits, increase exports, provide eco-friendly pest and nutrient management systems.

While working in the field of molecular biology, the Institute will be in a position to produce plant material of papaya having desired gene(s) through genetic engineering.

8. ISSUES AND STRATEGIES

1. CROP IMPROVEMENT

The strategy is to conserve varietal wealth and superior seedling germplasm of mango for future use. Screening of genotypes against diseases, pests and for their suitability for processing will be done. Conventional methods and biotechnological methods will be used to achieve the objectives of crop improvement.

In guava, the strategy is to conserve varietal wealth for future use. Screening of *Psidium* genotypes/species against wilt will be done for their suitability as rootstocks. Genes responsible for intense desirable characters, viz. fruit colour, quality, dwarfness, yield, etc. will be transferred to the hybrids.

The strategy in papaya is to transfer genes for frost and PRV resistance from wild species of *Carica*, viz. *Carica candamarcensis* and *Carica cauliflora* to cultivated varieties of *C. papaya* by hybridization and to induce genetic changes through mutations in commercial cultivars for frost and PRV resistance.

The strategy in other subtropical fruits like grape and litchi is to collect important varieties/hybrids/selections from different parts of the country and abroad to evaluate the introduced materials to select the promising cultivars having high yield, good fruit quality

and resistance to important pests and diseases and to develop new hybrids for this region of the country.

2. CROP PRODUCTION

The main issue is to increase productivity and production and also to improve the quality of mandate fruits. This will be achieved by adopting the following strategies:

i) To develop integrated nutrient management programme and to prepare ready reckoner.

ii) To develop dwarfing rootstocks for increasing the tree number per unit area.

iii) To screen *Psidium* genotypes/species against wilt for their suitability as rootstocks resistant to wilt.

iv) To standardize planting density and pruning time in mango.

v) To find out chemicals and their doses for regulating crop of guava for maximizing production.

vi) To standardize the time of planting of papaya for higher production and for escaping mosaic/PRV.

vii) To find out hormonal imbalances, isolation and characterization of mangiferin compounds and malformin like substances, biochemicals and metabolites involved in mango malformation and their effective control.

viii) To study regulation of flowering through growth regulators (PP333/ uniconazol), photosynthetic efficiency in different cultivars of mango, guava, papaya, improvement in source-sink relationship, causes for low productivity and the physiological and biochemical basis towards the development of stress resistant varieties of subtropical fruits.

ix) To conduct physiological studies on growth and development, cracking of fruits, fruit setting in litchi, sex expression, fruit setting and prevention of fruit drop in papaya, and the physiology of fruits on trees and physiological losses during ripening.

x) To optimise irrigation water and irrigation scheduling in mandate crops and to study microirrigation system for these crops *in situ* water harvesting.

xi) To study root system, feeding roots, feeding zones, time of maximum root activities to ensure higher and efficient uptake of nutrients.

xii) To develop fruit based cropping systems.

xiii) To screen rootstocks for salt tolerance to provide scope of increasing area under fruit trees by planting in salt affected soils.

xiv) To study the effect of phosphorus solubilizing microorganism (PSM) and vesicular arbuscular mycorrhizal fungi (VAM) alone and in combination on phosphorus uptake, growth and productivity of the plants (mango, papaya, litchi, grape and lime).

xv) To standardize micropropagation techniques in mandate crops.

3. CROP PROTECTION

The issue involves providing a complete protection to mandate fruit crops through chemical and/or biological means or by using plant products against insect pests and diseases. The following strategies will be adopted to solve the issue:

i) To find out the IPM schedule of major pests of mandate fruits.

ii) To find out important and useful bioagents, viz. parasites, predators and insect pathogens of major pests and their field applicability to control these pests.

iii) To find out resistant or less susceptible cultivars of mango, guava and papaya against major pests.

iv) To develop control measures of two serious pests, viz. mango fruitfly and stone weevil which are important from export point of view.

v) To layout large scale field trials to test the efficacy of plant products, viz. neem products, *Alpinia* sp. and essential oils.

vi) To develop pest forecasting mechanism, ETL and assessment of losses.

vii) To develop strategies to control plant parasitic nematodes of papaya and grape.

The following strategies will be followed for controlling diseases:

i) To ascertain the causes of diseases specially mango malformation and guava wilt.

ii) To develop epidemiological parameters for fungal, bacterial and viral diseases for developing suitable forecasting models.

iii) To detect the variability and establish pathotypes of various disease causing pathogens.

iv) To find out IPM control schedule of major diseases of mango, guava, papaya and grape with special reference to biological control.

v) To detect the tolerance limit and residue analysis of fungicides/bactericides in fruits and its products.

4. POSTHARVEST TECHNOLOGY

The major issue involves development of integrated postharvest management technology. The issue can be resolved by adopting following strategies:

i) To develop maturity standards, and to develop harvesting methods, harvesters and graders.

ii) To develop suitable packages and packaging methods for domestic and foreign markets.

iii) To find out storage atmosphere for increasing shelf-life.

iv) To develop new processing technology and new processed products (mango puree, blending of juice/pulp for colour, mango fruit bars and guava puree).

v) To assess losses occurring in handling, storage and transport.

vi) To study rheological properties of fruits.

vii) To develop complete packaging line for export of fruits.

viii) To develop complete package of procedures for exportable quality of mango and litchi.

ix) To apply postharvest coating of films (bioagents) on fruits to increase shelf-life.

x) To determine preharvest factors for improving postharvest quality of fruits.

xi) To develop quality control methods for fresh and processed products including pesticide residue.

5. TRANSFER OF TECHNOLOGY

Criticism often appears in the communications media that the technologies developed in various fields remain confined to labs. The most important issue related to technologies developed is their effective transfer to those for whom they have been developed. This issue can be tackled by adopting the following strategies:

i) To transfer technologies through demonstrations, radio and T.V. talks, farmers' *gosthis* and exhibitions.

ii) To adopt whole village for transfer of technologies.

iii) To evaluate transfer of technologies and their impact on users' economy.

9. PROGRAMMES

9.1 Time Frame

1996-2000

MANGO

CROP IMPROVEMENT

i) Collection of genetic resources, especially dwarf and coloured ones and elite clonal plants from within India, USA, Israel, Philippines and South Africa and to evaluate them.

ii) Characterization and cataloguing of genetic resources collected.

iii) Screening of germplasm for resistance to pests and diseases and for processing.

iv) Development of hybrids through conventional and nonconventional methods of breeding.

v) Multilocational trials of Dashehari-51 and Dashehari-35.

vi) Further evaluation of promising hybrid CISH-M-1.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards in U.P. and collection of samples for analysis.

ii) Development of integrated nutrient management programme.

iii) Conducting fertilizer (organic, inorganic and biofertilizer) trials.

iv) Screening of rootstocks for dwarfing, salt tolerance and waterlogged soils.

v) Standardization of clonal propagation.

vi) Developing high density planting and pruning systems for Dashehari, Langra, Chausa and Mallika.

vii) Studies on rejuvenation of old unproductive orchards.

viii) Developing integrated water management programme

a) Determining water requirement at different stages of plant and fruit growth.

b) *In situ* water harvesting through efficient rain water management (water conservation, mulching, etc.).

ix) Pollinator ecology, conservation and management of pollinators including artificial rearing and release of pollinators.

