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RESEARCH AND DEVELOPMENT REQUIREMENTS FOR POSTHARVEST TECHNOLOGY OF FRUITS AND VEGETABLES

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

AND

USAID/New Delhi, India

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RESEARCH AND DEVELOPMENT REQUIREMENTS FOR POSTHARVEST TECHNOLOGY OF FRUITS AND VEGETABLES

I. SUMMARY

The proposed subproject in post harvest research and development focuses on improving the postharvest system for seven perishable commodities namely, mangoes, citrus, guava, bananas, onions, potatoes and tomatoes. Investigations are to be conducted at four locations involved in the "All India Coordinated Program on Postharvest Technology of Horticultrual Crops," India Council of Agricultural Research (ICAR). Research is to be conducted based on the entire marketing system starting with preharvest and harvest problems and continuing to either the terminal market and/or the processing facility. The limitations of the present infrastructure, such as inadequate containers, insufficient cooling, and illequipped transport, are outlined with proposed research alternatives including the use of evaporative cooling, improved handling and harvest methods and variety selection. Economic losses and impact of new methods will be determined.

New and modified postharvest technology systems for fruits and vegetables focus on minimizing postharvest losses. The overall objective is to increase the food supply and improve the nutritional status of the Indian people by reducing postharvest losses and improving quality of horticultural crops.

II. SUBPROJECT DEFINITION

A. Primary Objectives

Research activities on postharvest technology of fruits and vegetables will focus on reducing losses of perishable crops such as bananas, citrus, mangoes, guava, onions, potatoes and tomatoes during harvesting, farm handling, storage marketing and processing. Losses of these perishable horticultual foods in India are realized to be extensive although the critical causes and magnitude of losses have not been clearly defined. This project will determine when, why and how much food is lost in present postharvest systems, and research with established postharvest technologies and innovated methods which are compatible with situations in India will be directed toward application to reduce these losses. To accomplish these objectives, postharvest research and training programs at three existing research centers will be strengthened and one new research center will be established.

B. Rationale

Postharvest losses of fruits and vegetables in India are extremely high. It has been estimated that at least 30 percent of harvested horticultural foods in India perish prior to human consumption. This estimate is for losses during the marketing while losses at the farm level are unknown but they could be substantial. India annually produces approximately 50 million tons of fruits and vegetables of which about 15 million tons are lost. These huge losses represent an economic value of Rs. 11 billion and more importantly an enormous loss of nutritive food value to a large and rapidly multiplying population.

Previous programs for increasing food supplies have primarily focused on increasing production, area, yields, and production frequency with considerable success. Reducing postharvest food losses is another method to significantly enhance food supplies, however, efforts in this area have been neglected. Fruits and vegetables play an important role in human diets by providing essential vitamins and minerals as well as carbohydrates and proteins. Presently per capita consumption of fruits and vegetables in India is only about 220 grams per day which is less than the amount necessary to obtain adequate quantities of essential nutrients. Reducing postharvest losses would have a large impact on reducing the severity of disorders associated with nutritional deficiencies in the Indian population.

Many important horticultural crops in India are highly seasonal which results in surplus supplies during the production period and shortages at other times. Prices fluctuate dramatically due to surplus and shortage cycles. Wastes are much higher during times of surplus. In addition, farmers could often increase their production but lack incentives to do so since this would lead to additional surpluses, a further depression of price and more food spoilage. The development of techniques to prolong longevity of perishable crops at the farm, during transit and marketing is urgently needed to allow for increased production, reduced spoilage and uniform distribution of food from regions of surplus to regions of shortages. Presently, information on systems for on-farm storage, proper transportation and handling during marketing and preservation which would be feasible for conditions in India, has not been developed.

Proper postharvest handling is dependent on the specific commodity; it begins at the time of harvesting and continues until consumption with each stage being critical to preventing losses. Until recently, farming has been solely concerned with production for immediate consumption and an adequate infrastructure of postharvest systems has not been developed. Now with horticultural crops growing in importance as cash crops and in supplying essential nutrition, the development of training and research programs to assist in the establishment of postharvst infrastructures to properly maintain quality of fruits and vegetables is critical.

Advanced postharvest technologies in certain countries developed gradually with each stage arising out of necessity and in synchrony with the existing economic situations. In India, a similar process is necessary since a direct transfer of advanced technology would not necessarily be compatible with present socio-economic conditions. Postharvest horticulture in India has unique problems and it is essential that innovative and creative research be conducted to develop new technologies which focus on solving these problems. As these new technologies are developed, more opportunities will become available for farmers and other elements of the private sector to expand their participation in postharvest food processing and utilization.

In this project, seven economically important horticultural crops have been identified (bananas, citrus, mango, guava, onions, potatoes, tomatoes), each having substantial postharvest losses which require immediate attention (Table 1). Research on reducing postharvest losses of these crops will be assigned to three existing research institutes:

Indian Agricultural Research Institute at Delhi (IARI), Central Mango Research Station (CMRS) at Lucknow and Indian Institute of Horticultural Research (IIHR) at Bangalore. In addition, the creation of a new research center at Nagpur is proposed. CMRS, IIHR and the Nagpur research center were identified on the basis of their strategic location in regions of excess crop production, which requires transport to other regions while IARI is located in Delhi which receives substantial quantities of produce from other regions. Each of the existing institutes have scientists and facilities capable of supporting limited research programs on reducing postharvesc food losses, however, additional scientists will be required to support the proposed research program.

Table 1

Production and Estimated Losses of
Important Fruits and Vegetables in India
(in thousands)

Crop	-----Production----- Hectares	Tons	Estimated Losses	Postharvest (Percent)
Bananas	318	5,608	30	-
Citrus	235	1,808	30	-
Mangoes	1,022	8,834	20-40	-
Guavas	156	1,350	20	-
Onions	192	2,620	20-60	-
Potatoes	700	3,165	10-15	-
Tomatoes	89	1,200	40	-
Total	2,712	24,585		

1. Commodities: Importance and Problems

Bananas

India is the second largest producer of bananas in the world with a production of 5,600,000 tons on 318,000 hectares. Bananas require a tropical climate with warm, humid and rainy conditions. Production in India is concentrated in the southern states (Tamil Nadu, Karnataka, Kerala, Gujarat and Maharashtra). About 60 varieties of bananas are grown in India with Robusta and Cavendish types being the most commercially important. Most production is from August to December.

Almost all bananas produced in India are consumed internally with an insignificant quantity exported in fresh form or as processed products. Export markets are available if quality standards could be met.

Bananas are highly perishable fruits which require rapid marketing with minimal and gentle handling. To extend marketability, bananas should be harvested and shipped green at about 13°C depending on variety. Below 12.5°C bananas are subject to chilling injury. To reduce bruise damage, it is recommended that the fruit be removed from the stem and packed in boxes prior to marketing. Upon arrival, bananas should be allowed to ripen in controlled temperature, humidity and air circulation. These practices are not followed in India.

In India, bananas are harvested green and transported as bunches in closed rail cars or open bed trucks with insufficient or no protective padding. Bunches are stacked up to 2 meters high in trucks and higher in rail cars. Excessive bruising occurs and due to slow transport at high temperatures without ventilation, ripening occurs. Upon arrival, fruits are unloaded and sorted. Most fruit arrive at the retail market blemished, bruised and excessively soft. Severe losses occur and those that reach the consumer are of sub-standard quality.

Research and training programs are critically needed to develop proper handling methods, reduce losses and improve quality. In addition, methods of processing excess production and fruit of inferior fresh market quality are needed to preserve the nutritional components of bananas in India.

Citrus

India has approximately 235,000 hectares in citrus production which yields 1,808,000 tons of fruit. Nearly two thirds of the country's production of citrus fruits consist of oranges; mandarin and sweet. The Nagpur mandarin is said to be one of the finest mandarins grown in the world and it is shipped throughout most of India. Citrus is produced in most states with the greatest concentration of production in Maharashtra, Andhra Pradesh and Karnataka. India exports less than 0.5 percent and processes only about 0.6 percent of its total citrus production.

In most major citrus producing countries of the world, postharvest technologies have been developed to prevent spoilage during marketing and storage. Optimum stage of maturity for harvesting, methods of harvesting, packing, grading, pesticide treatment and temperature, ventilation and humidity requirements have been developed for each citrus crop and production region. In addition, processing facilities have been developed to supply demand for citrus during non-producing season and to utilize surplus production. In India, harvesting and postharvest systems to reduce losses, optimize and maintain quality and provide processed products have not been developed. Fruits are harvested immature or excessively matured, often by pulling the fruit from the tree which results in tearing of the peel and entrance by decay organisms. Packing varies throughout the country. Baskets, crates and sacks are commonly used with little regard to over-filling. Fruits are mainly transported in open-bed trucks without padding, ventilation or cooling. Marketing is generally rough and very slow which results in decay, staling and loss of flavor, vitamins and appearance.

Mangoes

Mango fruits are grown in many countries with tropical climates. India is the largest producer of mangoes with a production of 8,834,000 tons from 1,022,000 hectares which represents about 65 percent of total world production. Mangoes are cultivated throughout India with Uttar Pradesh, Andhra Pradesh and Bihar having the greatest production. More than 1000 varieties of mango are grown in India, each having its own unique characteristics, but not all have commercial significance. India consumes almost all of its huge mango production; less than 1 percent is exported mainly in processed form. Although exports of processed mangoes are a small portion of total production, it accounts for about 70 percent of total exports of processed fruits and vegetables.

