PD-AAX-604
ISN 55373

REPORT

OCTOBER, 1986

SUBPROJECT PAPER DESIGN

PLANT GENETIC RESOURCES

September 13 - November 7, 1987

Agricultural Research Project (386-0470)

Delivery Order No.12

Contract No.386-00000-C-00-5039-00

WINROCK INTERNATIONAL
1611 North Kent St.
Arlington, VA 22209

SBB

Project No. 386-0470

SUBPROJECT PAPER DESIGN REPORT

PLANT GENETIC RESOURCES

Team Members

Dr. Robert P. Kahn
Dr. Eric E. Roos
Dr. Willis H. Skrdla

USAID/New Delhi, India

October, 1986

W

Table of Contents

I. Executive Summary

II. Introduction, Problem Areas and Solutions, and Objectives

III. Team Visits
- A. NBPGR - Delhi
- B. Outlying Stations

IV. Major Thrust Areas
- A. National Plant Germplasm Network
- B. Collection and Exploration within India
- C. Conservation
- D. Evaluation
- E. Plant Quarantine
- F. Training and Personnel Development
- G. Basic and Applied Research

V. Specific Needs for the National Plant Germplasm System
- A. National Headquarters
  - 1. Conservation
  - 2. Evaluation
  - 3. Collection and Exploration
- B. Outlying Stations
- C. Plant Quarantine
- D. Training
- E. Basic & Applied Research
- F. Additional Technical Support

VI. Indo-U.S. Collaboration
- A. Germplasm Exploration
- B. Germplasm Exchange
- C. Workshops

VII. Benefits for Indo-U.S. Agriculture

VIII. Monitoring and Evaluation
- A. Subproject Management Committee
- B. External Evaluation
- C. Biennial National Symposium on Subproject Accomplish.

IX. U.S. Technical Consultants
- A. Plant Quarantine Information Specialist
- B. Greenhouse Environment Engineer
- C. Computer Specialists - Hardware & Software
- D. Cryogenics
- E. U.S. Plant Introduction Officer
- F. Quarantine Greenhouse Procedures Specialist

Anticipated Achievements at End of Subproject

A. Fully Operational and Efficient System
B. Safe and Secure Medium and Long-term Storage Facilities
C. Highly Trained Scientific & Support Staff
D. Significant Reduction in Risk of Introducing Pests
E. Effective and Efficient Computer Network
F. Improved Health Status of Stored Germplasm
G. Improved Procedures for Timely Exchange with U.S. and other countries
H. Significant Improvement Propagation and Storage - Clonal Germplasm
I. Development of Centers of Excellence in Research on:
   1. Diagnosis of obscure pathogens
   2. Tissue culture maintainence of germplasm
   3. Identification & characterization of compounds (medicinal, aromatic)
   4. Cryopreservation of Germplasm

XI. Long Range Needs

A. Expansion of Storage Facilities
B. Utilization of Genetic Engineering Techniques
C. Duplication of Base Collection within or Outside India
D. Develop GOI-Industry Cooperation

XII. Financial Plan & an exemplary plan for period of 5 years.

XIII. Appendices

I. EXECUTIVE SUMMARY

The fourth session of the Indo-U.S. Subcommission on agriculture identified the conservation and management of germplasm resources as an area of high priority for both countries. Accordingly the Indian Council of Agricultural Research (ICAR) has sought the collaboration of USAID for the development of a major project to support this activity. It is expected that this project will be implemented as one of the key subprojects under the ongoing Agricultural Research Project.

A team from the US spent six weeks in India working closely with the scientific staff of the National Bureau for Plant Genetic Resources (NBPGR). The mission was to assess the current situation and develop a five year plan that would strengthen substantially the ability of NBPGR to collect, evaluate, document and maintain essential plant genetic resources. Important aspects of plant quarantine technology are also considered to reduce the risks of introducing unwanted hazardous pests or pathogens when germplasm is exchanged or transported.

Genetic diversity is the backbone of all plant breeding and improvement programs. In order to improve such plant characteristics as: yield, quality, nutritive value, resistance to pests, resistance to stress and other attributes plant breeders must have available a wide pool of genetic diversity to provide the genetic building blocks required. It is significant to note that the rapid advances being made in modern biological technology are increasing our ability to design plants with specific desirable characteristics which makes the availability of the needed genetic resources all the more critical.

No single country has all of the world's naturally occuring genetic diversity or even sufficient diversity for its own breeding programs. Therefore the free exchange of plant germplasm between all countries is essential for the welfare of mankind. India is of particular importance in this regard as it is currently extremely rich in genetic resources. As there are widely varying agro-climatic zones in the country there is great genetic diversity in wild plants. As cultivation of many agronomic crops has been practiced for many centuries throughout the full range of these agro-climatic zones there is a substantial genetic diversity among commonly cultivated species. The widescale adoption of limited numbers of improved varieties can reduce the diversity currently existing in widely cultivated species. Expansion of agriculture and industrial development into areas of great genetic diversity can also reduce the gene pool that exists in the wild. There are eight naturally occurring centers of origin of plant species (Vavilovian centers) and two of these important centers are in India.

This proposal focuses on six major activities which are all necessary for the realization of the objectives of the project:

- Exploration and collection of germplasm.

Ongoing efforts to collect representative germplasm from the wild as well as from cultivated crops must continue. It is especially important that collections be made in areas where the extinction of important species is most likely. Additional important germplasm must also be obtained from other countries and international research centers so that it can be made available to plant breeders through working collections.

- Evaluation of germplasm.

In order for collected germplasm to be useful to plant breeders it is important the major characteristics of each accession be carefully evaluated and enumerated. In large measure this evaluation is done by growing lines out in experimental plots and measuring important parameters. Modern techniques of genetic identification through DNA sequencing are becoming increasingly important tools serving to facilitate evaluation and cataloging.

- Information.

It is essential that a computerized data base be used to handle the information required to maintain and make use of plant genetic resources. There may be thousands of accessions in each of many species. Each accession has a very large number of characteristics which must be measured and the results known to the plant breeder if effective use is to be made of the resource. The users of the genetic material must have a simple means of sorting through the very large data sets to ascertain those accessions which are likely sources of the combinations of characteristics needed.

- Conservation.

Collected and evaluated material must be maintained under conditions that will preserve unique genetic characteristics. Environmentally controlled seed storage systems are essential for the medium and long term storage of seeds. Long term storage is required for base collections and medium term storage for working collections. Plant materials that are clonaly propagated must be maintained as living whole plants or in tissue culture.

- Research on maintenance methodology.

There are two emerging areas for maintaining plant genetic resources that show substantial promise for insuring reliable long term storage. For seeds cryopreservation in liquid nitrogen promises to dramatically extend safe storage life. For clonaly propagated plant tissue culture techniques are potentially safe and economical. Research is needed in adapting these techniques to increased numbers of important species.

- Quarantine.

The natural conditions and the varied agricultural practices that encourage diversity in plant genetic characteristics also encourage diversity in the hazardous pests and pathogens that prey upon these important plants. Also, to realize the full potential of plant genetic resources free exchange of plant germplasm between various research centers throughout the world is essential. To insure that risks are minimized adequate quarantine procedures are needed. To minimize delays in exchanging germplasm resources facilities are needed that are adequate for prompt handling of the quarantine process.

This project proposal contains specific recommendations to help accomplish all of the above six integrated objectives. Specific recommendations include:

- Equipment and personnel for the collection and evaluation of plant germplasm.

- Training and consultancies to support the collection and evaluation of plant germplasm

- Equipment, consultancies and training for the development of a modern computerized data handling system.

- Facilities and equipment for the long term storage at -20°C of seed at NBPGR headquarters in New Delhi.

- Facilities and equipment for the medium term storage at 4°C of working collections at thirteen regional stations.

- Facilities and equipment for the storage of clonaly propagated plant material.

- Facilities, equipment, consultancies and training for research on cryopreservation of seeds and tissue culture preservation of clonaly propagated plants.

- Facilities and equipment for the improvement of the implementation of essential quarantine procedures.

- Support for workshops and exchanges of scientists to encourage the collaboration of scientists engaged in plant germplasm collection, evaluation, preservation and utilization.

It is visualized that this subproject will provide mutual benefit to India and the U.S. because an improvement in the germplasm system in one country will benefit the other. Some achievements anticipated at end of subproject include (1) a fully operational and efficient germplasm system, (2) safe and secure medium and long-term storage facilities, (3) highly trained scientific staff, (4) significant reduction risk of introducing pests, (5) effective and efficient computer network (6) improved health status of stored germplasm (7) improved germplasm exchange procedures between India and U.S., (8) development of centers of excellence in research on diagnosis of obscure pathogens, (9) tissue culture maintenance of germplasm, (10) identification and characterization of compounds (medicinal, aromatic), and (11) cryopreservation of germplasm.

II. INTRODUCTION, PRESENT STATUS BACKGROUND AND OBJECTIVES

1. Introduction

A. Centers of Genetic Diversity of Plants and their Pests and Pathogens

Plants, animals, and microorganisms have evolved over time through selection processes in response to environmental stresses including not only adverse climate but the competition with other organisms some of which may be parasites and predators. Species or varieties whose populations are not genetically diverse enough to cope with these stresses die out. Their ecological niches are then occupied by species or varieties better able to compete in the struggle for existence and the survival of the fittest. As a result of the frequency and concentration of the interactions between species and their environments, certain areas of the earth are now known as centers of genetic diversity or centers of origin for various species. These areas are rich in genetic diversity because the present day progeny are descended from successful survivors of the struggle for existence.

In addition to natural selection, the agricultural activities of early man and his descendents have influenced the genetic constitution and diversity of cultivated plants. Early man apparently selected his seeds, perhaps unknowingly, for the next planting from genetically superior plants leading to the development of land races. The Indian sub-continent was one of the three very early cradles of civilization. Consequently, India has a rich legacy not only in wild species and land races developed through natural evolution, but in selections made by man over centuries. Consequently, it is not surprising, from a biological point of view, that the Indian Sub-continent contains two of the eight centers of genetic diversity which are known to occur in the world.

In order to improve the quality and quantity of agricultural production not only in India but throughout the world, scientists must take advantage of the wide spectrum of diversity which occurs in gene centers and in farmers' fields. Yields have been limited, particularly in marginal farmland, by the stresses placed upon crop plants by adverse environmental factors such as acid, alkalaine, or saline soils; flooding; water-logged soil; droughts; and pestillence.

The best place to find the genetic diversity which might be incorporated into local varieties to counteract these stresses is to collect plant materials from areas where these adverse environmental stresses have been interacting with plant species over time. Once the plant material has been collected, particularly from harsh climates, and then evaluated, documented, and conserved, the genetic diversity is then readily available, upon request by public, private, government, and university scientists. The collected genes could then be utilized not only in classical genetics but in the molecular biology (biotechnology) approach to gene manipulation.

Just as the centers of origin and diversity are often areas where abiotic stresses interact with plant evolution, they are also areas where biotic stresses interact with plants. Thus, the centers of diversity of plants are often centers of diversity of the pests and pathogens that infest or infect plants. Consequently, at the same time that plant species are taking advantage of their genetic mechanisms to develop populations that are resistent to their attackers, the attackers are using their own genetic variability to develop populations to overcome the resistence of their hosts. Thus, over time, plants that do not develop resistence to pests may die out; similarly, organisms that do not overcome this resistence may also die out. Thus, the best place to collect resistence to pests is at places where the host and pest have evolved in concert. The problem to collectors is how to ferret out the beneficial genetic variability of plants without also collecting harmful pests and pathogens found in areas where both the host and its pests have evolved.

Not all genetic diversity is collected in the wild - much is exchanged between scientists in cooperative programs on a national or international basis. The germplasm in these collections may have, at one time, originated in the wilds or farms but much of it consists of advanced breeding lines or varieties that have already been improved. As is the case with the germplasm collected in the wild, germplasm imported from scientific collections may also be the source of hazardous organisms inadvertently moved by the transfer of germplasm.