CROP PROTECTION

i) Developing integrated pest management (IPM) for insect pests (hopper, mealy bug, inflorescence midge and fruitfly) and diseases (powdery mildew, anthracnose, bacterial canker and sclerotium rot of seed).

ii) Developing forecasting models for insect pests (hopper, inflorescence midge, fruitfly and mealy bug) and disease (powdery mildew).

iii) Identifying alternate host plants for insect pests (fruitfly, hopper and mealy bug).

iv) Working out economic threshold levels (ETL) of insect pests (hopper and mealy bug) and diseases (powdery mildew and anthracnose).

POSTHARVEST TECHNOLOGY

i) Developing harvesting methods, harvester, graders and peeler.

ii) Developing maturity indices of fruits.

iii) Developing methods of handling and packaging.

iv) Screening packages for fresh fruits and processed products.

v) Developing integrated technology for increasing shelf life of Dashehari, Langra, Chausa, Mallika and Amrapali.

vi) Developing and improving processing technologies for processed products like puree, fruit bars, blends, slices, powder, pickles, etc. including minimally processed products.

vii) Developing complete processing line for producing export quality fruit products.

viii) Developing processes for making value added products from fruit wastes.

ix) Assesment of postharvest losses.

x) Developing technology for minimising postharvest losses.

xi) Determining rheological properties of Dashehari, Langra, Chausa, Mallika and Amrapali.

xii) Studying existing marketing system and developing better marketing technology.

xiii) Developing complete package of procedure for producing export quality fruits by pre and postharvest operations.

xiv) Developing complete packaging line including on-farm storage of fruits.

xv) Developing quality control protocol for fresh and processed products.

xvi) Finding out non-chemical control measures, including bioagent coating of fruits, of postharvest diseases (anthracnose and stem end rot).

BIOTECHNOLOGY

i) Standardization of *in vitro* propagation technique.

TRANSFER OF TECHNOLOGY

i) Adoption of whole village for transfer of technology

a) Gulabkhera

b) Sahlamau

ii) Impact studies of transferred technologies.

GUAVA

CROP IMPROVEMENT

i) Collection of genetic resources, especially dwarf, red coloured (skin and pulp), wilt resistant and elite clonal plants from within India (U.P., Bihar and Karnataka) and abroad (Hawaii, Seychelles, Brazil, Thailand, Mexico and Philippines) and to evaluate them.

ii) Characterization and cataloguing of genetic resources collected.

iii) Development of improved varieties with red coloured fruit skin and pulp, soft and less seeds and longer shelf life through selection and hybridization.

iv) Evaluation of hybrids.

v) Further evaluation of promising selections CISH-G-1, CISH-G-2 and CISH-G-3.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards of different regions and collection of soil and leaf samples for analysis.

ii) Development of integrated nutrient management programme. Fertilizer trials (organic, inorganic and biofertilizers) with cvs Sardar and Allahabad Safeda.

iii) Developing guava based cropping system.

iv) Screening of rootstocks for dwarfing and salt tolerance.

CROP PROTECTION

i) Development of IPM for insect pests (fruit borer and fruitfly).

ii) Developing forecasting model for fruitfly.

POSTHARVEST TECHNOLOGY

i) Developing harvesting methods, harvesters and graders.

ii) Standardizing maturity indices of fruits.

iii) Developing method of handling and packaging.

iv) Screening of packages for fresh and processed products.

v) Developing integrated technology for increasing shelf life of fruits.

vi) Developing and improving processing technology for processed products such as guava puree, guava based blends, guava juice and minimally processed products.

vii) Developing on-farm storage technology.

viii) Assessment of postharvest losses.

ix) Studying existing marketing systems and developing better marketing technology.

BIOTECHNOLOGY

i) Standardization of *in vitro* propagation technique.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technology to orchardists by adopting a whole village.

PAPAYA

CROP IMPROVEMENT

i) Collection of genetic resources including cold tolerant and papaya ringspot virus (PRV) resistant ones from India (Tamil Nadu, Bihar and Karnataka) and abroad (Hawaii, Mexico, Venezuela, Thailand and Costa Rica) and to evaluate them.

ii) Characterization and cataloguing of genetic resources.

iii) Developing cold tolerant and PRV resistant hybrids by conventional and non-conventional breeding methods.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards and collecting soil and leaf samples for analysis.

ii) Determining planting time for possible escape from PRV.

CROP PROTECTION

i) Developing control measures for nematodes.

ii) Developing control measures for *Phytophthora* sp., *Phythium* sp. and *Rhizoctonia* sp.

iii) Management of papaya ringspot virus through various methods, including cross protection.

POSTHARVEST TECHNOLOGY

i) Developing processed products such as papaya based blends, papaya fruit bars, etc.

ii) Screening suitable packages for fresh and processed products.

iii) Developing minimally processed products.

iv) Assessment of postharvest losses.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technology to end users.

LITCHI

CROP IMPROVEMENT

i) Collection of genetic resources including dwarf and environment non-specific varieties for wider adaptability from India (Bihar, Assam, Tripura, Punjab, H.P. and West Bengal) and abroad (China) and to evaluate them.

ii) Characterization and cataloguing of germplasm collected.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards and collecting samples for analysis.

CROP PROTECTION

i) Developing control measures for mite and fruit borer.

POSTHARVEST TECHNOLOGY

i) Prevention of discolouration of fruit skin.

BIOTECHNOLOGY

i) Standardization of *in vitro* technique for propagation.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technology to orchardists.

GRAPE

CROP IMPROVEMENT

i) Collection of early ripening varieties from India and abroad (USA, Germany and France) and to evaluate them.

ii) Characterization and cataloguing of genetic resources collected.

PROBLEMS OF NATIONAL IMPORTANCE

MANGO MALFORMATION

i) Finding out cause (s) of mango malformation by investigating involvement of *Fusarium*, malformin, biochemicals and metabolites.

ii) Studying relationship between malformin and delayed panicle emergence.

iii) Screening of varieties for resistance to malformation.

IRREGULAR BEARING IN MANGO

i) Regulating bearing of Dashehari and Langra varieties with the use of paclobutrazol and other chemicals.

ii) Clonal selection for regular bearing in commercial varieties.

GUAVA WILT

i) Determining cause(s) of guava wilt.

ii) Screening of rootstocks tolerant/resistant to guava wilt.

iii) Breeding for developing varieties and rootstocks resistant to guava wilt.

BASIC RESEARCH

i) Studies on photosynthetic efficiency and translocation of photosynthates in mango.

ii) Stress studies in mango and guava.

PESTICIDE RESIDUE

i) Pesticide residue analysis in fruits.