Most varieties of mango mature and ripen during the hot, humid summer months, conditions which favor decay and greatly contribute to postharvest losses. Mango production is concentrated over a relatively short time and due to inadequate harvesting, handling, storage, marketing, packaging, distribution and processing systems, large quantities perish prior to consumption. Mangoes are highly perishable and need to be handled gently, allowed to ripen at 22 to 25°C for best flavor characteristics, marketed rapidly and special care needs to be taken to protect against decay, such as anthracnose and diploidia. None of these practices are followed in India. Information is lacking on methods to adequately delay ripening to extend marketing and prevent postharvest losses.

Guavas

Guava production in India is estimated to involve 156,000 hectares which yield 1,350,000 tons of fruit. Guava is grown throughout India, but most commercial production is concentrated in Uttar Pradesh, Madhya Pradesh and Bihar. Numerous varieties and types are grown, most of which mature during the hot summer months. Indian consumes almost all of its production as fresh fruit, juice, jams and jellies. Processing industries have been growing mainly for processing of juice for export, although presently this represents a very small portion of production.

As with other horticultural crops in India, postharvest technologies are lacking which results in sizeable losses. With careful harvesting and handling at 10 to 13°C, guavas have a market-life of 2 to 3 weeks, however, with methods presently used in India, quality is maintained for only a few days.

Onion

India is the second largest producer of onions in the world with a production of 2,620,000 tons on 192,932 hectares. Onions are grown thoughout India while eight states contribute to 88 percent of total production. Maharashtra, Uttar Pradesh, Karnataka and Tamil Nadu are the predominant onion producing States. Over 85 percent of the onions produced in India are red and pink varieties which are consumed primarily as fresh onions. Most of the Indian population regularly consumes onions. Dehydration is the major form of processing and these are mainly for export.

Losses of onions in India are exceptionally large, sometimes as high as 60 percent of total production. These excessive losses are caused by poor variety selection, rough handling, high temperatures, improper curing and storage which results in desiccation, sprouting and decay. To reduce losses, onions should be well-matured at harvest, cured by ventilating with dry air then stored at low temperature (about 0°C) with a low relative humidity (65-70%). These conditions are difficult to obtain in India and research is necessary to evaluate varieties and develop new methods of curing, storing and marketing in order to reduce postharvest losses.

Potatoes

India produces 10,500,000 tons of potatoes on about 700,000 hectares. Production is concentrated in Uttar Pradesh, West Bengal and Bihar with Uttar Pradesh contributing to 35 percent of total production. Almost all of the potatoes produced are consumed within India in the fresh form. Harvesting is concentrated mostly from January to March. Potato production in India has been steadily increasing during the past 30 years. Due to inadequate marketing, processing and storage facilities, seasonal surpluses commonly occur which results in distress sales and large losses. India has cold storage facilities for 3,100,000 tons of potatoes, over half of which is required for storage of tubers for planting the following year. The use of seeds rather than tubers for planting appears to provide a revolutionary system for potato production in India. If implemented, it will allow for greater use of storage facilities for table potatoes, but research is critically needed to determine proper handling and storage conditions to reduce present and future storage losses.

Potatoes need to be harvested when mature, handled and transported gently, cured for 5 to 7 days at 15 to 20°C with 95 percent relative humidity and then held at 4 to 8°C. Conditions to follow these practices are not suitable in India and large losses occur due to decay, desiccation and sprouting.

Tomatoes

India produces over 1,000,000 tons of tomatoes on 81,300 hectares. Andhra Pradesh, Karnataka, Maharashtra and Uttar Pradesh are the leading states in tomato production. Most tomatoes are consumed within India in fresh form. Demand for processed products such as sauce and ketchup have been increasing. Production is seasonal depending on the region of the country resulting in surpluses which have to be transported to areas with deficit supplies. Many different varieties are grown, most being small types.

Tomatoes are highly perishable, having a maximum shelf-life of about 10 to 14 days at temperature of 13 to 15°C. Below 13°C tomatoes are subject to chilling injury while above 20°C excessive softening and spoilage progresses rapidly. To facilitate marketing, tomatoes should be harvested when mature green, cooled and transported rapidly and gently to retail markets in refrigerated containers. In India, tomatoes are often harvested when immature green which results in inadequate ripening and very poor quality, excessive softening and spoilage. Precooling is not practiced, nor is refrigerated transport and storage. Losses are extensive from bruising, decay, desiccation and excessive softening prior to and during marketing.

2. Location for Strengthening Postharvest Research of Horticultural Crops

Indian Institue of Horticultural Research (IIHR), Bangalore, Karnataka

IIHR is a large, modern research institution devoted to basic and applied research on many important horticultural crops. It is located in a region which produces surplus quantities of important perishable horticultural crops that require storage and distribution to other regions. The IIHR at Bangalore is composed of 10 divisions, one being the Division of Fruit and Vegetable Processing and Postharvest Technology, which consists of six scientists. Most research at this institution has emphasized studies on preharvest physiology, varietal improvement and basic biochemistry and physiology. The area of postharvest technology has been neglected and needs strengthening. Considering the strategic location of the IIHR, its present organization, research programs, facilities, personnel and space for expansion, excellent research programs could be readily developed which emphasize the reduction of postharvest losses of bananas, citrus, mango, onions and tomatoes.

Central Mango Research Station (CMRS), Lucknow, Uttar Pradesh

CMRS is a regional station of IIHR which is located in the center of the major mango, guava and potato production region of northern India. Research programs at CMRS have been primarily concerned with varietal evaluation and production problems. An excellent collection of mango and guava genotypes is being evaluated at the research farm. One scientist is responsible for postharvest and processing technology. Presently, the research laboratories are located in an overcrowded, leased building in Lucknow while the research farm is located about 25 km from Lucknow. These facilities are inadequate for conducting the proposed research program on postharvest technology and processing.

However, the foundation is present for CMRS to develop excellent programs which contribute to reducing postharvest losses of horticultural crops. The field station has buildings with adequate space to develop laboratories, offices and pilot operations for production, postharvest and processing research. Utilization of the field station could have a large impact on reducing losses of mangoes, guavas and potatoes from studies directed toward lab to land operations, storage transportation and processing systems. It is recommended that all research facilities, including staff, transfer their operations to the field station for implementing the proposed research program.

Central Citrus Research Station (CCRS), Nagpur, Maharashtra

The Indian Council of Agricultural Research has approved the development of the CCRS at Nagpur. This will provide a research facility in the center of a large and important citrus and banana production region. From this region fruits are distributed throughout most of India, however, due to improper harvesting and postharvest technologies, large losses occur from spoilage and quality deterioration. By emphasizing the initial development of research programs which focus on postharvest and preservation techniques, CCRS could play an important role in reducing losses of citrus and bananas.

Indian Agricultural Research Institute (IARI), Delhi

This large, major institution is located in the center of the largest consuming population of fruits and vegetables in India. Fruits and vegetables are brought to this area from throughout India. The largest terminal markets in India are located in Delhi and more markets are planned in order to fulfill the needs of the city. Several commercial cold storage facilities are used for certain perishable horticultural products. Delhi also has the largest processing industry in the country. Thus, IARI is strategically located to conduct research on handling, storage, marketing and preservation techniques to reduce losses of most of all horticultural crops.

Presently, the Division of Horticulture and Fruit Technology at IARI has personnel actively involved with studies on postharvest and processing technologies but progress is handicapped by teaching responsibilities and insufficient supplies and equipment. With sufficient strengthening and with cooperative research through shipping and processing industries (IIHR, CMRS and CCRS) this institute (IARI) has considerable potential to make significant progress in practices which reduce loss of horticultural foods.

III. STRATEGY (Components and Objectives)

To accomplish the primary objectives of this subproject on postharvest technology of fruits and vegetables, the following components and objectives will need to be addressed:

Component A

Determine methods to maximize quality and minimize postharvest losses of fruits and vegetables by improvement of preharvest and harvesting techniques.

The variety, its preharvest nutrient status, disease load, fruit maturity along with harvest techniques can have a large influence on predetermining subsequent postharvest qualtiy and losses during handling, transport, storage and processing. Nutrient deficiencies or imbalances may predispose fruits and vegetables to particular diseases and physiological disorders. Many fruits and vegetables have increased durability when internal calcium levels are substantially higher than required to prevent deficiency symptoms of the donor plant. Many postharvest diseases develop because of preharvest infections while fruit maturity and variety greatly influence ripening characteristics, etiology and manifestation of decay symptoms and overall durability and quality. In addition, harvesting methods which minimize bruising are highly important to minimizing entrance of decay organisms, desiccation and oxidation reactions.

Objectives

1. Evaluate the effect of the preharvest nutritional status and varieties on subsequent postharvest processing characteristics.

2. Evaluate the influence of preharvest disease control on subsequent postharvest decay.

3. Determine the optimum harvest maturity of varieties for maximizing quality characteristics, handling and storage durability and processing quality.

4. Develop methods of harvesting to reduce mechanical injury and postharvest losses.

5. Assess the economic feasibility of preharvest and harvesting techniques which reduce postharvest losses and improve quality.

6. Establish instructional materials and teaching program to implement operational research and educate farmers on preharvest and harvesting techniques to reduce postharvest losses.

Component B

Establish systems for precooling, handling and transport of fruits and vegetables which reduce postharvest losses and maintain quality characteristics.