In addition to serving as source of resistence to biotic and abiotic stresses, plants collected from areas of genetic diversity may also possess genetic diversity governing the type and percentage of useful chemical compounds. These compounds could include medicinal agents, dyes, industrial raw materials, gums, aromatic compounds, flavours, important human and animal nutritional factors, etc.

B. Problem: The loss and erosion of irreplaceable source of genetic diversity.

Solution: Under the Subproject, expand and enhance germplasm exploration, evaluation, documentation and conservation activities.

The genetic resources in the world, in general, and India in particular are endangered by their potential loss to the scientific community, and therefore, necessarily to the farmers throughout the world including India. The habitats of genetically important plants in the wild are threatened not only by natural calamities such as flooding, wildfire, pestilence, etc., but by activities of man such as overgrazing by animals and by deforestation as well as air, water, and soil pollution, which adversely affect these habitats.

Although scientists throughout the world collect germplasm, much of it is soon lost because of poor storage facilities or changes in breeding goals that impel scientists to discard germplasm that is not currently needed. Experience has demonstrated, time upon time again, that germplasm which has not been of current interest may become important in the future when pest or environmental conditions change -- but such germplasm, discarded because it was thought to be useless, was no longer available.

The solution to the problem of loss or erosion of genetic resources are national and international efforts to collect and then conserve valuable germplasm in facilities that will insure that losses do not occur both in the short and very long term. Scientists throughout the world are engaged in collection and conservation activities to prevent the loss of these irreplaceable genetic assets that took centuries of selection by man and nature.

India has already embarked, through the National Bureau of Plant Genetic Resources (NBPGR) and its many collaborators, on an extensive and comprehensive exploration venture — but has only been able but to tap the rich diversity in genetic resources for legumes, semi-arid, medicinal, under-utilized, vegetable, oil, tuber, industrial, and other crops. Indian agriculture, and indeed, the world's agriculture, stand to benefit from the germplasm exploration and conservation efforts within India. To this end, the resources of the NBPGR and its collaborators should be enhanced, under the Subproject to facilitate, in a timely manner, the exploration and collection of important diversity not only from the centers of origins on the Sub-continent but from areas of farmer-perpetuated variation within India.

Help needed from outside.

Indian agriculture would also benefit from an increase in the exploration for germplasm from other centers of diversity located outside of the Sub-continent as well as in the exchange of breeding lines and varietal collections located elsewhere. By having greater access to this advanced genetic material, India could not only improve, by breeding, its best local varieties but could expand crop diversification. Crop diversification may provide new cash and food crops, the production of which, might reduce dependence on foreign imports of such agricultural commodities as cooking oils.

Role of this subproject

Working hand-in-glove with exploration and evaluation is the scientific necessity to conserve the germplasm to protect its genetic integrity. Genetic resource scientists devote much of their time, effort, and resources to bring the thousands of accessions to the point where they are useful to scientists. In order to protect this investment, adequate storage facilities must be available.

However, germplasm resource scientists at outlying NBPGR and collaborator stations currently have either inadequate or no facilities for mid-term storage — and many have inadequate facilities for short-term storage. These scientists have no recourse but to grow-out the accessions <u>each year</u> in order to insure that the accessions survive from year-to-year. Growing-out each year is both administratively and scientifically unacceptable because:

(1) The genetic integrity of each accession is threatened by genetic drift in the population in response to abiotic and biotic stresses during the growing season.

(2) The accessions are exposed to repeated contamination by domestic pests and pathogens.

(3) Each accession must be chaperoned and shepherded through the growing season requiring significant operational outlays in land, labor and equipment.

(4) The time of scientists and technicians that might be available for research is eroded by the task of yearly grow-out.

(5) The survival of accessions may be jeopardized if rains fail at stations without irrigation if early grow-out is followed.

As a solution to this alarming problem, the Design Team recommends under its highest priority, that Subproject funds be allocated to the purchase of medium-term seed storage modules for immediate use at 13 outlying locations and that long-term seed storage facilities at Delhi be expanded to cover projected acquisition. In addition, the Team recommends that research in cryopreservation of seeds and vegetatively propagated crops be supported and that a Center of Excellence be developed. Furthermore, research on the preservation of germplasm by tissue culture should be accelerated and the possibility of low temperature storage of vegetatively propagated tropical root crops be evaluated through research.

Local procurement

Good!

Once the germplasm has been collected, or exchanged, it must be evaluated and documented in order to be of use to breeders and other scientists. Evaluation includes the determination of a wide spectrum of characters that include plant morphology, nutritional value, tolerance to abiotic and biotic stresses, length of growing season, etc. Then, the data acquired must be made available through computerized information, storage and retrieval systems. Therefore, the Design Team recommends that for evaluation, greenhouse and screenhouse facilities and equipment be supported under the Subproject.

Local procurement?

Equipment needs for evaluation range from conventional farm machinery designed for use in experimental plots to sophisticated laboratory equipment required for analysis of the chemical content of plants as well as genetic identification through DNA sequencing. Furthermore, computer hardware, software and consultant services are required - also on a priority basis.

How much local? How much imported

C. Problem: Risk of introducing hazardous pests and pathogens during the exchange and transfer of germplasm.

Solution: Under the Subproject, expand and improve plant quarantine services so as to facilitate the rapid but safe transfer of germplasm.

Pests and pathogens of quarantine importance may move along natural and manmade pathways from areas where they are known to occur to areas where they are not known to occur. Natural pathways include wind, storms, air currents, surface drainage, and vectors such as insects. Manmade pathways include cargo, mail, baggage, containers, packing materials, carriers such as ships or airplanes, scientific cultures of organisms, importation of soil and smuggling. Whether a pest or pathogen becomes established at the end of a pathway depends on the synchronization of three factors: presence of (1) susceptible hosts, (2) sufficient inoculum (or population threshold), and (3) a favorable environment. If any one of the factors is not operative, the organism does not become established. In theory, countries are continually "bombarded" by exotic organisms; yet, usually there is no establishment because the three factors are not operating in concert when the pest or pathogens arrives.

Exotic pests and pathogens may be considered in terms of "hazard" and "risk". Hazard refers to the danger that an exotic organism presents to a country's agriculture. Risk refers to the chances that the hazard will be expressed as a result of importation actions of man. "Safeguards" are actions taken by man to lower the risk (chances) that a hazardous organism will be introduced.

Governments promulgate rules and regulations that provide the legal basis for taking regulatory actions, often referred to as safeguards, in an attempt to block the movement of pests and pathogens along manmade pathways. Such actions are most effective when man rather than nature is the prime mover of the organisms. The actions (i.e., safeguards) taken by quarantine services are designed to prevent the three factors from operating. For example, the inoculum factor may be eliminated by treatment. The environment factor may be controlled by greenhouse growing. The host factor may be taken care of by safeguards, such as isolation, applied in the growing of the imported plant materials.

It is the consensus of quarantine officers that the highest risk manmade pathway for the entry of hazardous organism is the importation of infected or infested plants or plant propagation material. In many cases, the pest or pathogen is accompanied by its host — an event which does not often occur on natural pathways. Both the host and hazardous organism are protected from environmental stress during transit which is often very rapid even for long distances. Furthermore, the infected host is often planted in a similar environment as at its origin — thus often providing a favorable environment.

Germplasm, imported as plants or plant parts capable of propagation such as seeds, tubers, scions, cuttings, etc., is capable of harboring hazardous pests and pathogens. The real hazard presented by imported germplasm depends on its origin and the life cycles of exotic agents. Germplasm that originates in countries where hazardous agents occur constitutes a greater risk than the same germplasm originating from countries where such agents are not known to occur. Germplasm that originates from certification or other safeguarded programs constitutes less of a hazard. Germplasm collected in the wilds may be high risk if from areas where the local pest and pathogen distribution is unknown.

Many of the pests and pathogens associated with plants in natural and farming environments are latent (i.e. host plants are symptomless). Consequently, collectors of germplasm in the wilds or farms, scientists who exchange germplasm grown in plots, and even inspectors which examine plants by visual observation are often unable to detect such agents in germplasm entering from foreign sources.

Most governments prohibit the entry of host plants that might be infected or infested with hazardous agents that cannot be detected by visual observation and for which no effective eradicant treatment is known. Prohibition in the most drastic action that can be taken by a quarantine service. It is the consensus of quarantine officers that the least drastic action that will provide adequate safeguards should be taken in response to hazard and risk. The Plant Quarantine Division should be placed in the position so that it can provide safeguards so that the least drastic but safe action can be taken in a timely fashion.

? Many ?

Governments that can provide safeguards often allow the entry of high-risk germplasm imported for scientific purposes under conditions specified in permits, rules, or guidelines. However, these governments continue to deny entry to the same plant material imported for commercial purposes, shipped in mail, or carried by the travelling public. It is the goal of quarantine services to facilitate the entry of the beneficial genes imported in plant material but at the same time to exclude the entry of harmful agents that might be present and undetected by routine inspection.

The Design Team recommends, under Subproject sponsorship the expansion, improvement, and updating in the ability of the Plant Quarantine Division to provide quarantine services that will facilitate the timely entry of germplasm but at the same time reduce risk that hazardous agents may enter along the germplasm pathway.

Details?

D. Problem: Certain unsolved problem areas in the collection, evaluation, conservation and health of germplasm to act adversely on the development and progress of natural plant germplasm system.

Solution: Under the Subproject, support basic and applied research that will solve the problems so as to facilitate the rapid and safe exchange and transfer of germplasm in a national system.

In the previous sections, the need for research in germplasm storage methodology was emphasized. Among the areas singled out were cryopreservation, tissue culture and storage of vegetatively propagated crops. Coupled with this applied research is basic research on how these new or improved methods will effect the genetic stability of the conserved germplasm. The materials taken out of storage must have the same genetic characteristics as the material placed in storage if all the evaluation data on the accessions is to be meaningful to the germplasm resource users.

Role of NBPGR? Capability? Work by others? Recruitment of staff?

On one hand, storage requires genetic stability, but on the other, germplasm resource scientists and breeders also attempt to create variability, but not under storage, so as to find new characteristics and traits that have not yet been expressed by the collected germplasm. Biotechnology can be employed to increase variation not only by culture of undifferentiad plant cells and protoplasts (somatic variation) but by anther culture (pollen mother cells) and genetic manipulation through recombinant-DNA transfer. Research in the tissue culture aspects should be supported by the Subproject during the first part of the 5-year period. Research on biotechnology might be initiated during the last part depending on progress made in the more conventional aspects of the germplasm program and the results of review of biotechnology facilities and capabilities in India. Research should also be supported in mass propagation of plants that can currently only be multiplied with difficulty (e.g. plantation crops such as coconut). — — — — — — Bhabha Dr. Rao

With caution

Research to support quarantine services is required to salvage valuable genetic material that may be infected or infested with pests and pathogens. Research in seed treatment and in the elimination of pathogens by heat therapy, and other innovative techniques (e.g. microwave therapy) is required. In addition, research support is required to build up a diagnostic center for the detection of pathogen and pest and in the identification of new pests and pathogens associated with.

? current status

To support research and service activities, the Design Team recommends the acquisition of equipment and facilities, as well as the support of training and consultants as described in detail later in this report. Recommendations for equipment also include such phytosanitary facilities as glasshouses and screenhouses. The Design Team does not regard glasshouses and greenhouses structures but rather essential special purpose equipment which are as important to the subproject as any other high priority equipment. Equipment figures for these facilities are broken down into the cost of importing greenhouses and the cost of providing climate control and sanitation within these structures.

Locally available?

E. Objectives

The umbrella objective of the Subproject on Plant Germplasm is to strengthen the national germplasm system in India by providing both technical and material support in a joint Indo-U.S. venture for the benefit of both countries.