2001-2005

MANGO

CROP IMPROVEMENT

i) Collection of remaining genetic resources from within the country and abroad and to evaluate them.

ii) Evaluation of genetic resources, characterization and cataloguing.

iii) Development of hybrids through conventional and non-conventional breeding methods for regular bearing, high yielding, high quality, disease resistance and rootstocks suitable for saline soils and waterlogged conditions.

iv) Evaluation of hybrids.

v) Multilocational trials of promising hybrids.

vi) Continuation of multilocational trials of regular bearing clones.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards in Bihar and collection of soil and leaf samples for analysis.

ii) Developing integrated nutrient management programme

a) Conducting fertilizer trials (inorganic, organic and biofertilizer) on Dashehari, Langra, Mallika and Amrapali varieties.

b) Preparing nutrient standards, nutrient guide and nutrient ready reckoner for U.P.

iii) Screening rootstocks for dwarfing, salt tolerance and waterlogged conditions.

iv) Standardization of clonal propagation.

v) Developing high density planting and pruning systems for Dashehari, Langra, Chausa and Mallika.

vi) Studies on rejuvenation of old unproductive orchards.

vii) Developing integrated water management programme

a) Determining system of irrigation (drip, sprinkler, surface, etc.).

b) *In situ* water harvesting through efficient rainwater management (moisture conservation by mulching, etc.).

viii) Studying fertigation.

ix) Pollinator ecology, conservation and management of pollinator including artificial rearing and release of pollinators.

CROP PROTECTION

i) Developing integrated pest management (IPM) programme for insect pests and diseases.

ii) Developing forecasting models for insect pests and diseases.

iii) Mass multiplication of bioagents and their field applicability.

POSTHARVEST TECHNOLOGY

i) Developing harvesting methods, mechanical harvester, grader and peeler.

ii) Screening packages for fresh fruits and processed products.

iii) Developing integrated technology for increasing shelf life of Dashehari, Langra, Chausa, Mallika and Amrapali.

iv) Developing new processing techniques and processed products like puree, fruit bars, blends, slice, pickles, etc. including minimally processed products.

v) Developing technologies for minimizing postharvest losses.

vi) Developing better marketing technology.

vii) Developing complete package of procedures, including pre and postharvest operations, for producing export quality fruits.

viii) Developing complete packaging line, including on-farm storage of fruits.

ix) Developing quality control protocol for fresh and processed products.

BIOTECHNOLOGY

i) Standardization of *in vitro* propagation of plants.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies in the adopted village.

ii) Impact assessment studies of transferred technologies.

GUAVA

CROP IMPROVEMENT

i) Continuation of collection of germplasm resources.

ii) Evaluation, characterization and cataloguing of genetic resources.

iii) Development of superior wilt resistant varieties through selection and hybridization.

iv) Development of dwarf, wilt resistant rootstocks through interspecific hybridization and aneuploidy breeding.

v) Evaluation of hybrids.

vi) Multilocational trials of promising selections and hybrids.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards and collecting samples for analysis.

ii) Preparation of nutrient standards, nutrient guides and nutrient ready reckoner.

iii) Developing integrated nutrient management programme

   a) Fertilizer trials (inorganic, organic and biofertilizers).

   b) Nutrient build up studies in the soil in long term fertilizer trials.

iv) Developing guava based cropping systems.

v) Screening rootstocks for dwarfing and for salt tolerance and waterlogged soils.

CROP PROTECTION

i) Developing IPM for insect pests fruit borer, bark eating caterpillar and fruitfly.

ii) Developing forecasting model for fruitfly.

iii) Identifying alternate hosts.

POSTHARVEST TECHNOLOGY

i) Developing harvester and grader.

ii) Screening packages for fresh and processed products.

iii) Developing integrated technology for increasing shelf life of fruits.

iv) Developing new processing techniques and processed products such as guava puree, guava based blends, guava juice and minimally processed products.

v) Developing technology for minimising postharvest losses.

vi) Quality management of fruits by pre and postharvest operations.

vii) Developing better marketing technology.

BIOTECHNOLOGY

i) Standardization of *in vitro* propagation of plants from somatic and gametic tissues.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies to adopted villages.

ii) Impact assessment studies of transferred technologies.

PAPAYA

CROP IMPROVEMENT

i) Collection of genetic resources including cold tolerant and papaya ringspot virus (PRV) resistant ones from abroad (Venezuela, Brazil and Costa Rica).

ii) Evaluation, characterization and cataloguing of genetic resources.

iii) Developing cold tolerant and PRV resistant hybrids by conventional and non-conventional breeding methods.

iv) Evaluation of hybrids and advancing the generations.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards and collecting samples for analysis from different parts in the region.

ii) Preparation of nutrient standards, nutrient guide and nutrient ready reckoner.

iii) Developing integrated nutrient management programme

a) Fertilizer trials (inorganic, organic and biofertilizers).

iv) Developing integrated water management programme

a) Determining water requirement.

b) Determining system of irrigation.

c) Fertigation studies.

v) Developing papaya based cropping systems.

CROP PROTECTION

i) Developing control measures for *Phytophthora* sp., *Pythium* sp. and *Rhizoctonia* sp.

ii) Management of papaya ringspot virus by different methods, including cross protection.

POSTHARVEST TECHNOLOGY

i) Developing new processes and processed products.

ii) Developing minimally processed products.

iii) Screening packages for fresh and processed products.

iv) Developing technology for minimising postharvest losses.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies to adopted villages.

ii) Impact study of transferred technologies.

LITCHI

CROP IMPROVEMENT

i) Collection of genetic resources.

ii) Evaluation, characterization and cataloguing of genetic resources collected.

iii) Developing hybrids through different methods of breeding for higher yield and good quality fruits and for longer shelf life.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards and collecting soil samples for analysis.

ii) Preparation of nutrient standards, nutrient guide and nutrient ready reckoner.

iii) Developing integrated nutrient management programme

a) Fertilizer trial (inorganic, organic and biofertilizers).

b) Determining method of water application (microirrigation, *in situ* rain water harvesting).

v) Developing litchi based cropping systems.

CROP PROTECTION

i) Developing control measures for mite and fruit borer.

POSTHARVEST TECHNOLOGY

i) Preventing discolouration (browning) of fruit skin and products.

ii) Assessment of postharvest losses.

iii) Developing technology for minimising postharvest losses.

iv) Developing integrated technology for preservation of fruits and processed products.

BIOTECHNOLOGY

i) Standardizing *in vitro* propagation of plantlets from different explants.

GRAPE

CROP IMPROVEMENT

i) Collection of early ripening genetic resources from USA, Bulgaria and France.

ii) Evaluation, characterization and cataloguing of genetic resources collected.

iii) Developing early ripening varieties through conventional and non-conventional breeding methods.

PROBLEMS OF NATIONAL IMPORTANCE

MANGO MALFORMATION

i) Determining cause(s) of malformation.

ii) Producing malformation, both vegetative and floral artificially.

iii) Studying effect of trizoles and other chemicals on malformation.

iv) Screening varieties resistant to malformation.

IRREGULAR BEARING IN MANGO

i) Regulating bearing with the use of paclobutrazol and other chemicals in Dashehari, Langra and Chausa.

ii) Clonal selections for regular bearing.

iii) Hybridization for developing regular bearing varieties.