Presently, most fruits and vegetables are packed into baskets, burlap bags, earthen jars and rough wooden containers of various dimensions. Little or no attention is given to avoiding physical bruising and contamination by decay organisms. Cooling, ventilation and rapid movement are not practiced. Precooling to remove latent heat, disinfection, maintenance of sanitary conditions, gentle handling, waxing, fungicide treatment, controlled atmosphere, packaging and rapid refrigerated transport are methods that are commonly used to reduce spoilage and maintain quality. The feasibility of using these methods in India is questionable but these techniques should be examined and assessed for potential utilization. Rapid transport shoudl be emphasized, however, in view of present conditions which make this difficult, systems should be developed to reduce spoilage during slow handling and transport situations. Innovative methods which provide similar benefits that are compatible with situations in India need to be developed. Inexpensive cooling and ventilation systems that reduce temperature prior to and during rail and truck transport would substantially reduce postharvest spoilage.

Objectives

1. Develop efficient and operational methods of precooling fruits and vegetables prior to transport.

2. Develop methods of handling fruits and vegetables to reduce physical injury.

   a. Evaluate methods of containerization, packing and padding to reduce losses.
   b. Evaluate methods of bulk handling.

3. Establish methods and effects of waxing and fungicide application for reducing spoilage losses.

4. Design and evaluate inexpensive methods of cooling and ventilation during truck and rail transport.

5. Study methods to regulate ripening and physiological disorders.

6. Evaluate varieties for resistance to quality loss during handling and transport in refrigerated and non-refrigerated conditions.

7. Asses economical feasibility of precooling, handling and transport techniques which reduce postharvest losses.

8. Develop instruction materials and teaching programs in conjunction with operational research for educating farmers and shippers on precooling, handling and transporting techniques to reduce losses and maintain quality.

Component C

Develop techniques for storage of fruits and vegetables to minimize losses and prolong quality characteristics.

Many horticultural crops are highly seasonal which results in excess supplies during the production season and scarcity of particular crops when the production season is completed. The cycles of surplus to scarcity are reflected in large price fluctuations. In times of surplus, large quantities of produce are wasted due to lack of appropriate marketing facilities especially storage systems. Obviously, the development of methods to store fruits and vegetables would have a large impact on the marketing strategy of farmers, wholesalers and retailers and the uniformity of supplies available to consumers. In India, a limited number of cold storage facilities (capacity 5 million tons) have been developed to store mainly potatoes. Only about 7% of the capacity is utilized for other fruits, e.g., apple, citrus. Losses in these storages are substantial due to rough and inefficient handling, poor ventilation and improper temperature control. Little or no attempt have been made to prolong the storage life of the more perishable crops such as banana, citrus, mango, guava and tomato. These crops have limited storage life because of their sensitivity to injury at chilling temperatures (less than 12°C) and progressive ripening at nonchilling termperature.

Modified atmosphere coupled with reduced temperatures allow for extended storage life of various fruits and vegetables. In addition, methods to remove ethylene, a stimulator of senescence, aid in retarding ripening and prolonging storability of many crops. Presently, little information is available on the response of horticultural species and varieties produced in India to these postharvest techniques. Systems need to be developed and evaluated to prolong storability which are compatible with situations in India.

Objectives

1. Design and evaluate inexpensive storage facilities for farm operations.

2. Design and evaluate storage facilities for commercial operations.

3. Determine prestorage treatments which reduce losses during storage.

4. Define optimum storage requirements for each commodity.

   a. Temperature
   b. Humidity
   c. Ventilation
   d. Maturity

5. Evaluate varieties for extended storage life.

6. Evaluate modified atmospheric conditions for prolonging storability.

   a. Altered oxygen, carbon dioxide and nitrogen conditions.
   b. Use of carbon monoxide.
   c. Removal of ethylene.

7. Evaluate changes in quality components as influenced by storage conditions (appearance, flavor, color, texture, nutrients).

8. Assess economical feasibility of conventional and improved storage treatment and facilities.

9. Develop instructional materials and teaching program in conjunction with operational research to educate farmers and commercial storage operators on techniques to store fruit and vegetables and reduce storage losses.

Component D

Develop method of processing fruits and vegetables for maintaining quality components during storage and marketing.

Processing of fruits and vegetables into various stable and consumer acceptable products has considerable potential for reducin_ food losses in India. Fresh fruits and vegetables which are excessively soft, bruised or partially blemished for marketing may be utilized as processed products. Furthermore, processing of perishables crops in regions with surplus production would allow for subsequent marketing and distribution at times and/or to locations which have shortages. In India, only about 0.2 percent of the horticultrual crop production is processed, most of which is exported. Conventional canning and freezing require a high capital cost, high energy cost and expensive packaging which makes them unsuitable as methods of preserving foods for marketing in India. Dehydration, fermentation and acidification are low cost methods of preserving fruits and vegetables which need further evaluation and implementation.

Objectives

1. Design and evaluate food dehydration systems suitable for farm and industrial utilization.

2. Evaluate methods of preserving fruits and vegetables by fermentation, acidification and chemicals.

3. Investigate innovative methods of preserving perishable horticultural foods.

4. Investigate methods of packaging processed fruits and vegetables.

5. Determine storage conditions suitable for maintaining quality of processed foods.

6. Examine the influence of processing, packaging and storage systems on quality components.

7. Determine consumer acceptability of the processed food products.

8. Assess the economic feasibility of the processed products and market potentials.

9. Develop instructional materials and teaching programs in conjunction with operational research to educate farmers and industry personnel on practical methods of preserving fruits and vegetables.

Component E

Develop methods to utilize wastes from commercially unacceptable fruits and vegetables and from processing systems.

Another component of reducing postharvest losses of fruits and vegetables is the development of techniques to utilize waste products for certain constituents that would have utility. For example, postharvest and process wastes may be used for making sugar, vinegar, alcohols, pectin, pigments and flavorants as well as numerous organic chemical compounds useful in food and beverage industries.

Wastes generated by seed removal, peeling, trimming and finishing are often 30 to 50 percent of the original product, therefore, utilization of these wastes could have a large impact on reducing food losses and could potentially stimulate additional industrial development.

Objectives

1. Evaluate quantities of waste generated from spoilage and processing of fruits and vegetables.

2. Develop methods to extract and utilize constituents from waste materials.

3. Assess economic feasibility of utilizing wastes for certain compounds.

The research institutions at Bangalore, Delhi and Lucknow have some scientific staff, technical staff, laboratories and equipment presently involved with research related to a few of the specified components. Additional staff, training, equipment and facilities along with assistance of consultants will be required to fulfill the objectives of the subproject components. Implementation of research programs at Nagpur as well as other locations will be initiated upon completion of buildings and physical facilities. The subproject has a five-year plan for each location.

IV. SUBPROJECT IMPLEMENTATION

Since the project will be located at Bangalore, Delhi, Lucknow and Nagpur it is proposed that a senior scientist be appointed at the S-3 level to assist the ADG(H) for monitoring and execution of the program. Supportive and administrative staff will include one assistant (scientist S-2), one senior clerk, one junior clerk, and one typist/stenographer. This staff is proposed to be located at ICAR headquarters, Delhi. In addition, one scientist will be designated at each location as the principal investigator having the responsibility for the subproject at that location.

The overall implementation of the subproject shall be coordinated by the Deputy Director General for Crops, ICAR. A coordinations committee consisting of four members to continously montitor and evaluate the subproject is as follows:

1. Director General/Deputy Director General (crops), ICAR - Chairman

2. Director, Indian Agricultural Research Institute (IARI), New Delhi - Member
3. Director, Indian Institute of Horticultural Research (IIHR) - Member
4. Project Coordinator, IARI, New Delhi: Postharvest Horticulture Technology - Member
5. Assistant Director General (Horticulture). Subproject: Postharvest Technology of Fruits and Vegetables - Member Secretary

The coordinating committee will meet at least two times per year. Technical reviews should take place annually. Study tours by members of the coordinating committee will be made during first year to acquaint ICAR with the most recent advances in technology, identify institutions in the U.S.A. for training, consultancy and scientific research equipment requirements in the respective research disciplines. The first year will be required for equipment acquisition, personnel employment, study tours and training. Consultants should be used for assisting in acquisition, installation and operation of equipment during the initial phase of the subproject. Periodic progress reports should be submitted regarding equipment acquisition, training, consultation and ongoing research.

B. Collaboration Bodies

The exchange of technical information will be supported through the following national and international agencies:

1. All-India Postharvest Technology Scheme (ICAR)
2. Central Food Technology Research Institute (CFTRI)
3. National Agricultural Cooperative Marketing Federation of India Ltd. (NAFED)
4. Agricultural Universities in India
5. United Nations Food and Agriculture Organization
6. Postharvest Institute for Perishables, University of Idaho, Moscow, Idaho USA
7. United States Department of Agriculture
8. Agricultural Universities in the United States: Arkansas, Claifornia, Florida, Georgia, Hawaii, Michigan, North Carolina
9. Agricultural Research Organizations in Australia (CSIRO), Brazil, Canada, England (Tropical Products Research Institute), Japan, Israel and New Zealand (DSIR).

Scientists involved with postharvest technology at IIHR, IARI, CMRS and CCRS and other centers under coordinated programs on postharvest technology of horticultural crops should meet annually to interact professionally, discuss research accomplishments, future directions and coordinate cooperative investigations. Members of the coordination committee and appropriate representatives from collaborating bodies and industry should also be invited to participate in these professional meetings.