More specifically the objectives are to strengthen, develop, support or enhance the following activities:

1. A centralized national program for management of an effective, integrated, and coordinated network among NBPGR Regional Stations, Base stations, ICAR Institutes, and all other institutions and projects responsible for conservation of national genetic resources collections.

2. Exploration and collection of plant genetic resources, both within India, the United States and other countries.

3. International Exchange of plant germplasm resources.

4. Quarantine services so as not only to provide biologically-based safeguards that can lower the risk associated with the importation of certain high-risk germplasm but reduce delays associated with the time now required to process germplasm through quarantine procedures.

5. Conservation, maintenance, medium term seed storage, as well as monitoring of the viability of seeds in base and active collections.

6. Advanced evaluation and characterization of available germplasm in a systematic but timely manner using a multilocational coordinated approach and sophisticated technology.

7. National computer based program network for data processing, storage, and retrieval of data on exploration, conservation, germination, evaluation, distribution, plant health and other related matters.

8. Research on cryopreservation an' tissue culture to solve problems that are limiting factors in the preservation and conservation of hard-to-store seeds and vegetatively propagated crops such as tropical root crops.

9. Evaluation of the prospects of biotechnology in India and the United States to determine what role genetic engineering may play in the national plant germplasm system of India and the United States, and if warranted, implementation of such procedures which can be covered through cooperative research with molecular biologists.

10. Research for solving regulatory problems such as detection and identification of pests and disease agents as well as salvaging infested and infected germplasm by treatment or other regulatory actions.

11. Exchange of scientists between India and the United States in such areas of expertise as plant introduction, genetic resource evaluation, conservation and documentation, tissue culture, plant quarantine, and pathogen diagnosis.

12. Training or experience in the United States for Indian scientists and program managers involved in genetic resource or plant quarantine.

13. Consultants for special problem areas such as cryopreservation, greenhouse engineering, plant quarantine and introduction.

14. Workshops related to the accomplishment of objectives in such problem areas as cryopreservation, tissue culture, serology, virus-indexing, under-utilized crops, and oil seed crop propagation, conservation and plant health (to be held in India or the United States)

15. Creation of Centers of Excellence in (1) cryopreservation of germplasm (2) Diagnosis of obscure and latent plant pathogens, (3) identification and classification of compounds found in plants and (4) tissue culture applications to germplasm resource activities.

2. Present Status

India has rich genetic diversity of a large number of agri-horticultural crops. Much of their variability has been used effectively in crop breeding efforts, whereas much remains to be explored so that it is conserved for the future before it is lost forever. Presently, available genetic resources are maintained by a large number of Crop Research Institutes, Crop Coordinated Projects and a National Bureau of Plant Genetic Resources established by the Indian Council of Agricultural Research, besides a large number of agricultural universities. More intensified effort at national level are needed to coordinate activities such as exploration, exchange, evaluation, documentation, and above all, their conservation.

Presently, the facilities for long/medium term storage, which are so essential for conservation of available germplasm, do not exist at most Centers. Since this area of responsibility assumes high priority, it is proposed to create the required infra-structure and modern facilities to provide effective integration and coordination of seed storage as well as exploration, exchange, evaluation, and documentation at the national level. This design paper will address those needs.

Very superficial treatment

III. TEAM VISITS

In order to assess the current status of the Indian genetic resources collections, facilities and staffing, the design team travelled extensively throughout India to visit most NBPGR and ICAR stations that hold germplasm collections. The stations visited represent most geographical and climatic regions of the country and the various methods of conservation employed to preserve germplasm. Observed were seed producing crops, which are propagated and stored as seed, and sugarcane, spice, plantation, and tuber crops, in Kerala, which are propagated vegetatively and, with more research, may be successfully stored as plantlets developed from meristematic tissue. The importance and extent of silviculture work Prosopis, Acacia, and others at Jodhpur was impressive. Research on tissue culture at this location should also receive high priority.

Good itinery.

In all, the design team visited more than 37 facilities at 15 locations in 21 days and had interaction with more than 200 scientists in addition to several groups of 20 to 30 scientific staff at several locations. At some locations we were asked to present a brief summary of our individual specialities.

The travel included visits to 3 Regional stations, 6 Base stations, 2 Quarantine stations and 1 Experimental farm of the NBPGR plus visits to 9 ICAR Institutes, 3 Universities, 7 All India Crop Improvement Projects, 1 IARI activity and 2 private enterprises.

For the Map

At NBPGR Headquarters each member of the team presented a seminar for the staff and the participants of the NBPGR Summer Institute.

Locations visited are listed below :

1. Delhi
   - NBPGR Headquarters, IARI campus
   - NBPGR Quarantine Station
   - Division of Genetics, IARI campus
   - AICCIP for Wheat and Millet, IARI Campus
   - Pioneer Seed Company Ltd.

2. Issapur
   - NBPGR Experimental Farm
   - AICCIP for Underdeveloped Plants

3. Jodhpur
   - NBPGR Regional Station
   - NBPGR Base Center
   - CAZRI
   - Sukhadia University Regional Station

4. Cuttack
   - Central Rice Research Institute
   - NBPGR Base Station

5. Solan
   - Dr. Y.S. Parmar University of Horticulture and Forestry

6. Shimla
   - NBPGR Regional Station
   - NBPGR Base Station
   - Central Potato Research Institute

7. ICRISAT
   - Genetic Resources Unit
   - Plant Quarantine Unit

8. Hyderabad
   - NBPGR Base Center
   - NBPGR Quarantine Center
   - AICCIP for Rice
   - AICCIP for Sorghum
   - AICCIP for Oilseeds
   - IARI Regional Station

9. Bangalore
   - AICCIP for Minor Millets
   - Indian Horticultural Research Institute
   - Indo-American Hybrid Seeds

10. Cannanore
    - Sugarcane Breeding Institute Research Center

11. Calicut
    - National Research Center for Spices

12. Trichur
    - NBPGR Regional station
    - NBPGR Base station

13. Coimbatore
    - Sugarcane Breeding Institute
    - TNAU - Center for Plant Protection Studies
    - TNAU - Paddy Breeding Station

14. Kasargod
    - Central Plantation Crops Research Institute

15. Trivandrum
    - Central Tuber Crops Research Institute.

IV. MAJOR THRUST AREAS

A. National Plant Germplasm Network

For a plant genetic resources program to be successful, effective, and responsive to needs, it must be a national program managed and coordinated from a well organized, staffed, and equipped national headquarters. If it is not, germplasm collections will be fragmented, duplicated, largely inaccessible and ultimately lost or genetically changed.

India has a tremendous potential for developing a strong national program based on existing infrastructure, scientific capabilities and support from ICAR. Much progress has already been made to achieve this end. Based on Team visits to the many locations in India, it is obvious that much dialogue between the NBPGR Director and senior scientists and individual locations concerning development of a national program had already taken place.

In the past, no strong coordinated national program existed and hence germplasm collections remained often fragmented and maintained by frequent regenerations due to lack of proper seed storage facilities.

The visits revealed, however, that knowledge about the need for a national program was evident at most locations. The gap between interest and accomplishment is still quite wide and will require time and effort to fill. The positive note, however, is that the seeds for developing a strong national program have been sown.

Essential elements required to develop and maintain a national headquarters are:

OK, but where are they (NCPGR)?

1. Coordination and leadership from national headquarters. Leadership and coordination requires continued communication to enlist the greatest cooperation among participating activities. The success of a national program requires the cooperation of all participants.

2. Quarantine service for the safe export and import of germplasm.

3. Base collections of seed and vegetatively propagated materials Seeds are maintained at $-20^{o}C$ and consist of samples in sealed packets of all accessories from all active collections. As technology of tissue culture work develops in the future, the base collections should also include duplicate samples of vegetatively propagated stocks.

4. Centralized computer information network. The computer program for genetic resources material should be developed and coordinated from the national headquarters to make data recording and retrieval consistent as a common language, throughout the network. Data sets will be required for passport data, preliminary and advanced evaluations, germination data, seed inventory records, management of seed increases, seed distribution records, and others. The use of a uniform program throughout the system is essential for the exchange of information among activities and with NBPGR headquarters and in the development of germplasm catalogues.

Through the computer network, all germplasm data and records should be sent to NBPGR headquarters not only for duplicate storage but also for their analysis and use as a germplasm management tool. This would include records on distribution of seed and vegetative material.

5. Use of national numbering system for accessions introduced from outside India and for those collected within India. This is essential to maintain a centralized numbering system that will maintain a complete inventory of all germplasm material and provide easy identification wherever it is sent. Some activities now use their own local numbers but they should adopt the national numbering system too. Guidelines on use of local numbers follows:

some germplasm preservation activities may now have their own numbering system and may be reluctant to use a national number. The national number need not change their system except that they should now add the national number as a permanent record and use it when making reports of seed lists on germplasm and other official reports and publications.

- the computer program should contain a field for recording numbers, other than national numbers, and have the capability of searching and sorting that field as needed. The national number should be in a field of its own and always takes precedence over any other number assigned to the accession.

- when used in publications of any kind, the national number should take precedence over a local number. A public relations information campaign will be required to encourage authors not in the germplasm system to comply.

6. Assign crop responsibilities to germplasm preservation stations.

7. Each germplasm station should have complete collection of crops and species for which it is responsible.

- other stations maintaining local collections collected in their respective regions, like rice, should send distribution samples to the station responsible for the collection (Cuttack). Samples for the base collection at NBPGR headquarters should be sent simultaneously.

8. Only one station should be responsible for distribution of its assigned crops.

9. Work plan sessions at NBPGR headquarters

- Annual meetings or workshops should be held at NBPGR headquarters to bring together all germplasm curators in the country for developing work plans and policy, according to a schedule determined by NBPGR.

B. Collection and Exploration Within India

India is recognized as one of the Vavilovian centers of genetic diversity. As such it contains a rich heritage of plant genetic resources which includes about 160 cultivated species. In addition about 320 species of wild and weedy relatives of cultivated plants occur in one or more of the eight phytogeographical/agro-ecological zones. Thus, it is apparent that from a genetic resources standpoint India represents one of richest sources of plant diversity in the world. Some of the important world crops for which India is a primary or secondary center of origin include rice, corn, sorghum, citrus, banana, pepper, cucumber, squash, safflower, seasame, caroway, cardamom, coconut and sugarcane.

A primary activity of the NBPGR is active collection and exploration of new germplasm accessions throughout India. Although extensive collections have been made in the past, much remains to be done. In addition, many collected materials have been lost due to inadequate storage facilities or through loss to various diseases. For example in the case of ginger, maintenance of germplasm in the field has become difficult due to Phythium rot and bacterial wilt. No area is free from the disease and no variety or accession has been found to be resistant to the pathogens. In the case of seed propagated materials lack of adequate seed storage has resulted in the entire collection (for example rice) being grown out every year. It is inevitable that some accessions will be lost over time. Additionally, genetic selection, or drift, within an accession as a result of frequent regrowing can greatly reduce the genetic variability within an entire collection. The net result of these losses is that areas previously explored for germplasm may need to be recollected in addition to collection in new areas.

status?

The urgency for collection and exploration within India is typical of all germplasm centers around the world. Loss of wild habitants through deforestation, human expansion into new areas as well as uncontrollable forces of nature such as drought, flood, and others have increasingly depleted the plant genetic resources of India. As part of the overall germplasm program for India the collection of these valuable resources has become a very high priority. Plant scientists in the United States have expressed great interest in collaborative collection of species of interest to the U.S. Similarly Indian scientists have to develop collaborative exploration in the U.S.

C. Conservation

One of the most critical needs of the Indian genetic resources program is for adequate and secure storage space to maintain seeds as well as clonally propagated germplasm accessions. Looking first at the seed crops, there is the question of storage in both the base collection and the active (working) collections.