GUAVA WILT

i) Finding out control/preventive measures for guava wilt.

ii) Screening of rootstocks for resistance/ tolerance to guava wilt.

iii) Breeding for developing varieties and rootstocks resistant/tolerant to guava wilt.

BASIC RESEARCH

i) Photosynthetic efficiency and photosynthate translocation studies in mango.

ii) Stress study in mango and guava.

PESTICIDE RESIDUE STUDY

i) Pesticide residue analysis in fruits.

ii) Determining ways for containing pesticide residue build up in fruits.

PESTICIDE RESISTANCE STUDY IN INSECTS

i) Pesticides resistance studies in mango hopper, mealy bug and inflorescence midge.

2006-2010

MANGO

CROP IMPROVEMENT

i) Continuation of collection of genetic resources from within the country and abroad.

ii) Evaluation, characterization and cataloguing of genetic resources collected.

iii) Development of hybrids through conventional and non-conventional methods for regular bearing, dwarfing, longer shelf life, processing, disease resistance, saline and waterlogged soils.

iv) Continuation of multilocational trials of promising hybrids and regular bearing clones.

v) Evaluation of hybrids.

CROP PRODUCTION

i) Soil and leaf nutrient surveys of orchards and collecting soil and leaf samples for analysis.

ii) Developing integrated nutrient management programme

a) Conducting fertilizer trials (inorganic, organic and biofertilizers) on Dashehari, Langra, Mallika and Amrapali.

b) Preparation of nutrient standards, nutrient guide and nutrient ready reckoner for Bihar.

iii) Studies on the effect of rootstocks for dwarfing of scion varieties.

iv) Developing high density planting and pruning system in Dashehari, Langra, Chausa and newly developed varieties.

v) Rejuvenation of old unproductive orchards.

vi) Top working of seedling trees of inferior quality.

vii) Developing integrated water management programme.

viii) Studying fertigation.

CROP PROTECTION

i) Developing integrated pest management programme for insect pests and diseases.

ii) Developing control measures for guava wilt.

POSTHARVEST TECHNOLOGY

i) Developing mechanical harvester, grader and peeler.

ii) Developing new processing techniques and processed products.

iii) Pilot testing of developed processing technology and interaction with processing industry.

iv) Developing complete package of procedures, including pre and postharvest operations for producing export quality fruits.

v) Screening different polymers and combination of polymers as packages for processed products and other materials for boxes for packaging of fresh fruits.

BIOTECHNOLOGY

i) Standardizing *in vitro* propagation of plants from different explants.

ii) Establishment of plants in the field and preparation of handling manual for *in vitro* propagation and conservation of germplasm.

iii) Mass multiplication and *in vitro* conservation of germplasm.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies to adopted villages.

ii) Impact assessment studies of transferred technologies.

GUAVA

CROP IMPROVEMENT

i) Evaluation, characterization and cataloguing of genetic resources collected.

ii) Developing varieties through selection and hybrids through conventional and non-conventional methods of breeding.

iii) Evaluation of hybrids.

iv) Multilocational trials of promising hybrids.

v) Release of improved varieties.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards and collecting soil and leaf nutrient samples for analysis.

ii) Preparation of nutrient standards, nutrient guide and nutrient ready reckoner for U.P.

iii) Developing integrated nutrient management programme

   a) Conducting fertilizer trials (inorganic, organic and biofertilizers) for newly evolved varieties.

   b) Nutrient build up studies in soil in long term fertilizer trials.

iv) Screening of rootstocks for dwarfing, salt tolerance and waterlogged soils.

CROP PROTECTION

i) Identifying alternate hosts for insect pests.

POSTHARVEST TECHNOLOGY

i) Developing new processing technology and processed products.

BIOTECHNOLOGY

i) Standardizing *in vitro* propagation techniques.

ii) Establishing plantlets in the field and preparation of handling manual for *in vitro* propagation and conservation of germplasm.

iii) Mass multiplication and *in vitro* conservation of germplasm.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies to adopted villages.

ii) Impact assessment of transferred technologies.

PAPAYA

CROP IMPROVEMENT

i) Collection of genetic resources from within the country and abroad.

ii) Evaluation, characterization and cataloguing of germplasm collected.

iii) Developing cold tolerant and PRV resistant hybrids by conventional and non-conventional breeding methods.

iv) Evaluation of hybrids and advancing the generations.

v) Screening of germplasm for *Phytophthora* resistance.

CROP PRODUCTION

i) Developing nutrient standards, nutrient guide and nutrient ready reckoner for Bihar.

ii) Soil nutrient build up in fertilizer trials.

CROP PROTECTION

i) Management of papaya ringspot virus by cross protection studies.

POSTHARVEST TECHNOLOGY

i) Developing new processes and processed products.

ii) Pilot testing of developed processing technologies and interaction with processing industry.

BIOTECHNOLOGY

i) Developing PRV resistant papaya using coat protein mediated approach.

ii) Developing molecular markers like AFLP and RAPD for identification of cultivars and improvement of breeding projects.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies.

ii) Adoption of whole village for transferring technology.

iii) Impact study of transferred technology.

LITCHI

CROP IMPROVEMENT

i) Continuation of collection of genetic resources.

ii) Evaluation, characterization and cataloguing of genetic resources.

iii) Developing hybrids through conventional and non-conventional breeding methods for high yield, good quality fruits, longer shelf life and for resistance to cracking.

iv) Evaluation of hybrids.

v) Multilocational trials of promising hybrids.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards and collecting soil and leaf samples for analysis.

ii) Preparation of nutrient standards, nutrient guide and nutrient ready reckoner.

iii) Developing integrated nutrient management programme

a) Fertilizer trials (inorganic, organic and biofertilizers).

b) Micorrhizal studies for enhancing nutrient availability to plants.

iv) Developing integrated water management programme by determining water requirement, determining system of irrigation (microirrigation, *in situ* rain water harvesting).

v) Fertigation studies.

vi) Developing litchi based cropping systems.

vii) Pruning and training and determination of number of leaves required per fruiting bunch.

viii) Screening rootstocks for dwarfing.

CROP PROTECTION

i) Developing control measures for insects pests.

POSTHARVEST TECHNOLOGY

i) Developing new processing technology and processed products.

ii) Study on browning and other basic aspects during preservation of litchi fruits and products.

iii) Assessment of postharvest losses.

iv) Developing technology to minimize postharvest losses.

v) Studying different polymers and combination of polymers as packages for processed products.

BIOTECHNOLOGY

i) Standardizing *in vitro* propagation of plants.

ii) Establishment of plantlets in the field and preparation of handling manual for *in vitro* propagation and conservation of germplasm.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies to adopted villages.

ii) Impact assessment study of transferred technologies.

GRAPE

CROP IMPROVEMENT

i) Collection of early ripening genetic resources from abroad.

ii) Evaluation, characterization and cataloguing of germplasm collected.

iii) Developing early ripening varieties through conventional and non-conventional breeding methods.

iy) Evaluation of hybrids.

v) Multilocational trials of promising hybrids.

PROBLEMS OF NATIONAL IMPORTANCE

MANGO MALFORMATION

i) Finding out control measures of malformation.

ii) Screening varieties resistant to malformation.

iii) Breeding varieties resistant to malformation.

iv) Evaluation of hybrids.