V. PLAN OF WORK

Research on the objectives of components, specified in Section III, will be conducted at each institution with regard to particular crops as indicated in the following table:

Table 2

Institution and Location	Research Components	Crops
Indian Institute of Horticultural Research, BANGALORE	A-E	Banana, Mango, Onion Tomato
Indian Agricultural Research Institute, DELHI	B-E	Banana, Citrus, Mango Guava, Onion, Potato Tomato
Central Mango Research Station, LUCKNOW	A-E	Mango, Guava, Potato
Central Citrus Research Station, NAGPUR	A-E	Banana, Citrus

Components:

A. Preharvest and Harvesting
B. Precooling, Handling and Transport
C. Storage
D. Processing
E. Waste Utilization

Work on each component will be accomplished by existing and new personnel, equipment acquisition, training, and consulting services as designated for each institution in the subsequent subsections. Each institution has specific and different requirements to fulfill the objectives of this subproject. Of particular importance is the need to employ scientists qualified to conduct research relevant to postharvest and food technology problems.

c. Storage

This is an area of postharvest handling which requires the greatest input. The main problem is cooling without depending on mechanical refrigeration. Evaporative cooling shows great promise for crops such as banana, guava, mango, potato and tomato which show chilling injury.

Banana: All applicable objectives require attention.

Mango: All objectives should be pursued.

Onion: Well ventilated sacks are accepted worldwide as storage containers. Onions do not need to ripen after harvesting and no ripening work is required. Sprout inhibition is a most important objective. Onions show great varietal differences in storage life and this should be carefully examined.

Tomato: Presently available varieties of tomatoes have a short storage life. There is a good possibility in the near future of development of slow ripening varieties. Because of their delicate skin and soft texture, packaging of tomatoes requires particular attention.

d. Processing

Processing serves as an outlet for surplus production and therfore acts as a price stabilizer. In addition, processing can utilize produce that because of size, shape, color or physical damage is not suitable for the fresh market. Because of seasonal price fluctuations processed floods may be cheaper than fresh at some times of the year. Dehydration is a processing method which can be economical and provides a product which is cheap to transport and does not require expensive packaging. For some crops and some requirements, dehydration is not suitable and other methods such as aseptic bulk storage, concentration and chemical preservation are needed.

Banana: Bananas may be processed in many ways. General problems are undesirable flavor changes and development of non-enzymic browning in heat processed products.

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Mango: Mango is suitable for all types of processing, both immature and ripe and makes very good qualtiy pickles and juices; dried sheets or "leathers" are a traditional product.

Onion: Dehydrated white onions in the form of flakes or powder is very acceptable, and India is exporting it in substantial quantity.

Tomato: Tomato products are used mainly for cooking and purees or pastes and have wide acceptance. Drum dried tomato powder would provide cheaper products for off-season use.

e. Waste Utilization

Waste utilization implies separation of otherwise unusable material and processing it into a product or products which have some economic value. In order to do this, it is usually necessry to have fairly large quantities of material available at one location. In India, fresh produce is not normally handled in large packing houses where trimming, sorting, etc. is done. This limits the availability of wastes to by-products of processing operations. Although not a large user of horticultural crops, processing produces sufficient quantities of wastes to make research on their utilization worthwhile. At the farm level, wastes may be used for such things as animal feed, biogas production and compost. Work in these areas is being done by other agencies. Work in this program should be directed toward further processing to produce saleable products.

Banana: Banana peel can be investigated for oil and flavor recovery, possibly other compounds of commercial value can be found.

Guava and Mango: Seeds may yield oil and other materials.

Potato: Peelings and discards are a source of starch.

Tomato: Tomato yields very little waste, however, if peels are available, they might provide a source of lycopene for food coloring. Seed recovery should be investigated.

2. Personnel

Bangalore is the mian center engaged in postharvest research with the main emphasis in processing. At present, there is one S-1 Horticulturist position vacant. Only two technicians are available to support the six scientist positions. The group will total 18 scientists which is large enough to require one S-3 level scientist as Principal Investigator.

Available

Scientific:

Scientist	S-2	Horticulturist (Processing)	1
Scientist	S-2	Microbiologist (Fermentation)	1
Scientist	S-2	Horticulturist (Storage)	1
Scientist	S-1	Horticulturist (Processing)	1
Scientist	S-1	Microbiologist (Pathologist)	1
Scientist	S-1	Horticulturist (vacant)	1

Technical:

Technician	T-II-3		2

Proposed

Scientific:

Scientist	S-3	Principal Investigator	1
Scientist	S-2	Handling, Transport & Storage	1
Scientist	S-1	Handling, Transport & Storage	1
Scientist	S-2	Pathology	1
Scientist	S-1	Pathology and Microbiology	1
Scientist	S-2	Processing	1
Scientist	S-1	Processing	1
Scientist	S-2	Engineer, Postharvest	1
Scientist	S-1	Engineer, Processing	1
Scientist	S-2	Physical Chemist	1
Scientist	S-2	Economist	1

Technical:

Technician	T-II-3	Handling and Storage	1
Technician	T-1	Handling and Storage	1
Technician	T-II-3	Pathology	2
Technician	T-II-3	Packaging and Transport	3
Technician	T-II-3	Draftsman	1
Technician	T-II-3	Refrigeration Mechanic	1
Technician	T-II-3	Auto Mechanic	
Technician	T-1	Driver	2
Technician	T-II-3	Economics	1

Administrative:

Sr. Stenographer	1
Sr. Clerk	1
Jr. Clerk	1

Supporting:

Attender	2

3. Equipment (approx. $ cost)

Handling, Transport & Storage

Coolers for precooling all commodities
Self-contained refrigerated, portable storage chamber with temperature and humidity control for transport studies
Equipment for providing controlled atmospheres, controls and recorders
Walk-in coolers, complete with temperature control and monitoring (6)
Evaporative coolers
Truck (10-ton capacity) for transportation studies
Materials for fabrication of experimental evaporative coolers, ventilation systems, packages
Matador van and trailer

Containerization and Packaging

Compression tester for boxes
Gas transmission cell
Puncture tester
Pneumatic tester
Shrink-wrap machine
Airconditioner and climatizer equipment

Processing

Steam generator 15 H.P.
Double drum drier (approx. 0.2-0.3m^2 drum area)
Steam kettle (30 gal. capacity)
Powder mill
Vacuum juice concentrator with aroma recovery
Scaped surface heat exchangers, for heating and cooling (2 required)
Junior pulper
Vacuum pouch sealer, double jaw (heat above and below)
Aseptic packaging unit for bulk packaging of pulp, juices and concentrates (Scholle or similar)
Materials for construction of experimental solar driers
Aquasat IV moisture analyzer with recorder
Brookfield viscometer

Pathology and Microbiology

Refrigerated incubator shaker
Inoculation chamber with sterile air draft
Microscope with photo attachment
Microtome and accessories
Low temperature incubators (2)

Analytical (Common to all)

Spectrononic 2000 with all accessories
Instron texture measuring device
Gardner color difference meter
Miscellaneous supplies

Miscellaneous Support Materials (All Commodities)

Typewriter
Electronic desk calculator (2)
Filing cabinet (4)
Steel almirah (2)
Tables (12)
Chairs (12)
Index card cabinet
Books, texts and back issues of journals
Micro computer
Copying machine
Microfilm reader and projector
Carousel slide projector
Overhead slide projector
Projection screen

4. Training

Since Bangalore has an established postharvest program, training can begin immediately and should be completed by the third year.

Position	Duration
Year 1:	
S-2 Horticulturist	
Storage of tropical fruits & vegetables	12 months
S-1 Horticulturist	
Harvesting and transport	12 months
S-1 Microbiologist	
Spoilage problems of fresh fruits & vegetables	12 months
Year 2:	
S-2 Horticulturist (Processing)	
Aseptic packaging and/or solar drying	12 months
S-2 Engineer	
Design and testing of evaporative cooling	12 months
S-2 Physical Chemist	
Evaluation of packaging materials	12 months
S-2 Physiologist	
Storage - its effects on quality parameters	12 months

Position	Duration
Year 3:	
S-1 Engineer	
Design and testing of solar driers	12 months
S-1 Microbiologist	
Market rots in fruits and vegetables	12 months
S-2 Economist	
Methodology of marketing economics	12 months
S-2 Physiologist	
Techniques of advanced physiology	12 months
Total	132 months

5. Consulting Services

Year 1:

Microbiologist/Pathologist Causes of market spoilage Horticulturist/Physiologist Mango Storages	2 weeks

Year 2:

Economist Marketing economy of fruits and vegetables	3 weeks

Year 3:

Microbiologist/Pathologist Harvest caused infections Transportation Specialist Road transport Packaging Specialist Design of containers Food Technologist Aseptic packaging and solar drying	12 weeks

Year 4:

Horticulturist/Physiologist Storage of onion, potato and tomato Product development	10 weeks

Year 5:

Review of progress and suggestions for
further work by specialists in:

Storage/Physiology Food Technologist Packaging Specialist Economist Engineer (evaporative cooling & solar drying) Transportation Specialist Pathologist/Microbiologist	8 weeks
Total:	35 weeks

To visit locations as appropriate

6. Facilities

Proposed:

a. Processing hall with essential facilities for storage and analytical work.

b. Accelerated temperature storage chambers with complete automatic temperature and humidity control devices.

c. Ripening chambers, with complete automatic gas, temperature and humidity controls.