1. Base Collection (Seeds): The base collection contains seeds stored for the long term (20 to 50 years). Prescribed international standards call for storage of dry (5% moisture content) seeds in moisture-proof containers at $-18^{o}C$. At present NBPGR has about 30,000 seed accessions stored under these conditions at Delhi. The storage vault is a specially designed prefabricated unit which was purchased in England. The air conditioning and humidity control components are from different sources, however, they have been combined in a compatible unit which accomplishes the objective of providing the desired storage conditions.

Although technically humidity control is not necessary in the storage vault itself, it is important to maintain a dry atmosphere immediately adjacent to the vault to prevent a gradual build up of ice in the vault when the door is opened to move samples in and out of storage. Although the existing vaults are nearly filled, NBPGR has recently purchased two additional storage units which should soon be put into operation These vaults are slightly larger than the existing ones and should provide additional storage capacity for up to 80,000 accessions. NBPGR estimates that the number of accessions in the base collection should reach 200,000 in the next 5 years. Considering the great wealth of genetic diversity present in India and the gradual acceleration in the use of genetic resources from other countries it is entirely reasonable to expect that the number of accessions could easily double to 400,000 to 500,000 over the next 10 to 20 years.

A related function to seed storage is the periodic monitoring of seed germination to ensure that viability is not being lost. It is assumed that only good quality seed (germination at or above 90%) will be placed in long term storage. Germination tests using rules developed by the International Seed Testing Association should be conducted at 5 year intervals (or longer periods if experience warrants it). On the basis of these tests seed regeneration will be done when seed quality drops below 80% germination.

2. <u>Active Collections (Seeds)</u>: The majority of India's germplasm accessions are currently held in active (working) collections located at the various NBPGR regional stations, base centers and with various ICAR stations such as those responsible for the All India Coordinated Crop Improvement Research Projects. It has been somewhat difficult to get an estimate of the total number of accessions in the working collections, however, it is believed that between 150,000 and 200,000 accessions are available. In many cases, due to the lack of any satisfactory seed storage facility entire collections are being regrown every year (Cuttack, rice). In other crops the collection is regenerated every three years (Bangalore, minor Millets). Viability monitoring of working collections is rarely done due to lack of facilities and resources. As previously mentioned, frequent regrowing and lack of seed storage facilities leads inevitably to loss of germplasm accessions and/or genetic variability within an accession or collection.

Medium term seed storage facilities should meet the following minimum requirements: A storage temperature of approximately 4°C with a relative humidity of 30% or less. A seed drying and packaging room is needed immediately adjacent to the storage room which can maintain a temperature of 18 to 20°C and an RH of 15%. This latter room is critical for drying seed samples prior to their being placed in storage. A seed germination testing room adjoining the drying room would facilitate viability monitoring. In our team visits to the various locations it has become apparent the prefabricated storage vaults mentioned above would be most suitable.

The Lithium chloride type humidity control units are preferred over the silica gel type units because they are smaller, have fewer moving parts, and are more efficient from a power consumption standpoint. In addition engineering technology developed at ICRISAT has greatly prolonged the life span of the LiCl drums. The team strongly urges the adoption of a single technology throughout the germplasm system to maximize efficiency of maintenance.

SPACE FOR MODEL DRAWING OF SEED GERMINATION DYING AND STORAGE

3. Clonally Propagated Germplasm: Conservation of clonally propagated germplasm presents some special problems. Current technology involves maintaining individual plants in the field where they are at constant risk from insects, diseases, and climatic factors. Alternatively plants could be maintained in pots in screenhouses, etc. although this would be impractical for crops such as coconut, banana, and other large plants. In the team site visits, nowhere was this latter type of maintenance seen. Maintenance of clonal material via tissue culture offers the best alternative for field maintenance and at several locations active programs in this area have been initiated. For example at the Central Potato Research Institute in Shimla 350 out of 626 accessions of *Solanum tuberosum* have been established as microplants in test tubes. Also tissue culture of oil palm and cardamom have been initiated at Central Plantation Crops Research Institute, Kasargod. At the Central Arid Zone Research Institute at Jodhpur, the use of tissue culture in propagation of Silviculture plants is a very important means of propagation. However, from a national standpoint work in the area of tissue culture maintenace of germplasm is still in its infancy. A sizable effort is needed to develop this technology for the wide diversity of germplasm present in India. In many cases techniques must be worked out on a species by species basis.

Role of NCPGR

Along with the development of medium-term preservation techniques research must be initiated on the long-term (base collection) aspects of germplasm preservation. This idea is developed more fully under section IV G.

D. Evaluation

Collection and conservation of germplasm are only the first two steps in a chain leading to the development of new higher yielding, more resistant, and more nutritious cultivars. The key step along this pathway involves the detailed evaluation of the germplasm for morpho-agronomic traits (preliminary evaluation) and for such traits as disease, nematode, and insect resistance, chemical composition and combining ability with other desirable germplasm (advanced evaluation). During its visits to the various germplasm locations the team was pleased to note that for many crops extensive preliminary evaluation for up to 30 to 40 plant descriptors has been completed and inventories published. In some cases such inventories have not yet been compiled or are quite old (rice inventory, published in 1971).

In the case of advanced evaluations the team found many instances in which evaluation for various important diseases has been completed with the net result of identifying new and important sources of disease resistance, insect resistance or superior combining ability. In other cases complete screening of the collection resulted in no disease resistance (ginger). In summary the need to proceed with evaluation is still very great.

E. Plant Quarantine

The Plant Quarantine Division (PQD), NBPGR has delegated authority from the Plant Protection Advisor to provide quarantine services for the import and export of plant germplasm. These activities, which include the issuing of permits for imports and phytosanitary certificates for exports, are conducted in cooperation with the Plant Protection Advisor who is the senior national quarantine official of the Government of India. "Plant Germplasm" is defined herein as plant material imported or exported as seeds or vegetative propagations in small quantities for scientific purposes. In quarantine circles, "Small quantities," as a minimum, is often considered to be the number of seeds, cuttings, scions, tubers, etc. necessary to establish the importation. However, in India in plant germplasm circles, some accessions may be as large as a kilogram or even somewhat larger. The common denominator in any definition of germplasm is the intended use of plant propagations for scientific purposes.

Export certification responsibilities are related to the international flow of plant germplasm not only from India to the United States but to other countries. The Plant Germplasm Design Team does not intend to review this responsibility in detail but it does agree with the concept that this activity must be fully supported by adequate manpower and resources in order to meet the obligation of the Government of India under the International Plant Protection Convention of 1951 (i.e. "The Rome Convention").

Under the same Treaty the United States through, Plant Protection and Quarantine, Animal and Plant Health Inspection Service, USDA, provides similar export certification for germplasm consigned to India. Thus, each country has a mechanism already in place to reduce the risk of moving hazardous organisms on the India/USA plant germplasm pathway.

The Team has taken the position that both import and export activities are important in the transfer of germplasm between India and United States, and vice versa, and that both activities need continued support. Expansion in either of these areas should result from a real increase in the allocation of resources, when scientifically justified, rather than by shifting resources to either area at the expense of the other.

The quarantine services currently provided by the Plant Quarantine Division (PQD) NBPGR have reached a high level of development for the detection of seed borne organisms using conventional seed health testing, visual observation and limited growing-out testing. However, such techniques even though applied with a high level of expertise and efficiency are less than satisfactory for the detection of latent or obscure pathogens (e.g. viruses, mycoplasma-like organisms, most bacterial and some fungi and insects). Furthermore, current seed health testing facilities are inadequate to keep up with the current and projected volume of accessions. Consequently, unacceptable delays to germplasm users currently result.

PQD and NBPGR scientists have long been aware of the existing gap in the NBPGR defense against the potential invasion of pests and pathogens along the germplasm pathway. Perhaps, now is the time to reemphasize that it is less costly to any government to spend money on exclusion and prevention than on containment, suppression or eradication of pests and pathogens should even one catastrophic agent gain entry and become established at the farmers' level. The old adage "an ounce of prevention is worth a pound of cure" has, perhaps, never been more meaningful than in a plant protection and quarantine as well as integrated pest management contexts.

To solve this problem of delay due to processing germplasm, existing methodology and present facilities should be expanded and new procedures added. To solve the problem of detecting obscure pathogens a center of excellence for the detection of pests and pathogens should be superimposed on the present function which is excellent in so far as it goes. In addition, to close the gap on detecting latent pathogens, a germplasm inspection station as well as plant quarantine stations should be constructed and utilized. However, due to the diversity of agro-climates, crops and the volume of accessions to be processed, the Design Team recommends that at least four quarantine stations should be built. It must be understood by management that the constructing, staffing, equipping and operation of a quarantine station is costly but absolutely necessary if India is to expand and update its national plant germplasm system.

Once a commitment has been made, it must be supported over time so that phytosanitary standards are maintained for the benefit of the agriculture of India, in general, and farmers and consumers in particular. The bottom line figure for the cost of an ounce of prevention may appear to financial managers to be high. However, when viewed in the light of a cost of a "pound of cure" the cost of quarantine services can be administratively and biologically justified..

The thrusts of the Plant protection and quarantine aspects of the report are as follows:

1. providing quarantine services not only to facilitate the timely but safe importation of exotic high-risk plant germplasm but to salvage valuable germplasm found, upon entry into India, to be infected or infested with pests or pathogens of quarantine importance.

2. providing domestic or internal quarantine or isolation areas or facilities to handle the risk due to the collection of germplasm within India where the ecological range of the crop is much greater than the ecological range of its pests or pathogens.

3. providing plant pathology, nematology, and entomology support to locations where germplasm is evaluated to determine levels of resistance or tolerance to pests and disease agents. (By doing so, lines may be inoculated or infested with domestic and locally-occuring pathogens or pests to obtain evaluation data from several locations within India for the benefit of germplasm users).

4. providing plant protection and quarantine services to improve the health status of germplasm lines placed in mid-term or long-term storage.

5. to develop at NBPGR, Delhi, a center of excellence for the detection, characterization, and identification of exotic pests that may be found associated with exotic germplasm or reported as first occurrences in India.

6. to develop a consortium of four quarantine stations with laboratories, greenhouses, screenhouses, and plots at the following locations: (a) the principal station at NBPGR as a center of excellence for identification and to handle all crops not processed at other stations, (b) in a temperate region such as Bhowali for temperate vegetatively propagated crops (c) in the Andaman Islands for vegetatively propagated tropical and subtropical crops and (d) at Hyderabad for rice, ICRISAT crops and other crops of the southern region.

7. to mount a public information program directed to inform the commercial, scientific and general public about the risk associated with the importation of plant materials through non-safeguarded pathogens (smuggling or other forms of contravention).

F. Training and Personnel Development

Of critical importance in the development of the subproject is the need for training and personnel development by NBPGR staff members at all levels, including the Director NBPGR, all Division Heads, and Leader of the Biotechnology (Tissue Culture) laboratory. Senior staff members at New Delhi would make short-term (4 to 6 weeks) visits to the United States to obtain a good overview of the U.S.National Plant Germplasm System. Visits would be made with their U.S. counterparts to exchange views and discuss new emerging technologies.

At the working scientist level five scientists from each of the major divisions of NBPGR would spend 3 to 6 months in the U.S. for detailed study and training in their specific area. Specific areas to be covered would include exploration, evaluation, conservation, exchange, plant quarantine, cryopreservation, data acquisition and management and tissue culture. In addition to the above, scientists representing various genetic resources activities and crop disciplines at the outlying stations will receive training for a similar time.

Training of technicians in the use, maintainence, and rapair of sophisticated equipment made available through this subproject is essential to maintain the equipment in proper working order and to prevent work delays because of "down time" of equipment.

A third level of training would be graduate students at the Ph.D. level. The specific areas would be decided based on scientist need. Students would spend 2 to 4 years at leading U.S. universities working closely with scientists knowledgeable in the field of genetic resources.