IRREGULAR BEARING IN MANGO

i) Regulating bearing with the use of chemicals.

ii) Clonal selection for regular bearing.

iii) Hybridization for developing regular bearing varieties.

iv) Evaluation of hybrids.

v) Multilocational trials of regular bearing clones and promising hybrids.

GUAVA WILT

i) Finding out control of guava wilt.

ii) Screening rootstocks for wilt resistance.

iii) Breeding for developing varieties and rootstocks resistant to guava wilt.

BASIC RESEARCH

i) Studying biochemical changes taking place during growth, flowering, fruit development and ripening of fruits in mango and guava.

ii) Studying time involved in absorption, translocation and metabolism of nutrients sprayed on foliage of mango and guava.

PESTICIDE RESIDUE

i) Pesticide residue analysis in fruits.

ii) Determining ways for containing pesticide residue build up in fruits.

PESTICIDE RESISTANCE STUDIES IN INSECTS

i) Pesticides resistance studies in mango hopper, mealy bug and inflorescence midge.

2011-2015

MANGO

i) Evaluation, characterization and cataloguing of genetic resources collected.

ii) Developing hybrids through conventional and non-conventional breeding methods for regular bearing, dwarfing, longer shelf life, processing, saline and waterlogged soils.

iii) Evaluation of hybrids.

iv) Multilocational trials of superior hybrids and clones.

v) Release of hybrids and clones for cultivation.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards and collecting soil and leaf samples for analysis.

ii) Developing integrated nutrient management programme

   a) Conducting fertilizer trial on Langra.

   b) Preparing nutrient standards, nutrient guide and nutrient ready reckoner for West Bengal.

   c) Nutrient build up (nutrient residue) study in soil in long term fertilizer trials.

iii) Screening rootstocks for dwarfing, salt tolerance, wastelands and waterlogged soils.

iv) Rejuvenation of old unproductive orchards.

v) Top working seedling trees of inferior quality.

CROP PROTECTION

i) Developing mating disruptive technique in important insects.

POSTHARVEST TECHNOLOGY

i) Developing new processing technology and processed products.

ii) Pilot testing of developed processed technology and processed products and interaction with the processing industry.

BIOTECHNOLOGY

i) Mass multiplication and *in vitro* conservation of germplasm.

ii) Developing molecular markers like AFLP and RAPD for identification of cultivars and improvement of breeding projects.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies.

ii) Adoption of whole villages for transferring technology.

iii) Impact assessment studies of transferred technologies.

GUAVA

CROP IMPROVEMENT

i) Evaluation, characterization and cataloguing of germplasm collected.

ii) Developing varieties through conventional and non-conventional breeding methods.

iii) Conducting multilocational trials of superior hybrids.

iv) Release of improved varieties.

CROP PRODUCTION

i) Developing integrated nutrient management programme for newly developed varieties.

ii) Studying performance of plants budded/ grafted on salt tolerant rootstocks in saline soils.

iii) Rootstock trial on dwarfing rootstocks using scion of different varieties.

POSTHARVEST TECHNOLOGY

i) Pilot testing (pilot project) of newly developed technology and processed products.

ii) Interaction with processing industry.

BIOTECHNOLOGY

i) Mass multiplication and *in vitro* conservation of plants.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies.

ii) Adoption of whole villages for transferring technologies.

iii) Impact assessment of transferred technologies.

PAPAYA

CROP IMPROVEMENT

i) Collection of genetic resources from abroad.

ii) Evaluation, characterization and cataloguing of germplasm collected.

iii) Screening of germplasm for *Phytophthora* resistance.

iv) Developing cold tolerant and PRV resistant hybrids by conventional and non-conventional breeding methods.

v) Evaluation of lines.

vi) Multilocational trials of improved lines.

vii) Release of improved varieties.

BIOTECHNOLOGY

i) Developing PRV resistant varieties using coat protein mediated approach.

ii) Cloning ACC synthase gene into papaya through antisense gene technology for increased shelf life.

iii) Developing molecular markers like AFLP and RAPD for identification of cultivars and improvement of breeding projects.

TRANSFER OF TECHNOLOGY

i) Transfer of technologies developed.

ii) Adoption of whole village for transfer of technologies.

iii) Impact study of transferred technologies.

LITCHI

CROP IMPROVEMENT

i) Evaluation of germplasm collected.

ii) Developing hybrids through conventional and non-conventional breeding methods.

iii) Evaluation of hybrids.

iv) Multilocational trials.

v) Release of improved varieties.

CROP PRODUCTION

i) Soil and leaf nutrient survey of orchards of Assam and Bengal and collecting soil and leaf samples for analysis.

ii) Preparation of nutrient standards, nutrient guide and nutrient ready reckoner.

iii) Developing integrated nutrient management programme by

a) Fertilizer trials.

b) Micorrhizal studies for enhancing nutrient availability to plants.

iv) Developing litchi based cropping system.

v) Pruning and training studies.

vi) Screening rootstocks for dwarfing.

POSTHARVEST TECHNOLOGY

i) Developing new processing technology and processed products.

ii) Preventing discolouration (browning) of fruit skin.

iii) Studying different polymers and combinations of polymers as packages for processed products.

BIOTECHNOLOGY

i) Mass multiplication and *in vitro* conservation of plants.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies.

ii) Adoption of villages for transfer of technology.

iii) Impact assessment of technology transferred.

GRAPE

CROP IMPROVEMENT

i) Evaluation, characterization and cataloguing of genetic resources collected.

ii) Evaluation of hybrids.

iii) Multilocational trials of promising hybrids.

iv) Release of improved early ripening varieties.

TRANSFER OF TECHNOLOGY

i) Transfer of technologies.

ii) Adoption of whole village for transfer of technology.

iii) Impact assessment of transferred technology.

PROBLEMS OF NATIONAL IMPORTANCE

MANGO MALFORMATION

i) Breeding varieties resistant to malformation.

ii) Screening varieties resistant to malformation.

iii) Multilocational trials of resistant varieties.

IRREGULAR BEARING IN MANGO

i) Clonal selection for regular bearing.

ii) Identification, isolation and transferring gene(s) responsible for regular bearing to commercial irregular bearing varieties.

iii) Multilocational trials of promising hybrids.

GUAVA WILT

i) Multilocational trials of resistant varieties and rootstocks.

ii) Rootstock studies with scions of commercial varieties.

BASIC RESEARCH

i) Studying biochemical changes taking place during growth, flowering, fruiting and ripening of fruits in mango and guava.

ii) Studying time involved in absorption, translocation and metabolism of nutrients sprayed on foliage of mango and guava.

PESTICIDE RESIDUE

i) Pesticide residue analysis in fruits.

ii) Determining ways for containing pesticide residue build up in fruits.

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MANGO

CROP IMPROVEMENT

i) Evaluation, characterization and cataloguing of genetic resources.

ii) Evaluation of hybrids.

iii) Multilocational trials of promising hybrids.

iv) Release of improved hybrids for cultivation.