7. Principal Reports, Reviews and Evaluations

For all locations; Subprojects should be reviewed and evaluated annually. Annual reports should be prepared and results published in scientific journals as objectives are completed.

8. End of Project Status

Substantial progress for all commodities and objectives will be met as relfected in reduced losses. The main results are listed as follows:

a. Reduced losses of mangoes due to preharvest sprays of benomyl to control postharvest anthracnose rot. Less physical injury in terms of cuts and bruises, and subsequent decay due to improved harvesting, handling and packing methods.

b. Reduced losses of tomatoes due to chlorine in the postharvest wash water to control bacterial soft rot. Improved cultivars will be developed that will tolerate additional rough handling. This improvement will be coupled with reduced physical injury due to improved handling procedures.

c. Precise curing techniques of new and improved onion cultivars should provide an onion less susceptible to storage rot. Proper storage requirements will be established to the extent that excessively high temperatures will be avoided in favor of evaporative cooling systems at the local level.

B. Central Mango Research Station, Lucknow

1. Components

a. Preharvest and Harvesting

Guava: This will be the only center working on guava harvesting. Very little information is available on handling guava in India.

Mango: Lucknow has extensive plantings of many varieties and will provide a unique opportunity to evaluate harvesting characteristics of different varieties and their handling, storage, marketing procedures.

Potato: Potatoes are presently not being worked on in Lucknow. The area has unique growing conditions which effect harvesting.

b. Precooling, Handling and Transport

Guava: Guavas are susceptible to physical damage and rapid spoilage. This needs evaluation and prevention.

Mango: Established plantings will supply raw materials for completely controlled transport studies.

Potato: Studies should concentrate on problem areas affecting transport which are unique to the area.

c. Storage

Guava: Determination of extent of losses and prevention by evaporative cooling should receive immediate attention.

Mango: Storage work should take advantage of the unique varieties available.

Potato: Design and testing of on-farm evaporatively cooled storages is necessary.

d. Processing

Guava: Guava juices, nectars and concentrates are established commercial products and local varieties should be tested for their suitability. Dried mango in the form of "leathers" made from various blends should provide local and export markets.

Mango: Solar dehydration of mango products by both home and small industry show promise.

Potato: Variety trials for chipping quality and solar dehydration are important.

e. Waste Utilization

Any waste utilization potential is probably from processing by-products.

2. Personnel

Available

Scientific:

Scientist	S-2	Horticulturist	Vacant
Scientist	S-2	Horticulturist (Fruit Technology)	1
Scientist	S-1	Horticulturist (Processing, Postharvest)	1
Scientist	S-1	Microbiology (Wines) 1	
Engineer			Vacant

Technical:

Technician	T-II-3	2

Proposed

Scientific:

Scientist	S-3	Principal Investigator (Postharvest Technology)	1
Scientist	S-2	Handling, Transport, & Storage	2
Scientist	S-1	Handling, Transport, & Storage	1
Scientist	S-2	Pathology	1
Scientist	S-1	Economist	1
Scientist	S-2	Engineer, Mechanical	1
Scientist	S-1	Engineer, Food	1
Scientist	S-1	Processing	1

Technical:

Technician	T-1	1
Technician	T-II-3	9
Technician	T-4	2
Driver	T-1	2
Refrigeration Mechanic	T-II-3	1
Auto Mechanic	T-II-3	1

Administrative:	
Stenographer	1
Jr. Clerk	1
Supporting:	
Attender	2

3. Equipment (approx. $ cost)

Harvesting, Transport and Storage

Precooler with recorders and controls
Controls and monitors for controlled atmosphere storage
Walk-in coolers with controls (4)
Materials for evaporative coolers
Hygrometer
Truck for transport studies
Matador van

Containerization and Packaging

Materials for packaging

Processing

Steam generator 10 H.P.
Junior pulper
Scraped surface heat exchangers for heating and cooling (2)
Solar dryer and parabolic cooker materials
Vacuum heat sealer with top and bottom heating
Water seal vacuum pump
Vacuum kettle, 30 gallon
Steam kettle, 20 gallon
Steam blancher
Micsellaneous pumps, etc.
Brookfield viscometer
Aquastat moisture analyzer
Juice extractor

Pathology and Microbiology

Supplies and miscellaneous equipment

Economics

Microcomputer upgrading

Analytical

High pressure liquid chromatograph
Gas analyzer
Instron texture measuring device
Gardner color difference meter

Miscellaneous Support Materials

Typewriter
Electronic desk calculator (2)
Filing cabinet (2)
Steel almirah
Index card cabinet
Table (5)
Chairs (5)
Books, texts, and back issues of journals
Copying machine
Microfilm recorder and projectors
Carousel slide projector
Projector screen

4. Training Program

Lucknow has five established postharvest positions (2 vacant at present) which allows for some training in the first year. The main training emphasis will be in the second year with completion of training in the third year.

Position	Duration
Year 1:	
S-2 Horticulturist (Processing)	
Potato processing research	12 months

Position	Duration
Year 2:	
S-2 Pathologist Spoilage in stored products, particularly potatoes	12 months
S-1/ S-2 Phyiologist Quality factor evaluation	12 months
S-2 Engineer Package and solar drier design	12 months
S-2 Horticulturist Techniques of C.A. storage	12 months
S-1 Engineer Evaporative cooling	8 months
Year 3:	
S-3 Principal Investigator Survey of recent developments	2 months

5. Consulting Services

Year 1:	
Postharvest storage	3 weeks
Year 2:	
Packaging specialist Solar drying specialist Pathologist	3 weeks
Year 3:	
Food technologist Storage specialist, mango and guava	12 weeks
Year 4:	
Postharvest physiologist Engineer, evaporative cooling	10 weeks

Position	Duration
Year 5:	
Review of progress and suggestions for further work by specialists in:	
Storage/physiology Food technology Packaging Economic Engineering, evaporative cooling and solar drying Transport Pathology/microbiology	8 weeks
Total:	35 weeks

The services of these experts may be utilized by all four centers during their respective consultancy period. This will be decided by the ICAR.

6. Facilities

The present rented facilities in Lucknow are inadequate for the present staff and certainly could not accommodate the additional staff proposed. A move to another location is the only solution. The nucleus of the required building space is available at the institute field station approximately 25 km from the present laboratories. The field station buildings would require servicing, i.e. installation of laboratory benches, plumbing, wiring, etc. There is also a large shed available which would be suitable for a processing hall and workshop for construction of evaporative coolers, packaging and solar driers.

Establishment of the institute at the field station would have the great advantage of locating scientists near the experimental plots and would provide additional land as needed. The air at the station is much less hazy and would provide conditions for solar drying similar to those encountered on the farm.

Location at the field station would require staff transportation since most of the staff prefer to live in the city. However, the institute presently operates a bus to the station and the move would create a situation similar to that at Bangalore. The institue at Bangalore appears to be functioning well and there do not seem to be undue staff problems.

Because of the uncertainty of location, it is impossible at this time to present a realistic facility budget. However, the following additional facilities are necessary and cannot be constructed at the present location:

a. Processing hall, 30 x 40'.
b. Controlled temperature storage rooms, variable from 0 C to ambient, each 12 x 20'; four required.
c. Laboratory space: (to accommodate 12 scientists)
   - Analytical
   - Pathology
   - Physiology
   - Processing
   - Engineering
   - Horticulture

7. Principal Reports, Reviews and Evaluations

For all locations the subproject should be reviewed and evaluated. Annual reports should be prepared and results published in scientific journals as objectives are completed.

8. End of Project Status

a. Precise curing techniques involving ventilation, humidity and temperature control of potatoes with better storage characteristics. Handling procedures will be improved at harvest to reduce cuts and bruises that often lead to storage decay.

b. New and better designed solar drying structures should result in acceptable quality mango and guava products.

c. The establishment of improved harvesting practices which reduces cuts and bruises thereby minimizing storage decay.

d. The availability of improved storage systems which improves the curing and healing of potatoes.

e. New potato, mango and guava cultivars will be selected which are disease-resistant and durable during handling, transport and storage.

f. The development of new and better designed cooling systems.

g. The establishment of a standardized method for transportation and packaging materials to enable proper cooling and related improved product quality.

C. Central Citrus Research Station, Nagpur

This facility has not yet been established. It will be located in the center of one of the largest citrus and banana producing areas in India and the fruit shipped throughout much of India. The Indian Institute of Horticultural Research is planning to set up a regional station at this location in the Sixth Plan. Detailed planning is difficult to carry out at this stage and the following is suggested, subject to further consultation at a more advanced planning stage.

1. Components

Research will be on prevention of postharvest losses in citrus and banana. Processing will concentrate on citrus.

a. Preharvest and harvesting

Citrus: Nagpur is the main centre for mandarin growing in India. This area is different from Assam and Coorg (Karnataka) where oranges are grown. As this is a major orange producing area, it is highly essential to study the improved harvesting methods and quality indices.

Banana: Maharashtra is an important Banana growing area. Emphasis will be given to cover all objectives and improved harvesting methods and quality indices.

b. Transport and handling

Citrus: Nagpur area produces abundant quality oranges which are transported to different parts of the country. Hence losses in transport need to be studied by suitable packaging and temperature control. The extent of losses and suitable control measures need to be determined.