In addition, within the area of plant quarantine, train-the-trainer training is recommended for plant quarantine inspectors and pesticide applicators. Under this concept 3-4 scientists or specialists would take training on how to teach the subject in India. Training is recommended in virus indexing, the operating of a germplasm quarantine station and plant quarantine stations in a study/work program custom-made to meet the needs of each participant. Advanced program manager training in pest risk analysis and biological decision making is also recommended as is training for writer/editor information specialist in how to communicate plant quarantine concepts to the public.

G. Basic and Applied Research

As a support to the entire germplasm program a vigorous and effective research program is essential. Two key areas in this effort would be research on preservation in tissue culture of vegetatively propagated materials including silviculture plants, and the use of cryopreservation for long-term storage. Also basic studies in such areas as cytogenetics and biochemistry are needed in order to further breeding programs using wide-crosses, haploids, polyploids, etc. Applied research is needed to discover optimum germination conditions for many species which are becoming more important as plant germplasm. Research on short-term storage of many tuber and root crops is also needed.

? Role of IBPGR ?

It is recommended that the headquarters location serve as a center of excellence for research on cryopreservation and tissue culture preservation. Outlying stations would also carry out research and periodic conferences would be used to communicate research results.

It is further recommended that an applied research program be expanded to solve regulatory problems not usually covered in University or Research Institute programs. Such problems include eradicant chemical and physical treatments for seed and plant propagative material, heat therapy and meristem tip culture to salvage virus infected germplasm, and unraveling certain complex taxonomic relationships for microorganisms, nematodes, insects, and mites.

V. SPECIFIC NEEDS FOR NATIONAL PLANT GERMPLASM SYSTEM

A. National Headquarters

1. Conservation

a. Long and short-term seed storage modules

The establishment of the National Repository for plant genetic resources at the NBPGR Headquarters at New Delhi involves building up the long-term seed storage facility. This could be done by installing prefabricated modules (imported) which can be maintained at a temperature of $-20^{o}C$. Another approach would be to fabricate cold storage rooms for long term seed storage in the forthcoming National Repository building. In the view of the design team, prefabricated modules are preferable. The reason being, that in addition to the storage needs at the National Headquarters, many of the outlying regional stations and institutes will require medium term storage units. Therefore, for the sake of uniformity of construction, temperature and humidity control, maintenance, and operating requirements, the prefabricated module is preferred for both long and medium term storage.

Locally = in new Delhi? Imported?

b. Gene Bank Development

At present, long-term seed storage modules are temporarily being placed outdoors on a concrete base. Additional new modules will be placed alongside at the same location which will be covered with a roof. Three modules are now on hand, two new and one older unit. The two new ones are on the concrete base and the third is at another location under a temporary cover. Two additional modules are expected soon, making a total of 5 modules. A total of 13 modules are envisioned to eventually house the base storage collections and to also provide some medium term storage space. Therefore, 8 new ones are needed.

To develop a fully operational, safe, secure, effective, and efficient gene bank, a permanent and protected location for the modules should be provided. To provide this, a new headquarters building is planned to which the gene bank should be attached. Consequently, it should include a large temperature (15-20°C) and humidity (25-30%) controlled room where the modules are placed side by side with sufficient walk through space between them for future maintenance requirements. The exhaust from the compressor fans should be vented outside, using ducts, if needed, with an inlet nearby to allow adequate circulation of air for the compressors. The dehumidifying units should likewise be vented to exhaust heat generated by recharging the Lithium chloride wheels.

who to fund? when?

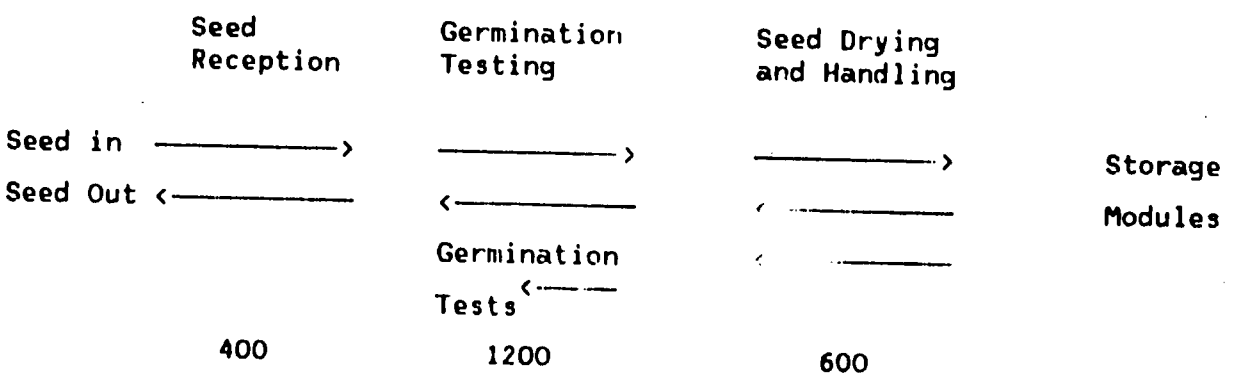
On the front side, the space between modules should be filled in and an opposite wall constructed to form a long corridor for access to the modules. The corridor temperature and humidity should be the same as described above. In this way, the corridor serves as an ante-room to the modules when they are entered and the low humidity will also prevent moisture accumulation on cold spots around module doors when the outdoor humidity is high. Adjacent to the corridor with access to it, should be a seed drying and packaging room, which should be kept at 15% RH and 18 to 20°C temperature. All seeds should pass through this room for necessary handling before being placed into the module.

Adjacent to the drying room should be an air-conditioned germination laboratory where all seed germination testing should be performed.

Adjacent to the germination room should be a seed reception and distribution area. All incoming and outgoing seed would pass through this room for documentation and other necessary procedures.

In summary, the pathway for seed would be as follows:

MODEL FOR GENE BANK SEED FLOW: INCOMING, OUTGOING, AND VIABILITY TESTING



Estimated Cost:

- Based on $30 per sq.ft. construction cost

- Floor space in sq.ft.

Seed reception	400
Germination testing	1200
Seed drying and handling	600
Room to house storage modules	20,520
Total Area	22,720 x 30 = 681,600

c. <u>Specific equipment for NBPGR gene bank needs are as follows</u>:

1.	Long-term (-20°C) cold storage vaults (176M³) with back-up compressors and heat exchangers	4x50,000 =	200,000	Locally-found
2.	Medium-term (4°C, 30% RH) storage vaults with back-up compressors and heat exchangers	4x50,000 =	200,000	"
3.	Emergency back-up generators (135 KV)	2x50,000 =	100,000	"
4.	Controlled temperature (15-20°C), humidity (15-20% RH) room for seed drying and packaging	=	20,000	"
5.	Temperature controlled walk-in germination rooms (10'x12') one each for 20, 25, 30 and alternating 20-30°C	4x10,000 =	40,000	"
6.	Seed germinators (cabinet type)	6x 6,000 =	36,000	"
7.	Micro balances (Cahn) (0.1 mg accuracy)	2 x 7,500 =	15,000	
8.	Analytical balances (Mettler) (0.1mg accuracy)	2 x 3,000 =	6,000	
9.	Top loading balances (Sartorius) (0.1g accuracy)	2 x 2,000	4,000	
10.	Soft X-ray machine, film reader & film processor		12,000	
11.	Drying ovens (high temperature)	4 x 2,000	8,000	
12.	Thermo-gradient plate with water baths		20,000	
13.	Distilled water apparatus (Barnstead)19 l/hr	2 x 12,000	24,000	
14.	Stereoscopic binocular microscope	2 x 1,500	3,000	

15. Ultra cold (-75°C) freezer		7,000
16. Passenger vehicle for general use of gene bank.		15,000
16. Hygrothermographs (use one in each medium term storage module)	5 x 1,200	6,000
17. Miscellaneous equipment (Vitascope, seed packet sealing machines, seed cleaners and counters, vacuum-head seed planters, etc.		19,000
18. Microcomputer with printer and hard disk		10,000
19. Other equipment for use at gene bank		70,000
SUB-TOTAL		815,000

2. Evaluation

In the area of germplasm evaluation the following equipment is needed for both field (main farm at Issapur) and laboratory studies:

a) Field location - Issapur

1.	Microcomputer with printer and hard disk		10,000
2.	Hand-held data loggers	3 x 2,000	6,000
3.	Generator to provide back-up power		50,000
4.	Refrigerator type air conditioners for storage of onion and garlic bulbs (20,000 BTU or greater)	2 x 2000	4,000
5.	Field cultivation equipment (roto-tillers small and medium size tractors, seed bed preparation		35,000
6.	Cage material for pollination control. Nylon screen available from a well known manufacturer in Georgia (will require replacement after 4 years of use)	200 cages @ 300	60,000
7.	Special large 1/2 bushel to weather resistant kraft paper bags for pollination control of cross pollinated crops. Bags must be imported.	200,000 @ 150/1000	30,000

b. Main Station - New Delhi

1.	Mettler balance		6,000
2.	Seed counters, each with 3 different size heads; with multiple packet loader, vacuum attachment - Old Mill brand (ICRISAT has one and could provide info)	2 @ 8,000	16,000
3.	Balances, small	6 @ 500	3,000

4.	Single head threshers	2x10,000	20,000
5.	Growth Chambers	2x10,000	20,000
6.	Frost Chamber		12,000
7.	Office Clippers (for cleaning seed) with complete set of screens	4x2500	10,000
8.	Heating equipment for walk in drier (electrical heating)		5,000
9.	Photocopier with enlarging and reducing capability		15,000
10.	Word processor & printer		3,000
11.	Binocular microscope for laboratory use		4,000
12.	Camera and related photo equipment		2,500
13.	Large capacity air conditioners, refrigerated type, for short-term storage of incoming seed from regional stations. 20,000 BTU or greater	4x2000	8,000
14.	Plastic column seed blower (South Dakota brand or similar)		1,500
15.	Miscellaneous equipment		20,000
16.	Gas chromatograph with accessories		15,000
17.	Mass spectrometer with computer library		40,000
18.	HPLC system with complete accessories		45,000
19.	Balances (2) Analytical (micro) and top loading		10,000
20.	Thin layer chromatography equipment		5,000
21.	Lyophylizer		6,000

22. Ice machine (Scottsman)		4,000
23. Protein and amino acid analyzer		50,000
24. Fractionating columns and related equipment		5,000
25. Rotary evaporators	4 x 2,000	8,000
26. Microcomputer with printer and hard disk		10,000
27. Graphics plotter		4,000
28. Software		2,000
29. Vehicle (25 passenger van)		40,000
30. NMR		50,000
31. NIR		75,000
32. Cyto Photometer		65,000
33. Miscellaneous equipment for packaging and labelling seed packets		15,000
*34. Glasshouses 30'x60' to be built locally but glasshouse climate control equipment to be purchased in U.S. after design by Indian and U.S. glasshouse engineers. Figures represent cost of imported materials and not glasshouses.	4x45,000	180,000
*35. Screen or net houses 30'x60' to be constructed locally using imported 40 mesh aluminium screen and corrugated fibre glass materials. Figures represent cost of materials.	4x15,000	60,000
*Note: Should it be administratively determined that AID should import glasshouses for item 34 an additional 300,000 would be required		300,000
SUB-TOTAL		1,330,000

3. Collection and Exploration

Jeep for exploration		18,000
Camera and equipment		2,000
Exploration kit (compass, binoculars, altimeter)		1,000
Stero binocular microscopes	2 x 2,000	4,000
SUB-TOTAL		25,000
TOTAL		2,851,600

B. Outlying Stations

1. Medium-term Seed Storage Facilities

At certain NBPGR regional stations, ICAR Institutes and other stations concerned with preservation of germplasm, medium-term seed storage modules are needed as well as laboratory, field and seed cleaning equipment. The team has identified the following 11 stations to receive a package of equipment needed to perform their function:

NBPGR Regional Stations

Akola
Jodhpur
Hyderabad
Shillong
Shimla
Trichur

ICAR Activities

Indian Agricultural Research Institute (New Delhi)
Central Rice Research Institute (Cuttack)
Central Institute for Cotton (Nagpur)
Project Coordinator for Pulses (Kanpur)
Project Coordinator for Rapeseed and Mustard (Hissar)
Project Coordinator for Minor Millets (Bangalore)
Central Plantation Crops Research Institute, Kasargod

Equipment Needs for each of the above stations:

1.	Medium -term (4°C), humidity controlled (25-30% RH) storage vaults each must be equipped with back up compressor and heat exchanger.		50,000
2.	Seed dryer (humidity controlled) capable of producing 15% RH at 15-20°C		10,000
3.	Seed germinator		6,000
4.	Drying oven (high temperature)		2,000
5.	Analytical Balance (0.1mg)		3,000
6.	Top Loading Balance (0.1g)		2,000
7.	Seed Blower		2,000
8.	Office clipper with complete set of screens	3x2500	7,500
9.	Growth Chamber		8,000
10.	Farm Equipment (small plot thresher, roto-tiller, etc.)		15,000
11.	Deep Freeze -20°C (for new germplasm)		2,000
12.	Seed Counter, Old Mill brand		6,000
13.	Photocopier		6,000
14.	Word Processor		2,000
15.	Microscope (binocular-stereoscopic)		1,500
16.	Camera equipment		1,500
17.	Microcomputer with printer & hard disk		10,000
18.	Backup electrical generator		50,000
19.	Contingencies for evaluation		20,000
	SUB-TOTAL		204,500
			x 13
	TOTAL		2,658,500

2. Special Needs of Outlying Stations

a) 5 Base Centers

- Jeep	18,000
- Camera and equipment	2,000
- Exploration kit (compass, binoculars, altimeter)	1,000
- Stereo binocular microscope	4,000
	25,000
	x 5
	125,000

b) NBPGR Regional Centre - Jodhpur

- Leaf area meter for evaluation	2,000
-*Glasshouse 30'x60' to be built locally but glasshouse climate control equipment to be purchased in U.S. after design by Indian and U.S. glasshouse engineers. Figures represent cost of imported materials and not glasshouses.	45,000
- Renovate irrigation well for irrigating seed increases. Present as well as non-functional.	50,000
*Note: Should it be administratively determined that AID should import glasshouses an additional 300,000 is be required	300,000
SUB-TOTAL	397,000

c. Central Potato Research Institute - Shimla

- Medium-term (4°C) storage facility for maintaining in-vitro cultures. (Note: A prefabricated storage module would suit this purpose)	50,000
- Cryopreservation equipment to include:	
- Controlled freezing-rate apparatus	20,000
- Cryotank (850 ltr.)	15,000
- Cryovials and miscellaneous supplies	10,000
- Electrophoresis equipment	5,000
SUB-TOTAL	150,000

d) National Research Center for Spices - Calicut

- Amino acid analyzer	50,000
- Gas chromatograph	20,000
- HPLC apparatus	45,000
- Isoelectric focussing apparatus	10,000
- Walk-in cooler	25,000
SUB-TOTAL	150,000

e) Central Tuber Crops Research Institute - Trivandrum

- Growth chamber	8,000
- Microcomputer with printer and hard disk	10,000
- Mist chamber	2,000
- Heat chamber (for thermotherapy)	24,000
- Fumigation chamber	20,000
- Stereo binocular microscope	2,000
- Photocopier	7,000
- Jeep for exploration work	18,000
- Camera and equipment	2,000
- ELISA equipment	20,000
SUB-TOTAL	113,000

f) Sugarcane Breeding Institute - Coimbatore

- Medium-term storage vault to maintain in-vitro cultures	50,000
- Electrophoresis equipment	5,000
- Balance (0.1g)	2,000
- Glasshouse 30x60' to be built locally but glasshouse climate control equipment to be purchased in U.S. after design by Indian and U.S. glasshouse engineers. Figures represent cost of imported materials and not glasshouses.	45,000
Note: Should it be administratively determined that AID should import this glasshouse, this amount should be added	100,000
- Autoclave	25,000
- Lyophilizer	6,000
- Electron microscope	100,000
SUB-TOTAL	333,000

g) Central Plantation Crops Research Institute - Kasargod

- HPLC with complete accessories		45,000
- Miscellaneous and Auto Analyzer equipment		20,000
- Shigometer		2,000
- Controlled temperature Box		10,000
- Growth Chambers	2x8,000	16,000
SUB-TOTAL		93,000

h) Indian Horticultural Research Institute - Bangalore

- Storage facilities can be developed as an additional base center for horticultural crops - seed storage module		50,000
- Large cryotank		15,000
- Micro balance		7,500
- Balances (0.1g)	3x2000	6,000
- Seed germinator		5,000
- Seed blowers (plastic tube columnar)		1,500
- Seed cleaner (office clipper)		2,500
- Computer with hard disk and printer		10,000
- Ultra centrifuge		40,000
- Electrophoresis		5,000
- Photocopier		6,000
- Laminar flow hood		5,000
- Autoclave		25,000
- Gas chromatograph		20,000
- Glasshouse 30'x60' to be built locally but glasshouse climate control equipment to be purchased in U.S. after design by Indian and U.S. glasshouse engineers. Figures represent cost of imported materials and not glasshouses		45,000
Note: Should it be administratively determined that AID should import this glasshouse this amount should be added		100,000
SUB-TOTAL		343,000

C. Plant Quarantine

1. Equipment

	Number requested	Cost per Unit	Total
(a) Vacuum fumigation 1000 l. capacity with accessories			
(1) Delhi	1	20,000	20,000
(2) Hyderabad	1	20,000	20,000
(3) Andamans	1	20,000	20,000
(b) Vacuum fumigation 500 l. capacity with accessories			
(1) Bhowali	1	8,000	8,000
(c) Miscellaneous fumigation equipment including dispensors fumiscope, detectors, interferometer, gas masks and other safety equipment			
(1) Delhi	–	2,500	2,500
(2) Hyderabad	–	2,500	2,500
(3) Andamans	–	2,500	2,500
(4) Bhowali	–	2,500	2,500
(d) Seed X-Ray machines Softex model ISB 40			
(1) Delhi	1	8,000	8,000
(1) Hyderabad	1	8,000	8,000
(e) Laminar flow benches for tissue culture & general use			
(1) Delhi	2	5,000	10,000
(2) Hyderabad	1	5,000	5,000
(3) Andamans	1	5,000	5,000
(4) Bhowali	1	5,000	5,000
(f) Biohazard safety cabinet for high-risk situation laminar flow			
(1) Delhi	1	10,000	10,000

	Number Requested	Cost per Unit	Total
(g) Steroscopic microscope (WILD M54) with accessories including viewer			
(1) Delhi	5	3,000	15,000
(2) Hyderabad	2	3,000	6,000
(3) Andamans	5	3,000	15,000
(4) Bhowali	2	3,000	6,000
(h) Research compound microscopes with phase, darkfield & fluoroscent capability			
(1) Delhi	1	20,000	20,000
(i) Research microscope compound with accessories			
(1) Delhi	2	5,000	10,000
(2) Hyderabad	2	6,000	10,000
(3) Andamans	3	5,000	15,000
(4) Bhowali	1	5,000	5,000
(j) High speed ultra centrifuge with 3 rotors & accessories			
(1) Delhi	1	40,000	40,000
(2) Hyderabad	1	40,000	40,000
(3) Andamans	1	40,000	40,000
(4) Bhowali	1	40,000	40,000
(k) Centrifuge, refrigerated general purpose			
(1) Delhi	1	7,000	7,000
(2) Hyderabad	1	7,000	7,000
(3) Andamans	1	7,000	7,000
(4) Bhowali	1	7,000	7,000
(l) Metal Balance Semi-micro			
(1) Delhi	1	5,000	5,000
(2) Hyderabad	1	5,000	5,000
(3) Andamans	1	5,000	5,000
(4) Bhowali	1	5,000	5,000

	Number Requested	Cost per Unit	Total
(m) Deep Freezer (upto -40°C)			
(1) Delhi	1	2,000	2,000
(2) Hyderabad	1	2,000	2,000
(3) Andamans	1	2,000	2,000
(4) Bhowali	1	2,000	2,000
(n) Black light tubes			
(1) Delhi	200	10	2,000
(2) Hyderabad	100	10	1,000
(o) Serological lab equipment			
(1) Delhi	-	20,000	20,000
(2) Hyderabad	-	20,000	20,000
(3) Andamans	-	20,000	20,000
(4) Bhowali	-	20,000	20,000
(p) Seed Counter w/vacuum			
(1) Delhi	1	7,000	7,000
(2) Hyderabad	1	7,000	7,000
(q) 35mm Camera with 3 lenses & accessories			
(1) Delhi	1	3,000	3,000
(2) Hyderabad	1	3,000	3,000
(3) Andamans	1	3,000	3,000
(4) Bhowali	1	3,000	3,000
(r) Slide Projector 35mm and portable screen & accessories			
(1) Delhi	1	1,800	1,800
(2) Hyderabad	1	1,800	1,800
(s) Soil Sterilizer 2.5 cu yd. capacity such as 1 INDIG Steam Aerator and 2 Soil Treating Carts or equivalent			
(1) Delhi	1	10,000	10,000
(2) Hyderabad	1	10,000	10,000
(3) Andamans	1	10,000	10,000
(4) Bhowali	1	10,000	10,000

	Number Requested	Cost per Unit	Total
(t) Photocopy machine (which will take books) with supplies			
(1) Delhi	1	7,000	7,000
(2) Hyderabad	1	7,000	7,000
(3) Andamans	1	7,000	7,000
(4) Bhowali	1	7,000	7,000
(u) Jeep			
(1) Delhi	1	18,000	18,000
(2) Hyderabad	1	18,000	18,000
(3) Andamans	1	18,000	18,000
(v) Double-door autoclave with steam generating capacity, interior dimension, approximately 3'x4'x6'			
1. Delhi	1	40,000	40,000
2. Hyderabad	1	40,000	40,000
3. Andamans	1	40,000	40,000
4. Bhowali	1	40,000	40,000
(w) Laboratory Autoclave			
1. Delhi	1	5,000	5,000
2. Hyderabad	1	5,000	5,000
3. Andamans	1	5,000	5,000
4. Bhowali	1	5,000	5,000
(x) Backup Electrical Generators			
1. Delhi	1	100,000	100,000
2. Hyderabad	1	75,000	75,000
3. Andamans	1	150,000	150,000
4. Bhowali	1	75,000	75,000

SUB-TOTAL

1,261,000

2. <u>Phytosanitary Plant Growing or Storage Equipment</u>

	Number Requested	Cost per Unit	Total
(a) PHYTOTRON or WALK-IN Chambers with light temperature and humidity control 15x10'			
(1) Delhi	2	45,000	90,000
(2) Hyderabad	1	45,000	45,000
(3) Andamans	1	45,000	45,000
(4) Bhowali	1	45,000	45,000
(b) Low temperature storage module 10°C 10'x10' for storage of Germplasm or Dormant plant materials			
(1) Delhi	1	28,000	28,000
(2) Hyderabad	1	28,000	28,000
(3) Andamans	1	28,000	28,000
(4) Bhowali	1	28,000	28,000
*(c) Plant Propagation Glasshouse, ventilated insect-proof 30'x40' to be constructed locally. Propagation equipment such as misters, horticultural tools, watering devices etc. to be purchased in U.S. Figures represent cost of equipment and supplies - not greenhouse			
(1) Delhi	2	3,500	7,000
(2) Hyderabad	2	3,500	7,000
(3) Andamans	2	3,500	7,000
(4) Bhowali	2	3,500	7,000
(d) Screen or net houses 25'x75' to be constructed locally using imported 40 mesh aluminium screen and corrugated fibre glass materials. Figures represent cost of materials; and not structures			
(1) Delhi	2	15,000	30,000
(2) Hyderabad	2	15,000	30,000
(3) Andamans	4	15,000	60,000
(4) Bhowali	4	15,000	60,000

	Number Requested	Cost per Unit	Total
*(e) Quarantine Glasshouses 10'x15' to be built locally but glasshouse climate control and phytosanitory features to be purchased in U.S. after design by Indian & U.S. glasshouse engineers and quarantine officials. Figures represent cost of imported materials; and not glasshouses			
(1) Delhi	20	8,000	160,000
(2) Hyderabad	10	8,000	80,000
(3) Andamans	10	8,000	80,000
(4) Bhowali	10	8,000	80,000
*(f) Virus Indexing Glasshouse 10'x30' to be built locally in India. Climate control and phytosanitation features to be purchased in U.S. after design by Indian and U.S. glasshouse consultants and quarantine officials. Figures refer to cost of these controls and equipment - not to glasshouses.			
(1) Delhi	3	15,000	45,000
(2) Hyderabad	3	15,000	45,000
(3) Andamans	3	15,000	45,000
(4) Bhowali	3	15,000	45,000

SUB-TOTAL 1,125,000

*Note: Items (c), (e), and (f) above do not include the cost of structures. Should it be administratively determined that glasshouses should be imported from the U S., it is estimated that the cost would exceed $1,000,000. An exact figure cannot be determined until a glasshouse design engineer and quarantine officers have determined the design (particularly for tropical areas).