CROP PRODUCTION

i) Developing integrated nutrient management programme

   a) Preparing nutrient standards, nutrients guide and nutrient ready reckoner for M.P. and Orissa.

   b) Nutrient build up (nutrient residue) study in soil in long term fertilizer trial.

ii) Rejuvenation of old unproductive orchards.

iii) Top working of seedling trees of inferior quality.

POSTHARVEST TECHNOLOGY

i) Identification and recovery of flavour and aroma compounds.

ii) Application of membrane technology in preparation of fruit juice and beverage.

BIOTECHNOLOGY

i) Mass multiplication and *in vitro* conservation of germplasm.

ii) Developing and application of molecular marker (AFLP and RAPD) technology for identification of cultivars and improvement of breeding projects.

iii) Transferring gene that codes for protein toxic to specific insects and diseases.

iv) Cloning of antifreeze proteins into fruits to prevent freeze damage.

TRANSFER OF TECHNOLOGY

i) Transfer of newly developed technologies.

ii) Adoption of whole villages for transferring technology.

iii) Impact assessment of transferred technology.

iv) Economic analysis of technologies transferred on whole plan period basis.

GUAVA

CROP IMPROVEMENT

i) Release of varieties and rootstocks resistant to wilt.

BIOTECHNOLOGY

i) Developing and application of molecular markers technology.

TRANSFER OF TECHNOLOGY

i) Transfer of technologies developed.

ii) Adoption of whole villages for transferring technologies.

iii) Impact assessment of transferred technologies.

PAPAYA

CROP IMPROVEMENT

i) Release of varieties resistant to PRV and frost having long shelf life for cultivation.

TRANSFER OF TECHNOLOGY

i) Transfer of technologies developed.

ii) Adoption of whole village for transferring technologies.

iii) Impact assessment of transferred technologies.

LITCHI

CROP IMPROVEMENT

i) Evaluation of hybrids.

ii) Multilocational trials of promising hybrids.

iii) Release of new improved varieties for cultivation.

CROP PRODUCTION

i) Preparation of nutrient standards, nutrient guide and nutrient ready reckoner.

ii) Developing integrated nutrient management programme.

iii) Developing litchi based cropping systems.

iv) Pruning and training studies.

v) Screening rootstock for dwarfing.

POSTHARVEST TECHNOLOGY

i) Application of membrane technolgoy in preparation of fruit juice and beverages.

BIOTECHNOLOGY

i) Mass multiplication and *in vitro* conservation of genetic resources.

ii) Developing and application of molecular marker technology.

TRANSFER OF TECHNOLOGY

i) Transfer of developed technologies to end users.

ii) Adoption of whole village for transfer of technology.

iii) Impact assessment of technology transferred.

GRAPE

CROP IMPROVEMENT

i) Release of high yielding, superior quality early ripening varieties.

PROBLEMS OF NATIONAL IMPORTANCE

MANGO MALFORMATION

i) Multilocational trials of malformation resistant/tolerant varieties.

ii) Release of malformation resistant/tolerant varieties.

IRREGULAR BEARING IN MANGO

i) Clonal selection for regular bearing.

ii) Transferring gene responsible for regular bearing to commercial irregular bearing varieties.

iii) Multilocational trials of regular bearing hybrids/clones.

iv) Release of regular bearing varieites and clones.

GUAVA WILT

i) Release of varieties resistant to wilt.

ii) Rootstock (resistant) trials with scions of commercial varieties.

iii) Release of wilt resistant rootstocks.

BASIC RESEARCH

i) Studying relationship of carbohydrates and flower formation in mango.

ii) Studying biochemical basis of some shoots producing flowers and fruits consecutively for two years while some others alternating with vegetative growth in mango.

PESTICIDE RESIDUE

i) Monitoring pesticide residues in fruits and finding out means to contain their build up.

9.2 Funds

(Rs in lakhs)

Crops/Programmes	Percentage Expenditure	Amount
1. Mango	50	13243.00
2. Guava	10	2648.00
3. Papaya	5	1324.00
4. Litchi	5	1324.00
5. Grape	3	795.00
6. Problems of National Importance (Mango malformation, alternate bearing and guava wilt)	10	2648.00
7. Basic research	10	2648.00
8. Pesticides residue and resistance studies	2	530.00
9. Transfer of technology	5	1324.00
Total		26484.00

9.3 Linkage, Coordination and Execution Arrangements

With the advancement in horticultural research all over the world, no research institute can afford to work in isolation. If it has to keep pace with the classical research programmes, going on in newer areas at various research institutions where the researches in its related fields are being conducted, it must develop linkages with these institutions for exchange of knowledge, research material and to fulfil the need of training of research personnel. Keeping in view their capabilities, the following research institutions, both national and international, have been identified with which useful linkages can be established for advancing research on the mandate fruits of the Institute for solving problems to foster their growth. A memorandum of understanding (MOU) will be signed

with the collaborating partner for sharing research facilities, research material, exchange of plant material, sharing research results, research expenditure and exchange of personnel for training.

The programme will be coordinated by the Director at the Institute level and by DDG (Hort.) at the ICAR level. All Coordination arrangements whether interdisciplinary or interinstitutional will be made by the Director.

Director, Central Institute for Subtropical Horticulture shall be responsible for execution of the projects with the help of scientists.

Linkages will be needed with the following national and international institutions in various areas of research:

International and National Linkages

A. International

Institute/Organisation	Area of collaboration/ training
1. University of Florida, Homstead, Florida, U.S.A.	i) Mango breeding
	ii) Fruit trees canopy management
	iii) Postharvest pathology
	iv) Tissue culture
	v) Instrumentation
2. University of California, Davis, California, U.S.A.	i) Aseptic processing technology of fruits
	ii) Freeze drying or quick freezing of fruit products
	iii) Fungicidal resistance
	iv) Photosynthetic efficiency, translocation and canopy manipulations in horticultural crops
3. University of Hawaii, Honolulu, Hawaii, U.S.A.	i) Guava and papaya breeding
	ii) Papaya production technology

Institute/Organisation	Area of collaboration/ training
	iii) Crop regulation studies on guava and other subtropical fruits
4. Michigan State University, East Lansing, Michigan, U.S.A.	i) Packages and packings for storage of fresh produce
	ii) Modelling of bruising in fruits due to mechanical forces in storage, handling and transport of shipping packages in dynamic transport environment
5. University of Georgia, Athens, Georgia, U.S.A.	i) Use of automatic computer aided design (Autocad) in development of postharvest equipments for fruits
	ii) Membrane technology as applied to food processing
6. Cornell University, Geneva, New York, U.S.A.	i) Microbial utilization of fruit processing industry waste
	ii) Techniques in assessment of fruit flavours
7. USDA, Beltsville, Maryland, U.S.A.	Fruit crop nutrition
8. Bee Research Laboratory, Beltsville, U.S.A.	Fruit tree pollinators
9. University of Georgia, Griffin, Georgia, U.S.A.	Systems approach in postharvest handling of fruits
10. University of Florida, Gainsville, Florida, U.S.A.	Quality control in processing of fruit products
11. University of Florida, Lake Alfred, Florida, U.S.A.	Microbial quality of processed products
12. University of California, Berkley, California, U.S.A.	Biological control of insect pests of fruits