Banana: Due to lack of suitable packaing and temperature control, extensive damage occurs. The extent of losses and suitable control measures need to be worked out.

c. Storage

Evaporative cooling to minimise the cost of refrigeration should be studied.

Citrus: Post harvest treatment to minimise the spoilage during storage.

Banana: Regulation of ripening and control of spoilage during storage need to be investigated.

d. Processing

Citrus: Work on canning of segments, juice and juice concentrate and marmalade should be taken up for full utilisation of the orange;s produced during the period.

Banana: Methods should be standardised for production of banana puree and juice.

e. Waste Utilization

Citrus: Peels should be investigated for essential oil and pectin.

Banana: Peel may be investigated for recovering flavour components.

2. Personnel

Available: None

Proposed:

Scientific:

Scientist	S-3	Principal Investigator (Fruit Physiology)	1
Scientist	S-2	Horticulturist (Pathologist)	1
Scientist	S-2	Horticulturist (Processing)	1
Scientist	S-1	Pathologist	1
Scientist	S-1	Engineer, packaging	1
Scientist	S-1	Economist	1

Technical:

Technician T-II-3 6
Mechanic (Maintenance)
T-II-3 1

Administrative:

Jr. Clerk 1

Supporting:

Attender 1

3. Equipment (approx. $ cost)

Harvesting, Transport and Storage

Cooler for precooling
Controled temperature walk-in chambers (4)
Equipment for providing and monitoring
modified atmospheres
Evaporative cooler materials

Processing

Steam generator 10 H.P.
Vaccum juice concentrate unit complete
with aroma recovery
Brookfield viscometer
Packaging line, American Machinery Corp.,
miniature, with washer, sizer, dispenser,
dryer, waxer and all connecting belts and rollers
Miscellaneous small equipment and glassware
Juice extractor

Pathology and Microbiology

Incubator
Laboratory pressure cooker

Analytical

Gardner color difference meter
Spectrophotometer, Spectronic 20
pH meter
Abbe refractometer
Monpan balance
Top pan balance
Oven

Economist

Microcomputer

Miscellaneous Support Materials

Typewriter
Desk calculator
Filing cabinet
Steel cabinet
Index card cabinet
Table
Chair
Books and journals
Copying machine
Microfilm reader and projector
Slide projector
Overhead projector
Projection screen
Library acquisitions

4. Training

Year 1:		
S-3	Physiologist	8 months
S-2	Horticulturist (Processing)	8 months
S-2	Horticulturist (Pathologist)	8 months
Year 3:		
S-1	Economist	4 months
S-1	Engineer	4 months
		32 months

5. Consulting Services

Year 1:	
Horticulturist	2 weeks
Year 2:	
Pathologist	2 weeks
Year 3:	
Post Harvest Technologist Handling & Storage	4 weeks
	8 weeks

6. Facilities

a. Processing hall.
b. Common storage:
Controlled temperature storage is included in equipment.
Laboratory and office space for five scientists.
Space for administration and technical.

7. Principal Reports, Reviews and Evaluations

For all locations the subproject should be reviewed and evaluated annually. Annual reports should be prepared and results published in scientific journals as objectives are completed.

8. End of Project Status

The serious neglect in handling and use of various postharvest treatments for citrus result in a striking reduction of losses and improved quality. The use of ethylene with early fruit will eliminate the green peel color and give an attractive orange-colored peel. The packing line with all of its processing treatments of washing, applying fungicides, waxing and grading will further improve quality and reduce stem-end decay.

D. Indian Agricultural Research Institute, Delhi

Delhi acts as a major marketing, repacking and distribution center for all crops and is therefore located to allow work on all crops.

1. Components

a. Preharvesting and Harvesting

No work will be done on this component.

b. Precooling, Handling and Transport

Banana: Bananas are often received by rail under very poor conditions. Feasibility of improving rail transport should be investigated.

Citrus: Quality of fruit, particularly Nagpur mandarins, arriving at Delhi should be surveyed and sources of spoilage identified. Design effective evaporative coolers.

Guava: Monitor and identify transport losses and design more effective packing.

Mango: Act in cooperation with Bangalore and Lucknow in studying effects of transport.

Onion: Determine transport losses and improve packaging if necessary.

Potato: Determine transport losses and their causes. Design effective evaporative cooling.

Tomato: Evaluate maturity and other quality factors on arrival at market. Design effective, economical packaging and evaporative cooling.

c. Storage

Banana: Design effective evaporative cooling. Determine optimum modified atmospheres.

Citrus: Design effective packaging and cooling. Study storage diseases. Determine optimum storage conditions.

Guava: Determine optimum storage conditions. Develop controls for storage diseases.

Mango: Determine optimum storage conditons after transport.

Onion: Develop methods to prevent storage rots. Design effective cooling.

Potato: Design effective evaporative cooling. Prevent sprouting.

Tomato: Design effective evaporative cooling and packaging.

d. Processing

Banana: Solar dehydration and aseptic packaging of pulp.

Citrus: Citrus processing will not receive a great deal of emphasis.

Guava: Aseptic packaging and chemical preservation of guava pulp.

Mango: Preparation of mango leather. Aseptic packaging and chemical preservation of juice.

Onion: Solar drying of onion flakes. Variety evaluation for drying quality.

Potato: Solar dehydration, evaluation of quality for processing. Aseptic packaging and chemical preservation.

e. Waste Utilization

Delhi is a center for processing and all crops should be examined for potential useful materials from processing waste.

2. Personnel

Available

Scientific:

Scientist	S-3	Senior Horticulturist Technologist	1 (vacant)
Scientist	S-2	Horticulturist (Storage)	1
Scientist	S-2	Horticulturist (Processing)	1
Scientist	S-1	Horticulturist (Processing)	2
Scientist	S-1	Storage and Transport	1 (vacant)

Technical:

Technician	T-II-3	3 (2 vacant)
Driver	T-1	1

Administrative:

Administrative Office Assistant	1
Laboratory attendants	1

Support:

Laboratory attendants	4

Proposed:

Scientific:

Scientist	S-2	Storage and Handling	1
Scientist	S-2	Postharvest Physiology	1
Scientist	S-1	Postharvest Physiology	1
Scientist	S-2	Pathology	1
Scientist	S-1	Patholgy	1
Scientist	S-2	Engineer, Packaging/Cooling	1
Scientist	S-1	Physicist, Packaging	1
Scientist	S-2	Economist	1
Scientist	S-1	Economist	1

Technical:

Technician	T-2	2
Technician	T-3	8
Auto Mechanic	T-3	1
Refrigeration Mechanic	T-3	1
Driver	T-1	1

Administrative:

Senior Clerk	1
Senior Stenographer	1

Support:

Attendants 4

3. Equipment

Harvesting, Transport and Storage

Controls and monitoring equipment for
controlled atmosphere
Portable ethylene detector (4)
CO_2 analyzer, gas partitioner
Recording thermometer with humididty meter (12)
Rotary flash evaporator
Miscellaneous items
Waxer
Box vibrator
Compression tester for boxes
Puncture tester
Walk-in temperature controlled rooms,
0°C to ambient (4)
Air conditioning and climatizer equipment
Material for construction of experimental
evaporative coolers
Matador van

Processing

Remote temperature sensor recorder, 12 point,
with thermo-couples
Aseptic packaging unit for bulk packaging
Steam generator, 15 H.P.
Laboratory pressure sterilizer, with
provision for air over pressure control,
FMC Universal, model 610-10
Vaccum sealer, double bar
Aquastat moisture analyzer and recorder
Brookfield viscometer
Instron texture measuring device
Air compressor
Steam blancher
Food pump
Vacuum pump water seal
Material for construcion of experimental
solar dryers

Microbiology and Pathology

High power microscope with flourescence attachment; attachments and camera for photomicrography
Microscope, high power
Incubator (2)
Incubator, B.O.D. (2)
Refrigerator
Deep freeze
Refrigerated centrifuge
Oil bath adjustable to 200°C
Inoculating chamber, laminar flow
Lyophilizer

Analytical

Gas chromotograph with recorder
Spectrophotometer, Spectronic 2000 with fluorescence attachment
Balance, Mettler
pH meter
Gardner color difference meter

Miscellaneous Support Materials

Electronic desk calculator
Typewriter
Filing cabinet
Steel almirah (12)
Tables (12)
Chairs (24)

4. Training Program

Delhi has five established scientist positions (2 vacant) in postharvest area at presnt, with nine to be added. Training should be completed by Year 3.

Position		Duration
Year 1:		
S-3	Scientist, Principal Investigator*	2 months
S-2	Horticulturist (Processing)	14 months

* Assuming this position is filled by the start of the project, the principal investigator should visit various institutions involved in postharvest and processing research in order to develop some familiarity with the whole field.

Year 2:

S-2	Horticulturist Techniques of controlled atmosphere storage	12 months
S-2	Postharvest Physiologist Physiological disorders and analytical procedures	12 months
S-2	Pathologist Micro-organisms in spoilage	12 months
S-2	Engineer Evaporative cooling and packaging design	12 months

Year 3:

S-1	Physicist Processed food packaging	12 months
S-2	Economist Study of marketing economics	17 months
	Total	91 months

5. Consulting Services

Year 1:

Postharvest storage specialist - all crops Toward end of year when some new staff have arrived	2 weeks

Year 2:

Economist Marketing economics	3 weeks

Year 3:

Pathologist Tropical postharvest pathogens	12 weeks
Physiologist Disorders of tropical crops	3 months

Year 4:

Food Technologist/Analytical Chemist Analytical techniques in food, including texture and color measurement	10 weeks

Year 5:

Review of progress and suggestions for further work by specialists in:

Storage/physiology	
Food technologist	
Packaging specialist	8 weeks
Economist	
Engineer (evaporative cooling)	
Pathologist/Microbiologist	
Total:	35 weeks

The services of these experts may be utilized by all four centers during their respective consultancy period. This will be decided by the ICAR.