SUB-TOTAL 1,000,000

	Number Requested	Cost per Unit	Total
*(g) Isolation Glasshouse 30'x40'			
(1) Trichur	1		
(2) Shillong	1		
(3) Jodhpur	1		
(4) Shimla	1		
(5) Akola	1		
(6) Amaravati	1		
(h) Isolation Screenhouse 30'x40'			
(1) Trichur	1		
(2) Shillong	1		
(3) Jodhpur	1		
(4) Shimla	1		
(5) Akola	1		
(6) Amaravati	1		

*The design team endorses the usefulness of these structures (at the various stations) to be used for phytosanitary purposes. However, the structure could be constructed locally in India. The team suggests that the greenhouse climate control be furnished locally in accordance with the needs dictated by local climate.

Note: Should it be administratively determined that the glasshouses in part (g) above should be purchased in the U.S., the cost is estimated at $600,000. However, greenhouses in (c), (e) and (f) should have a much high priority. If climate control is required for glasshouses 300,000 should be budgeted

SUB-TOTAL	900,000
TOTAL	3,625,000*

* Includes 1,900,000 of tentative recommendations

D. Training and Management Level Needs

Plant Genetic Resources

1. NBPGR Headquarters

a. - Team of 2-3 top level administrators from NBPGR and ICAR could visit top level officials in the USDA agricultural research service, various universities and laboratories doing work of interest in India, various commercial seed companies like Pioneer Hi-Bred Seed, (which has assisted the USDA by supporting seed increase of maize from Central and South America collection and which has a high level of interest in genetic resources), and make an overview of various kinds of high cost equipment and supplies recommended in this report

Travel	5,000	
Per diem	3,000	
	8,000 x 3	24,000

b. Senior staff visits to the U.S. for short term (4-6 weeks) to obtain a good overview of the U.S. National Plant Germplasm System. When possible, timing of Division Heads should be planned to coincide with special seasonal techniques like hand pollination of sunflowers in July at Ames, Iowa..

- Director, NBPGR, 1 month

Travel	5,000	
Per diem	3,000	8,000

- All NBPGR Division heads and Leader of Biotechnology (Tissue Culture Laboratory, 1 month)

Travel	5,000	
Per diem	3,000	
	8,000 x 6	48,000
		80,000

c. The computer specialist at headquarters will provide leadership for the national computer network and training for computer operators at outlying locations. He had one training session at Beltsville and provisions are made for 2 more trips during the 5 year period of 1 month each

Travel	3,000	
Per diem	2,500 x 2	11,500
SUB-TOTAL		91,500

2. Possible locations for scientist training in the U.S. For training, the following locations offer possibilities in the areas indicated

a) Beltsville, Maryland
- Plant Exchange
- Plant Exploration
- Computer training for a national computer network (Germplasm Resources Information Network, GRIN)
- Quarantine Station, Glenn Dale and Beltsville Agricultural Research Center (BARC)
- Cereal and Rice world collections
- Other

b) National Seed Storage Laboratory, Ft. Collins, Colorado
- Long term seed storage
- Physiology of seeds and seed aging
- Methods of germination testing
- Cryopreservation research

c) Regional Plant Introduction Stations,
Ames, Iowa (North Central)
Pullman, Washington (Western)
Experiment, Georgia (Southern)
Geneva, New York (North Eastern)
- Evaluation
- Documentation
- Storage
- Underdeveloped crops (Ames & Pullman)
- Pollination control methods at Ames and Pullman. At Ames, pollination control and cucumber, pumpkin, corn, sunflower, alfalfa (contracted out with a station in Nevada) sugar beets, through cooperation with breeders, and private industry.
- Computer programs for research and tie in with GRIN.
- Vegetative propogation of forage grasses and wild groundnuts at Experiment.
- Sweet potato germplasm with Regional program at Experiment

d) National clonal Repositories
- Small fruits, mint, hops at Corvallis, Oregon
- Grapes and miscellaneous fruit at Davis, California
- Apples and pears at Geneva, New York
- Others
- Methods of propagation and preservation

e) Virus - free tree fruits, Prosser, Washington
- an isolated area
- Methods of treating vegetative stocks on receipt and before placing in repository

f) Interregional Potato Station. Sturgeon Bay, Wisconsin
- Collections of many wild species in addition to Solanum tuberosum
- Research on germplasm enhancement in potato.

g) Salinity Laboratory, Riverside, California

h) University of California, Davis
- Dr. C.M. Rick, Semi-retired
  Tomato geneticist and famous plant explorer, specializing in tomatoes in South America - maintains tomato genetic stocks for Ames Regional Station.

i) Sub-Tropical Horticultural Research Station (formerly the U.S. Plant Introduction Station, Miami, Florida)
- Tropical and subtropical ornamental and fruit plants

j) Pioneer Hi-Bred Seed Company, Johnston, Iowa (Actively cooperates in germplasm activities)

k) Crop Evolution Laboratory, University of Illinois, Urbana (Dr. J.R. Harlan)

l) Sugarcane collection, Canal Point and Miami, Florida

m) Biotechnology (to be suggested after specific interests of participants is known)

n) Iowa State University, Ames, Iowa - Plant Breeding, Utilization of genes from wild species (Dr. K.J. Frey)

o) In addition, there are many special kinds of training, like Plant Breeding, Genetics, Plant Pathology and others that can be obtained at Universities, USDA Laboratories and other locations. Information on specialized training can be obtained on request to the Plant Introduction Officer at Beltsville, Maryland or Dr. Henry Shands, Leader, National Plant Germplasm System, Beltsville.

3) The above information provides a menu from which prospective scientist trainees can choose locations which best serves their need, although, other locations not listed here may be considered, too. With that in view, provision is made for scientists at various locations to request and receive training for a period of 3 to 6 months or more, if needed.

a) Scientists from each of the 5 divisions and biotechnology sections. Propose sending three from each Division and Section who will be selected by the Division Head and Director, NBPGR.

- Exploration and Collection

Per diem 2500/MO x 6	15,000	
Travel	3,000	
	18,000 x 3	54,000

- Conservation

Per diem 2500/MO x 6	15,000	
Travel	3,000	
	18,000 x 3	54,000

- Evaluation

Per diem 2500/MO x 6	15,000	
Travel	3,000	
	18,000 x 3	54,000

- Exchange

Per diem 2500/MO x 6	15,000	
Travel	3,000	
	18,000 x 3	54,000

- Quarantine

Per diem 2500/MO x 6	15,000	
Travel	3,000	
	18,000 x 3	54,000

b) Five additional training slots to be held by the Director NBPGR for allocation at headquarters like for aromatic and Biochemical labs.

Per diem 2500/MO x 6	15,000	
Travel	3,000	
	18,000 x 5	90,000

SUB-TOTAL	360,000

4) Outlying Stations

a) One training slot is allocated for the following activities in an area most needed and designated by the coordinator of regional stations and the Director, NBPGR, unless otherwise noted.
- Akola
- Jodhpur
- Hyderabad
- Shillong
- Shimla
- Trichur
- Central Rice Research Institute, Cuttack
- Central Plantation Crops Research Institute, Kasargod
  1 for Computer training
  1 for Tissue Culture training
- Indian Horticultural Research Institute, Bangalore (Director, Genetic Resources)
  1 for seed storage
  1 for tissue culture of horticultural crops

Total 11 slots

Per diem 2500/M x 6 =	15,000	
Travel	3,000	
	18,000 x 11	198,000

IARI, New Delhi, coordinator of All India Coordinated Wheat Project for short-term visit to U.S.

Travel 5,000		
Per diem	3,000	
	8,000 x 2	16,000

- Central Tuber Crops Research Institute, Trivandrum
  - Senior administrative staff, 1 or 2 to make a short-term (1 month) orientation visit to various locations in the U.S.A., like Florida, Texas, North Corolina, as Puerto Rico and Georgia to see and discuss germplasm development, methods of preservation, and others.

Travel	5,000	
Per diem	3,000	8,000

  - 2 scientists to obtain training (3 to 6 months) in tissue culture and cryopreservation.

Travel	3,000	
Per diem 2500/MOx6	15,000	
	18,000 x 2	36,000

b) Eight additional slots to be held by the Director, NBPGR for allocation for for training of scientists at outlying regional stations.

Per diem 2500/MO x 6	15,000	
Travel	3,000	
	18,000 x 8	144,000

SUB-TOTAL 402,000

5) Graduate training should be available to scientists entering the fields of advanced evaluation, seed technology (conservation) tissue culture, cryopreservation and other technical areas of NBPGR headquart/ · or outlying stations where advanced work in these areas might take place. It is proposed to make this study available but not make specific assignment now because opportunities must first be publicized before applications are made.

These study positions will be assigned to the Director, NBPGR who will allocate them to the most qualified person(s) in areas most beneficial to genetic resources work.