Institute/Organisation	Area of collaboration/ training
13. Agricultural Research Organisation, Bet Dagan, Israel	i) Mango breeding ii) Propagation and rootstock iii) Modified/controlled atmosphere storage iv) Papaya product technology v) Photosynthetic enzyme studies vi) Water management
14. University of New South Wales, Kensington, NSW, Australia	Advances in study of ethylene in postharvest technology
15. Council of Scientific and Industrial Research Organisation, Adelaide SA, Australia	Establishment and operation of packaging line for fresh fruits
16. Queensland University of Technology, Brisbane, Queensland, Australia	Tissue culture on litchi
17. Central Mango Research Station, Darwin, Australia	Physiology of fruits during storage
18. Rothemsted Experiment Station, Harpanden, Herti, U.K.	Advance technique on detection of plant viruses
19. Fruit Research Station, Tsukuba, Ibaraki, Japan	Physiological and biochemical approaches towards the development of stress resistance like temperature, water and cold
20. Institute for Tropical and Subtropical Crops, Nelsprit, South Africa	Subtropical fruit pathology
21. Asian Institute of Technology, Bangkok, Thailand	Greenhouse, glasshouse and growth chamber technology

Institute/Organisation	Area of collaboration/ training
22. International Agriculture Centre, Wageningen, The Netherlands	Nematode management
23. International Institute of Tropical Agriculture, Ibadan, Nigeria	Water Management

B. National

Institute/ Organisation	Area of collaboration
1. Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, Karnataka	Research on mango, guava and papaya and exchange of germplasm
2. Central Food Technological Research Institute, Mysore, Karnataka	Research on postharvest technology
3. National Bureau of Plant Genetic Resources, New Delhi	Genetic resource collection and introduction of plant material
4. Indian Agricultural Research Institute, New Delhi	Development of early ripening grape varieties and testing of technology developed
5. Bhabha Atomic Researh Centre Trombay, Mumbai	i) Physiological disorder studies ii) Irradiation of fruits for extending shelf life
6. National Botanical Research Institute, Lucknow, U.P.	Tissue culture studies
7. Industrial Toxicology Research Centre, Lucknow, U.P.	Pesticide residue studies
8. Project Directorate of Biological Control, Hebbal, Bangalore, Karnataka	Studies on biological control of pests and diseases

Institute/ Organisation	Area of collaboration
9. Central Horticultural Experiment Station, Ranchi, Bihar	Research on litchi
10. Agricultural and Processed Food Products Export Development Authority, New Delhi	Export promotion of fresh fruits and processed products
11. Directorate of Horticulture and Food Processing, Lucknow, U.P.	Transfer of technology
12. Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, U.P.	High density orcharding of mango and testing of technology developed in mango
13. Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu	Papaya breeding and testing of technology developed in papaya
14. Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, U.P.	Screening of fruit plants for problematic soils and testing of technologies

9.4 Critical Inputs

9.4.1 Funds

Funds constitute an important input of the programmes. The programmes focus at perenneal fruit crops such as mango, guava, litchi and grape with only papaya as short duration fruit crop. Some of the problems are of national importance in mango and guava which are to be tackled from various angles involving several disciplines. The plan spreads over a period of 25 years. Considering all these points, an amount of about 26484 lakhs will be required during the whole plan period to run the various programmes efficiently and to achieve the objectives of the programmes.

9.4.2 Manpower

The existing manpower at the Institute comprises 43 scientific, 48 technical, 26 administrative and 63 auxiliary. The programmes cannot be run for a period of 25 years with the existing manpower. Therefore, additional manpower will be required to carry out the various programmes projected in the perspective plan. Additional manpower required approximately at various levels is as follows:

Scientific - 35
Technical - 63
Administrative - 28
Supporting - 114

9.4.3 Human Resource Development

Human resource development is an integral part of any research programme. Scientists cannot work in isolation in the area of their research. Their exposure to latest research developments going on round the world in their specific fields must form part of the strategy to achieve their goals. The scientists should be sponsored for training in the national and international institutions where advance researches are going on in the areas similar to the ones being tackled by the scientists of this Institute. For this, a programme should be chalked out well in advance mentioning specifically the area of research, duration of training, feasibility of incorporation of the knowledge gained in their ongoing research projects at home, etc. The scientists can be sponsored for training at the Institutes shown at item 9.3. Apart from scientists, technical and administrative personnel will also be trained to improve their skill in technical and administrative fields.

9.5 Risk Analysis

1. CROP IMPROVEMENT

A large population of hybrids is required for proper selection failing which there is less possibility of getting the desired hybrids in mango, guava and other subtropical fruits. The development of frost and PRV resistant varieties of papaya largely depends upon successful transfer of the genes governing these characters from wild species, viz. *C. candamarcensis* and *C. cauliflora*. This will involve raising of large number of progenies through rescue of hybrid embryos. The hybrids may not be of immediate use because of poor fruit quality. Further backcrossing with commercial cultivars having desirable qualities has to be done to get the desirable fruit qualities from them and at the same time it has to be ensured that the resistance to frost and PRV is not lost or diluted in the process of backcrossing, the possibility of which cannot be completely ruled out.

Raising of healthy papaya germplasm is difficult due to approximately 95 per cent infestation of plants with PR virus.

2. CROP PRODUCTION

Although natural calamities such as rains, hailstorms, winds, epidemics of insect pests and diseases at the time of flowering and fruiting in mango are the risk factors and these may extend the period of the project, no major risk factors are involved in the plan.

Financial crunch may also cause setback to the plan. Irregular bearing in mango may create problem in production plans.

The rootstocks selected for observational trials may not have desirable characters. This fact is usually revealed after a long period. Since graft combinations show incompatibility reaction with regard to growth of the tree, the resistant rootstocks may show incompatibility with scions of various *Psidium* species.

3. CROP PROTECTION

The continuous and indiscriminate use of chemical insecticides against pests have been found to affect adversely the environment, development of resistance to insecticide, destruction of parasites, predators and pollinators, residue hazards, upsetting of insect balance in nature. Hence, there is an urgent need to minimize the use of chemicals and promote the development of ecofriendly approaches to pest management.

There are chances that chemical management may not be effective due to development of resistance in the various pathogens/development of pathotypes. So alternatively resistance source and IPM may be useful which will be exploited.

4. POSTHARVEST TECHNOLOGY

We may have to face competition with the processed products developed by the private firms who have better facilities.

5. BIOTECHNOLOGY

Many difficulties may be faced in achieving the objectives of biotechnology programme because of the presence of phenolic compounds in mango and the problem of regeneration of plantlets in some mandate fruits.

9.6 Output and Expected Situation

1. CROP IMPROVEMENT

By the end of the programme, the Institute will have a rich collection of germplasm of subtropical fruits. A number of superior varieties of mandate fruits suitable for export and domestic markets and varieties resistant to important pests and diseases will be available. We may have frost and PRV resistant good quality high yielding papaya varieties for table and papain purposes which can be grown in north India. Attractively coloured varieties of mango, guava and litchi and superior grape varieties ripening earlier than Perlette will also be available.