6. Facilities

Additional space will be required to house the additional staff. This may be available soon when the preharvest physiology unit relocates.

Proposed:

a. Laboratory (50x30x15') with fittings and tables (5)
b. Fumigation chamber (1)
c. Ripening chamber with complete automatic gas temperature and humidity controls and recording devices (1)

7. Principal Reports, Reviews and Evaluations

For all locations the subproject should be reviewed and evaluated annually. Annual reports should be prepared and results published in scientific journals as objectives are completed.

8. End of Project Status

Progress for all commodities and objectives will be reached due to the reduced losses found at this terminal market center. The improved product leaving the production areas, the better designed packages and the more efficient transport systems in conjunction with commodity cooling will all contribute to reduced losses.

Potato storage facilities in Delhi should be more effective since they will be dealing with better cured and handled product. Advances will be made in the evaporative cooling systems, especially if input is realized from cooperation with the National Physical Laboratory and the Indian Institute of Technology.

Training of Scientists

It is proposed that scientists be supported for training for a short duration of time at appropriate institutions. Rather than visiting and observing many research facilities, it is recommended that the scientists actively participate in a specific research program at a cooperating institution. Selection of an institution and research program should be based on obtaining particular skills, experience and knowledge relevant to the scientist's program in India. The scientist should prepare a proposal to describe the plan of study and objectives for his particular training program.

Many institutions will require compensation for personnel time, transportation, materials, equipment, facility maintenance and overhead in order to accept a visiting scientist. It is proposed that support for the host institution be provided through this project. This will provide an incentive to the host institution to accept the visiting scientist and develop a meaningful training program. More importantly, this will greatly benefit the ability and flexibility to select a particular host institution and research program by the Indian scientists. In addition, an initial study tour of Indian project management staff should be developed during the first year.

Suggested Training Institution in the USA

Institution	Speciality
1. University of California Davis, California	a. Short course on postharvest handling and storage (date announced in Hort. Science). b. Postharvest horticulture/ physiology. c. Pathology/microbiology. d. Processing/enology. e. Packaging, engineering.
2. University of California Riverside, California	a. Postharvest physiology mainly of citrus and tropical fruits.
3. USDA, Western Regional Lab Albany, California	a. Processing, waste utilization, solar dehydration.

4. USDA, Market Quality and Transportation Research Lab Fresno, California	a. Harvesting, handling, transport and storage. b. Pathology.
5. USDA, Citrus and Subtropical Products Winterhaven, Florida	a. Citrus and subtropical product processing. b. Storage of citrus.
6. USDA Beltsville, Maryland	a. Marketing quality of stored products. b. Instrumentation. c. Postharvest horticulture/ physiology.
7. University of Hawaii Honolulu, Hawaii	a. Storage b. Processing.
8. University of Arkansas Fayetteville, Arkansas	a. Harvesting, handling, transport and storage. b. Postharvest horticulture/ physiology. c. Processing, instrumentation: Short course announed in Food Technology.
9. University of Idaho Moscow, Idaho	a. Storage and processing (potatoes).
10. Texas A&M University College Station, Texas	a. Storage and transport. b. Processing.
11. Arizona State University Tucson, Arizona	a. Evaporative cooling. b. Solar dehydration.
12. University of Georgia Athens, Georgia	a. Storage and transport. b. Postharvest horticulture/ physiology. c. Engineering.

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13. Michigan State University
East Lansing, Michigan

a. Packaging: Short course announced in Food Technology.
b. Postharvest horticulture/ physiology.
c. Harvesting, handling, storage and transport.
d. Instrumentation.
e. Processing.

14. Purdue University
Lafayette, Indiana

a. Physiology.
b. Pathology.
c. Processing and instrumentation.
d. Engineering.

15. Cornell University
Ithaca, New York

a. Postharvest horticulture.
b. Processing.
c. Pathology.
d. Engineering.

It is recommended that as much training as possible be done within India. Program on operation and maintenance of various types of analytical equipment could be accomplished at cooperating institutions within India.

Appendix B

Consultants

It is recommended that during the initiation of this project at each institution, consultants should participate in equipment acquisition, installation and instruction of operation. Assisting with designing experiments to focus on specific objectives should also be a role of the consultant. Once equipment and facilities are established, then the consultant should become an active participant in particular research programs. His role would be more as a visiting scientist doing cooperative research with an Indian colleague rather than a short-term consultant. These joint projects between Indian and foreign scientists should provide a greater efficiency and advancement of results than traditionally short visits by a consultant. Some joint projects could be initiated by the Indian scientists, when working at host institutions during the training program.

In view of the suggested roles of the consultant in this project, the costs in the budget table allocated to consultancy are probably higher than actual costs. A consultant working for two or more months at a particular institution would incur less monthly and transportation expenses than one working for only one month with only one week at each of four locations. The budget tables reflect the costs estimated for the latter situation.

Appendix C

Training Schedule

Location of Scientist	Year 1 Technical Area	Months	Year 2 Technical Area	Months	Year 3 Technical Area	Months
IIHR, Bangalore	a. Storage and Hangling b. Handling and Transport c. Pathology and Spoilage	12 12 12	a. Processing b. Design & testing of evaporative coolers or solar c. Packaging d. Storage Physiology	12 12 12 12	a. Drying and Cooling b. Pathology c. Marketing d. Physiology and Biochemistry	12 12 12 12
CCMS, Lucknow	a. Potato processing and research	12	a. Pathology b. Quality eval., Physiology c. Packaging and solar drying d. Storage and Handling e. Precooling and evaporative cooling	12 12 12 12 12	a. Survey new development	2
CCRS, Nagpur	a. Storage and Physiology b. Processing	8 8	a. Pathology		a. Cooling and Drying	8
IARI, Delhi	a. Survey processing and Postharvest Research b. Processing and Packaging	2 14	a. Storage and Handling b. Physiology and Analysis c. Pathology d. Cooling and Dehydration	12 12 12 12	a. Handling and Packaging b. Marketing	12 17

Total Months by Location: Bangalore - 132
Lucknow - 70
Nagpur - 32
Delhi - 93

Total Months by Year: Year 1 - 80
Year 2 - 160
Year 3 - 93

Grand Total: 327 Months

DETAILED SUBPROJECT BUDGET - FRUITS & VEGETABLES, ICAR HEADQUARTERS
($000)

Annex A

ITEM	YEAR 1				YEAR 2				YEAR 3			
	AID				AID				AID			
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL
Training z/												
U.S. (Study Tours)	20			20								
India												
Workshops & Conferences												
Consultants y/												
Research Equipment												
U.S.												
India												
Facilities												
Office Equipment & Supplies	7			7	5			5				
Operational Research												
Vehicles												
Maintenance												
Research Equipment												
Office Equipment												
Vehicles												
Staff												
Present												
New		10		10		11		11		11		11
In-Country Travel			1	1			1	1			1	1
TOTAL	27	10	1	38	5	11	1	17		11	1	12

z - Refer to appendix on training y - Refer to appendix on consultants

Annex A (contd.)

ITEM	YEAR 4				YEAR 5				TOTAL ALL YEARS				
	AID				AID				AID				GRAND
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	TOTAL	ICAR	TOTAL
Training													
U.S.									20		20		20
India													
Workshops & Conferences													
Consultants													
Research Equipment													
U.S.													
India													
Facilities													
Office Equipment & Supplies													
Operational Research										12	12		12
Vehicles													
Maintenance													
Research Equipment													
Office Equipment													
Vehicles													
Staff													
Present													
New		12		12		22		22		66	66		66
In-Country Travel			1	1			1	1				5	5
TOTAL		12	1	13		22	1	23	32	66	98	5	103

DETAILED SUBPROJECT BUDGET - FRUITS & VEGETABLES, IIHR, Bangalore
($000)

Annex B

ITEM	YEAR 1				YEAR 2				YEAR 3			
	AID				AID				AID			
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL
Training z/												
U.S.	180			180	240			240	240			240
India												
Workshops & Conferences		5		5		5		5		5		5
Consultants y/	8			8	11			11	45			45
Research Equipment												
U.S.	160			160	120			120	30			30
India		90		90		56		56		20		20
Facilities			36	36			90	90			55	55
Office Equipment & Supplies			52	52			3	3			3	3
Operational Research						5		5		5		5
Vehicles			45	45								
Maintenance												
Research Equipment					27	9		36	27	9		36
Office Equipment							5	5			5	5
Vehicles							3	3			3	3
Staff												
Present			24	24			38	38			50	50
New		34		34		34		34		34		34
In-Country Travel			5	5			5	5			5	5
TOTAL	348	129	162	639	398	109	144	651	342	73	121	536

z -Refer to appendix on training

y - Refer to appendix on consultants

Annex B (contd.)