2. CROP PRODUCTION

By the end of the programme, integrated nutrient management programme will be available for increasing productivity and production of mandate fruits. The rootstocks

resistant to guava wilt, imparting dwarfing to scions, tolerant to salt and having compatibility to scions will be available. Problem of irregular bearing in mango and rainy season fruiting in guava would have been solved by using chemicals. Causes and control of mango malformation are most likely to emerge. Photosynthetic efficiency will be increased if found affecting the yield. High density planting system and pruning methods will be developed by the end of the programme. Water requirement of subtropical fruits will be known and microirrigation system would have been standardized by the end of programme.

3. CROP PROTECTION

It is envisaged that integrated pest and disease management programmes will be available for effective control of important pests and diseases of subtropical fruits. We will have better understanding of bioecology of important insect pests and their population dynamics for their effective control. Plant products having pesticidal properties will be available for recommendation for control of insect pests and diseases. Control of guava wilt will emerge by the end of the programme.

4. POSTHARVEST TECHNOLOGY

Technologies of methods of harvesting, handling, transportation and marketing will be available for transfer. Integrated approach for increasing shelf-life of subtropical fruits, new processing technologies, new processed products, suitable packages for fresh and processed products and processes for waste management will emerge by the end of the programme. Postharvest losses of mandate fruits would have been assessed. Harvesters and graders will be available. Rheological properties of fruits will be known to plan strategy in packaging and transportation. Complete packaging lines for export of fruits would have been developed.

5. BIOTECHNOLOGY

Standardization of micropropagation technologies of subtropical fruits wul be completed and mass multiplication of fruit plants will be started by the end of the programme. *In vitro* conservation of germplasm of mandate fruits would have commenced after tissue culture technique is standardized. Molecular marker (AFLP and RAPD) technology would have been standardized for identification of cultivars and improvement of breeding projects.

6. TRANSFER OF TECHNOLOGY

Technologies developed by the Institute from time to time would be transferred to orchardists by adopting whole village, organising *gosthis*, exhibitions, radio and T.V. talks, demonstrations and replying to postal queries.

10. PROJECT REVIEW, REPORTING AND EVALUATION ARRANGEMENTS

The working and progress of the projects will be presented in the Staff Research Council and Research Advisory Committee meetings of the Institute for review and evaluation. The suggestions made by the above two committees, if any, will be incorporated in the projects. The results of the projects will be reported in the Annual Reports of the Institute and published in research journals of repute. Quinquennial Review Team constituted by ICAR will review the progress of the projects after every five years.

11. RESOURCE GENERATION

Though the Government has been providing budget for executing research programmes of the Institute and increasing total outlay over the years, the resource crunch is being felt at all levels and it would not be possible for the Government to meet the growing budgetary requirement of the Institute. In view of this, it is necessary for the Institute to generate its own resources so that the programmes projected in the perspective plan could be fully executed. The following areas have been identified for resource mobilization:

i) Utilizing farm area not covered by experiments for commercial cultivation.

ii) Intercropping planted area with annual crops and fruit crops.

iii) Advisory service to commercial agencies and hiring out instrumentation capacity to other institutions/organisations during lean period.

iv) Revolving fund scheme for producing and selling elite plant material.

v) Selling products and varieties developed by the Institute.

vi) Selling or contracting technologies developed.

vii) Charging royalties/license fees on patented technologies and innovation of commercial values.

viii) Charging fee from Indian students and trainees in Indian currency and from foreigners in foreign currency.

ix) Charging for diagnostic, analytical and other services rendered to companies and other clients.

x) Contracting research projects.

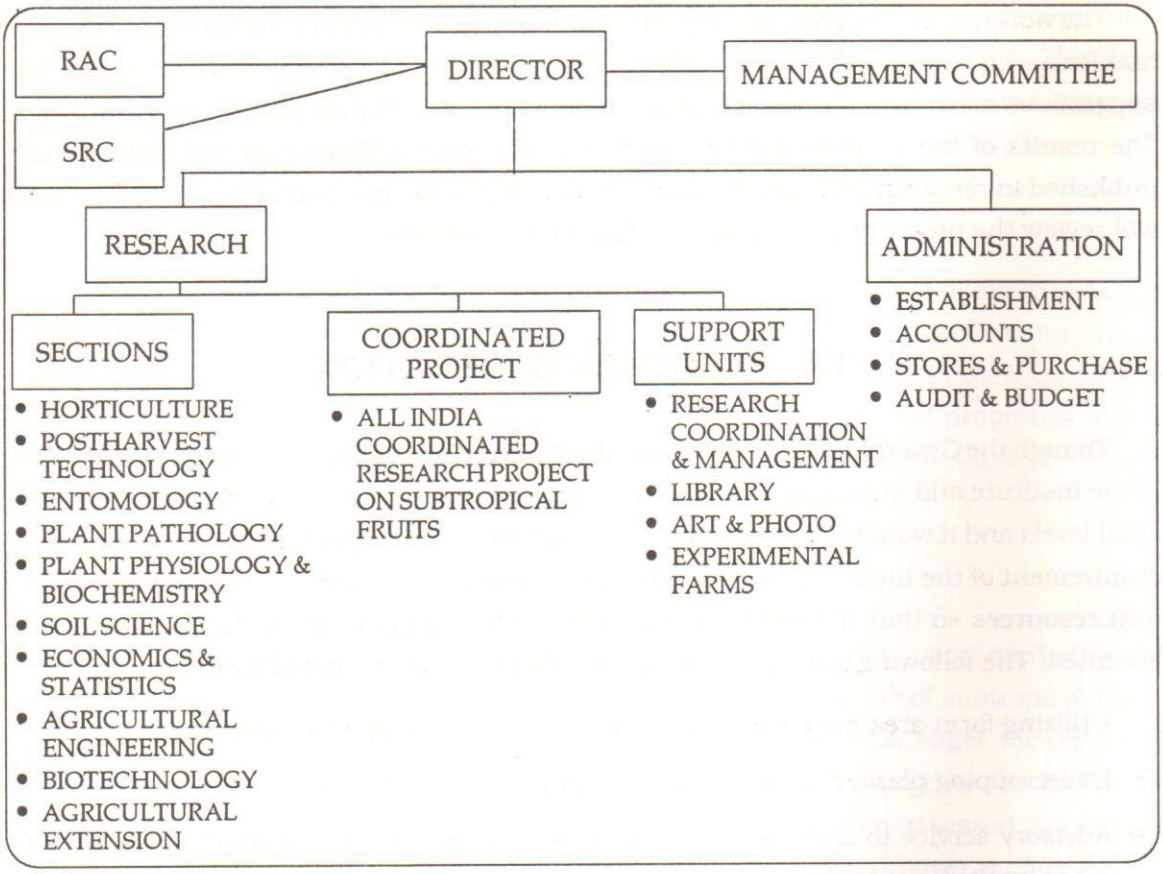
xi) Collaborating research projects.

xii) Charging for extension service rendered.

xiii) Selling orchard produce.

12. ANNEXURE

Existing Organogram of CISH, Lucknow



Proposed Organogram of CISH, Lucknow