I T E M	YEAR 4				YEAR 5				TOTAL ALL YEARS				
	AID				AID				AID				GRAND
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	TOTAL	ICAR	TOTAL
Training													
U.S.									660		660		660
India													
Workshops & Conferences		5		5		5		5		25	25		25
Consultants	38			38	30			30	132		132		132
Research Equipment													
U.S.									310		310		310
India		20		20		20		20		206	206		206
Facilities			57	57								238	238
Office Equipment & Supplies			3	3			3	3				64	64
Operational Research		5		5		10		10		25	25		25
Vehicles												45	45
Maintenance													
Research Equipment	27	9		36	27	9		36	108	36	144		144
Office Equipment			5	5			5	5				20	20
Vehicles			3	3			3	3				12	12
Staff													
Present			57	57			57	57				226	226
New		34		34		34		34		170	170		170
In-Country Travel			5	5			5	5				25	25
T O T A L	65	73	130	268	57	78	73	208	1210	462	1672	630	2302

DETAILED SUBPROJECT BUDGET - FRUITS & VEGETABLES, CMRS, Lucknow
($000)

Annex C

ITEM	YEAR 1 AID FX	YEAR 1 AID LC	YEAR 1 ICAR	YEAR 1 TOTAL	YEAR 2 AID FX	YEAR 2 AID LC	YEAR 2 ICAR	YEAR 2 TOTAL	YEAR 3 AID FX	YEAR 3 AID LC	YEAR 3 ICAR	YEAR 3 TOTAL
Training z/												
U.S.	60			60	280			280	10			10
India												
Workshops & Conferences		3		3		5		5		5		5
Consultants y/	8			8	11			11	45			45
Research Equipment												
U.S.	45			45	80			80	30			30
India		50		50		50		50		27		27
Facilities			36	36			90	90			50	50
Office Equipment & Supplies	2		10	12	3		11	14	2		1	3
Operational Research						2		2		3		3
Vehicles			9	9			20	20				
Maintenance												
Research Equipment					11	6		17	12	6		18
Office Equipment							1	1			1	1
Vehicles							1	1			1	1
Staff												
Present			9	9			10	10			12	12
New		27		27		27		27		27		27
In-Country Travel			2	2			3	3			3	3
TOTAL	115	80	66	261	385	90	136	611	99	68	68	235

z - Refer to appendix on training

y - Refer to appendix on consultants

Annex C (contd.)

I T E M	YEAR 4				YEAR 5				TOTAL ALL YEARS				
	AID				AID				AID				GRAND
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	TOTAL	ICAR	TOTAL
Training													
U.S.									350		350		350
India													
Workshops & Conferences		5		5		5		5		23	23		23
Consultants	38			38	30			30	132		132		132
Research Equipment													
U.S.									155		155		155
India										127	127		127
Facilities												176	176
Office Equipment & Supplies	2		1	3	2		1	3	11		11	24	35
Operational Research		3		3		3		3		11	11		11
Vehicles												29	29
Maintenance													
Research Equipment	12	7		19	12	7		19	47	26	73		73
Office Equipment			1	1			1	1				4	4
Vehicles			2	2			2	2				6	6
Staff													
Present			15	15			18	18				64	64
New		27		27		27		27		135	135		135
In-Country Travel			3	3			3	3				14	14
T O T A L	52	42	22	116	44	42	25	111	695	322	1017	317	1334

DETAILED SUBPROJECT BUDGET - FRUITS & VEGETABLES, CCRS, Nagpur
($000)

Annex D

ITEM	YEAR 1				YEAR 2				YEAR 3			
	AID				AID				AID			
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL
Training z/												
U.S.	80			80	40			40	40			40
India												
Workshops & Conferences		1		1		3		3		3		3
Consultants y/	8			8	11			11	45			45
Research Equipment												
U.S.	90			90	100			100				
India		25		25		33		33				
Facilities			36	36			90	90			32	32
Office Equipment & Supplies	2		15	17	4		13	17	4		2	6
Operational Research										2		2
Vehicles			20	20								
Maintenance												
Research Equipment					14	2		16	14	3		17
Office Equipment							1	1			1	1
Vehicles							1	1			1	1
Staff												
Present												
New		17		17		17		17		17		17
In-Country Travel			1	1			3	3			3	3
TOTAL	180	43	72	295	169	55	108	332	103	25	39	167

z - Refer to appendix on training y - Refer to appendix on consultants

Annex D (contd.)

I T E M	YEAR 4				YEAR 5				TOTAL ALL YEARS				
	AID				AID				AID				GRAND
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	TOTAL	ICAR	TOTAL
Training													
U.S.	40			40					200		200		200
India													
Workshops & Conferences		3		3		3		3		13	13		13
Consultants	38			38	30			30	132		132		132
Research Equipment													
U.S.									190		190		190
India										58	58		58
Facilities												158	158
Office Equipment & Supplies	2		1	3			1	1	12		12	32	44
Operational Research		2		2		3		3		7	7		7
Vehicles												20	20
Maintenance													
Research Equipment	14	3		17	15	4		19	57	12	69		69
Office Equipment			2	2			2	2				6	6
Vehicles			1	1			1	1				4	4
Staff													
Present													
New		17		17		17		17		85	85		85
In-Country Travel			3	3			3	3				13	13
T O T A L	94	25	7	126	45	27	7	79	591	175	766	233	999

DETAILED SUBPROJECT BUDGET - FRUITS & VEGETABLES, IARI, Delhi
($000)

Annex E

I T E M	YEAR 1				YEAR 2				YEAR 3			
	AID				AID				AID			
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL
Training z/												
U.S.	80			80	240			240	145			145
India												
Workshops & Conferences		3		3		5		5		5		5
Consultants y/	8			8	11			11	45			45
Research Equipment												
U.S.	70			70	150			150	110			110
India		50		50		80		80		45		45
Facilities			90	90			330	330			23	23
Office Equipment & Supplies			10	10			3	3			2	2
Operational Research		1		1		3		3		3		3
Vehicles			15	15								
Maintenance												
Research Equipment					24	8		32	25	9		34
Office Equipment							2	2			2	2
Vehicles							1	1			1	1
Staff												
Present			14	14			17	17			20	20
New		29		29		29		29		29		29
In-Country Travel			3	3			5	5			5	5
T O T A L	158	83	132	373	425	125	358	908	325	91	53	469

z -Refer to appendix on training y - Refer to appendix on consultants

Annex E (contd.)

I T E M	YEAR 4				YEAR 5				TOTAL ALL YEARS				
	AID				AID				AID				GRAND
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	TOTAL	ICAR	TOTAL
Training													
U.S.									465		465		465
India													
Workshops & Conferences		5		5		5		5		23	23		23
Consultants	38			38	30			30	132		132		132
Research Equipment													
U.S.									330		330		330
India										175	175		175
Facilities												443	443
Office Equipment & Supplies			2	2			2	2				19	19
Operational Research		3		3		3		3		13	13		13
Vehicles												15	15
Maintenance													
Research Equipment	25	9		34	25	9		34	99	35	134		134
Office Equipment			1	1			1	1				6	6
Vehicles			1	1			1	1				4	4
Staff													
Present			24	24			29	29				104	104
New		29		29		29		29		145	145		145
In-Country Travel			5	5			5	5				23	23
T O T A L	63	46	33	142	55	46	38	139	1026	391	1417	614	2031

DETAILED SUBPROJECT BUDGET - FRUITS & VEGETABLES

Totals All Locations (including headquarters) ($000)

Annex F

ITEM	YEAR 1				YEAR 2				YEAR 3			
	AID				AID				AID			
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL
Training												
U.S.	420			420	800			800	435			435
India												
Workshops & Conferences		12		12		18		18		18		18
Consultants	32			32	44			44	180			180
Research Equipment												
U.S.	365			365	450			450	170			170
India		215		215		219		219		92		92
Facilities			198	198			600	600			160	160
Office Equipment & Supplies	11		87	98	12		30	42	6		8	14
Operational Research		1		1		10		10		13		13
Vehicles			89	89			20	20				
Maintenance												
Research Equipment					76	25		101	78	27		105
Office Equipment							9	9			9	9
Vehicles							6	6			6	6
Staff												
Present			47	47			65	65			82	82
New		117		117		118		118		118		118
In-Country Travel			12	12			17	17			17	17
TOTAL	828	345	433	1606	1382	390	747	2519	869	268	282	1419

Annex F (contd.)

I T E M	YEAR 4				YEAR 5				TOTAL ALL YEARS				
	AID				AID				AID				GRAND
	FX	LC	ICAR	TOTAL	FX	LC	ICAR	TOTAL	FX	LC	TOTAL	ICAR	TOTAL
Training													
U.S.	40			40					1695		1695		1695
India													
Workshops & Conferences		18		18		18		18		84	84		84
Consultants	152			152	120			120	528		528		528
Research Equipment													
U.S.									985		985		985
India		20		20		20		20		566	566		566
Facilities			57	57								1015	1015
Office Equipment & Supplies	4		7	11	2		7	9	35		35	139	174
Operational Research		13		13		19		19		56	56		56
Vehicles												109	109
Maintenance													
Research Equipment	78	28		106	79	29		108	311	109	420		420
Office Equipment			9	9			9	9				36	36
Vehicles			7	7			7	7				26	26
Staff													
Present			96	96			104	104				394	394
New		119		119		129		129		601	601		601
In-Country Travel			17	17			17	17				80	80
T O T A L	274	198	193	665	201	215	144	560	3554	1416	4970	1799	6769