6 students x 3 years =	
18 man-yrs @ 18,000/yr	324,000
Associated travel costs 6 x 3,000	18,000
SUB-TOTAL	342,000

- <u>Plant Quarantine</u>

1. Virus Indexing Training and experience for virologists		
a. Delhi: Seedborne virus indexing, Pullman, Washington; Ames, Iowa and other locations	6 months	30,000
b. Hyderabad: Seedborne virus indexing, Georgia and other locations	6 months	30,000
c. Andamans: Virus indexing, Tropical Vegetatively Propagated Crops, Homstead, Fla; Puerto Rico or Hawaii; North Carolina	9 months	54,000
d. Bhowali: Temperate Vegetatively Propagated Crops: Beltsville, Maryland; Prosser, Washington; Davis, Sacramento, Riverside, California	12 months	60,000
2. Plant Bacteriology		
a. Delhi. Seedborne bacteria Moscow, Idaho, Ames, Iowa Serology of bacteria, Beltsville, Md.	6 months	30,000
3. Plant Nematology		
a. Delhi. Regulatory taxonomic problems and survey methodology: Gainsville, Fl; Beltsville, Maryland; Sacramento, California	4 months	20,000
b. Hyderabad. North Carolina State University: advanced root knot nematode detection techniques. visit to Sacramento, California	5 months	25,000

4. Entomology - Biocontrol. Quarantine procedures for importation of biocontrol insects; Albany, California; Beltsville, Maryland; New Jersey and/or Gainsville, Florida	6 months	30,000
5. Taxanomic Entomology Smithsonian Institute and Systematic Entomology Lab, Beltsville. One entomologist to work on taxonomic problems and set up insect identification cooperation	6 months	30,000
6. Serologic Testing: Scientist to return to duty station to implement program and train others. Possible locations for training in U.S.: West Lafayette, Indiana; Corvallis, Oregon, Davis, California, Gainsville, Florida and several others		
a. Delhi	4 months	20,000
b. Hyderabad	4 months	20,000
c. Andamans	4 months	20,000
d. Bhowali	4 months	20,000
7. Information Specialist (requires a writer/editor with a biological background). At Professional Development Centre Frederick, Maryland and Information Division, Hyattsville, Maryland; PPQ-APHIS-USDA	3 months	15,000
8. Training-the-trainer-training: Trainee takes subject matter course followed by a course in how to train others. PPQ-APHIS-USDA, Federick, Maryland; followed by two site visits.		
a. Entomologist for pesticide application and safety, visits to Hoboken, N.J. Treatment Center and Port of New York	8 months	40,000

b. Plant Pathologist for plant quarantine inspector's training. Visit to inspection stations in Miami and New Orleans and Beltsville, Md	8 months	40,000
c. Entomologist for quarantine inspector's training and visit to Los Angeles and Seattle, Washington Inspection Stations and Beltsville, Md	8 months	40,000
d. Plant Pathologist involved in germplasm inspection, Plant Protection Advisor, Delhi	8 months	40,000
9. Advanced Program Manager training in pest risk analysis, biological decision making, operation of germplasm inspection station and plant quarantine station, diagnostic laboratory Beltsville and Hyattsville, Maryland; College Park, Maryland; Plant Disease Lab, Frederick, Md.		
Plant Pathologist (Manager)	3 months	15,000
Entomologist (Manager)	3 months	15,000
Nematologist (Manager)	3 months	15,000
10. U.S. Sugar Cane Quarantine site visit, Head, Plant Pathology Department, Sugar Cane Breeding Institute Beltsville, Md; Canal Point and Miami, Florida	3 months	4,500
11. Identification of seedborne pathogens. Danish Government Institute of Seed Pathology (DANIDA), Copenhagen, Denmark. The design team recommends that a plant pathologist from the Hyderabad Quarantine Station receive the training but assumes that DANIDA will pay for the training as is the custom.	6 months	(no cost)

12. Study tour of plant quarantine facilities at Frederick, Maryland; Beltsville, Maryland; and Miami, Florida; New Orleans. a. Hyderabad Plant Pathologist	5 months	7,500
13. Post Doctoral research in Seed Treatment at the Seed Pathology Center, Iowa State University, Ames, Iowa Pathologist, Plant Quarantine Division, Delhi	15 months	100,000
SUB-TOTAL		721,000

E. <u>Basic and Applied Research (Delhi)</u>

1.	Cryogenic equipment	
	a. 5 Cryotanks (850l) @15,000	75,000
	b. Controlling freezing rate apparatus	20,000
	c. Cryovials and storage containers	20,000
		115,000
2.	Tissue Culture	
	a. Autoclave	25,000
	b. Tissue culture rooms 4 @ 15,000	60,000
	c. Supplies (culture vials, racks, etc.)	15,000
		100,000
3.	Germination testing	
	a. Seed germination incubators 4 @ 7,500	30,000
	b. Misc. equipment (disecting microscopes, vacuum planters, etc.)	10,000
		40,000
4.	Salvaging infected and infested germplasm, plant quarantine	
	a. Hot water treating equipment	3,000
	b. Growth Chamber for heat therapy	25,000
	c. Chemical treatment equipment	4,000
	d. Experimental microwave equipment	3,000
	e. Pesticide, unported	3,000
		38,000
	SUB-TOTAL	293,000

F. Additional Technical Support

The Design Team reviewed in rather general terms the staffing of various NBPGR stations and NBPGR germplasm collaborators. The Team considers that it is beyond the scope of review to recommend specific increases in staffing since time did not permit a detailed enough review.

Never the less, the Design Team did make some general observations where staffing patterns were less than adequate. For example, the design team concluded that lack of technical support was a limiting factor in the ability of scientists to conduct basic or applied research. In some cases, 5 scientists shared one technician. It is recommended as a minimum, that each scientist involved in germplasm research be assigned at least one full time technician recognizing that many projects may require more than 1:1 ratio.

In addition, evaluation for resistance or tolerance to disease agents, insects and nematodes is hampered by a dependency on the use of "borrowed" scientific support at some stations. Staffing for plant pathogists and entomologists who could artifically inoculate germplasm collections; thereby circumventing a dependence on natural infection. In years where natural infection is not present, data cannot be collected. In addition, the health status of germplasm collections could be improved by the full time services of entomologist and pathologists at stations where resistance or tolerance evaluations take place.

At some locations it was observed that scientists were doing the work of technicians, which were not available in sufficient numbers. In anticipation of an increase in the scope of work upon implementation of this subproject, it is essential to augment technical support early, as a minimum toward making increases in personnel.

The following suggestions, which are made, either temporary or permanent, as the circumstances dictate.

- Evaluations at headquarters
  - 5 data recording technicians
  - 2 for compilation of data for computer
  - 2 for making quality evaluations

- Regional stations
  - 5 technicians for evaluation at each regional station - Shimla, Jodhpur, Akola, Trichur, Shillong, and Bhowali.
  - 2 technicians at Hyderabad Regional station.
  - 2 technicians for evaluation and other mandates, in addition to quarantine requirements, at Base Centers of Cuttack, Ranchi, Andamans, and Srinagar.

- Indian Horticultural Research Institute, Bangalore
  - 4 technicians for evaluation

- These requirements reflect only evaluation requirements but this kind of work requires a great deal of time because it is so extensive and all-inclusive. There are many crops that require evaluation and many traits must be evaluated for each crop (20-50)

- At the Plant Quarantine Division, Delhi 2 additional technicians for each of the 3 sections.

VI INDO-U.S. COLLABORATION

A. Germplasm Exploration

It is proposed that provisions be made for joint plant explorations in the U.S. and in India. While the U.S. is not a rich source of endemic germplasm there are a few genera in which India may have an interest. For example the U.S., including most of North America, is a rich source of wild sunflower species. Some have been collected and are now held in germplasm collections in Texas and at the Regional Plant Introduction Station, Ames, Iowa. Indigenous material of tepary bean, Jojoba, buffalo guord, Guyule, oilseed halphytes, Pecan, Pome and Stone fruits, other hydrocarbon plants and non-tuber bearing Solanum species, all in southern and western U.S., can be found in the wild. Some collections have been made. Also, many species of ornamental and silviculture plants can be found in the plains and the Rocky and Sierra mountain areas of the western states. Many species and ecotypes of Rhododendron species can be found in the Appalachian mountains along the east coast.

Another approach to collecting is to visit USDA stations and state agricultural experiment stations where advanced breeding and development work on crops both endemic and non-endemic to the U.S. is underway. The plant collector could examine the materials being grown and obtain seed of available lines at the time of visit or make arrangement for their shipment at a later date. For example, India is interested in salinity tolerant germplasm and in Jojoba. Visits could be made to the salinity laboratory in Riverside, California and other locations.

On the other hand, the U.S. is interested in germplasm indigenous to India. For example, the U.S. is interested in fruits, nuts, Cucurbita (squash and pumpkin species), and cucumis (cucumber). There may also be an interest in collecting ecotypes of Amaranth in the northern areas of India.

To provide for joint explorations, a schedule of scientist months to be spent for collecting in each country is proposed. In this way, there is latitude for each country to decide on what crops it wishes to explore and how much time is needed. In making joint explorations, each country in which the exploration is made will provide a counterpart scientist to accompany the visiting scientists.

The following total scientist months for collecting in each country are proposed:

For collecting in the U.S.

12 scientist months, assuming 8 trips at 45 days each:

$ 7,000	Travel (2 scientists)	
$ 9,000	Per diem ($100/day for 45 days) (2 scientists)	
$ 2,000	Supplies and contingencies	
$18,000 x 8 trips	=	$144,000

For collecting in India

12 scientist months, assuming 8 trips at 45 days each:

$ 7,000	Travel (2 scientists)	
$ 6,050	Per Diem ($70/day for 45 days) (2 scientists)	
$ 2,000	Supplies and contingencies	
$15,000 x 8 trips	=	$120,000
	TOTAL	$264,000

B. Germplasm Exchange

1. General Items

Both india and the U.S. are interested in developing a more effective exchange of germplasm in the form of both seed and vegetative material in different agri-horticultural and agri-silviculture crops with emphasis on disease/pest resistance, cold/drought adaptable types, etc. India's main interest is in temperate and subtropical/tropical fruits, oilseeds, pulses, medicinal, and aromatic plants and other crops, such as, sweet potato, yams, avacados, etc. and processing edible oil yield halophytes like Cakile Maritima, Cakile edentula, and Crithmum Maritimum and other oil yielding plants, quick growing tree species, and hydrocarbon/industrial plants like Jojoba (Simmondsia chinensis) and guayule (Parthenium argentatum).

The U.S. interests are in temperate and subtropical forage plants, field crops, vegetables, fruits, oil crops, new or underutilized crops and others. The exchange of evaluation information as it is accumulated and published will be helpful in selecting specific accessions by scientists in each country and also by the plant exchange officers.

2. Seed Catalogues and related Publications

The exchange of seed catalogues will be very useful in developing a more effective seed exchange mechanism. The development of computer data recording and retrieval systems in India for evaluation data will help develop seed catalogues more quickly, accurately, and make them easy to update. As the Germplasm Information Network (GRIN) develops in the U.S. and becomes more functional, seed lists will also be prepared more quickly.

3. Passport Data

The exchange of passport data on individual accessions is useful and necessary. It would be desirable for both countries to include such information, which includes data pertaining to agro-climatic conditions, sampling techniques, and other information relative to the source of the accession, on their seed transmittal slips.

4. Procurement of germplasm in large quantity for exchange

The Bureau reports that it has had problems in making payment in foreign exchange for the cost of seed/planting material which is procured from private nurseries or growers in the U.S.A. This involves much time and undue delay in procurement/release of consignments which are often many times the cost of perishable plant propagating material. This includes vegetative material of grapes, ornamental plants, and others.

In response to that problem, this Team recognizes the problem involved and agrees that some procedure should be developed to alleviate it. The most expeditious solution would be for the plant exchange officers in each country to have a fund available to cover purchase and shipping charges of seed and vegetative material not held in that country's germplasm collections. The material could then be shipped direct without any further monetary involvement. Such an arrangement should apply to exchange of research material and material for preservation in the germplasm system.

Proposed amount to be set aside in special funds:

India	10,000/yr	
U.S.A.	10,000/yr	
Total	20,000 x 5	100,000

C. Workshop

The Design Team proposes that a series of Indo-U.S. workshops be held in both India and the U.S. on several subject matters that are basic to germplasm preservation. The workshops could be organized independent of other Institutional or Society Meetings but in order to attract a larger group of participants, the team proposes that the workshops be held in connection with selected society meetings, either before or after the meetings. Indo-U.S. scientists would be reimbursed through this subproject. If a few selected outside scientists were invited reimbursement could also be made.

The following workshops are proposed:

1. Cryopreservation workshop at the national seed storage laboratory, Ft. Collins, Colorado, USA.
   - Preservation techniques for seeds, meristem, callus etc.
   - Basic research on cell membranes, biochemistry and physiology of freezing injury.

2. Oilseed Crops, New Delhi
   - Development of agronomic potential, i.e., production technology, problems, needs;
   - Quality and biochemistry of oil and utilization of by-products of extraction;
   - Genetic resources Collections and their use in oilseed crop improvement.

3. Tissue Culture Workshop, U.S.A.
   Ft. Collins
   Lake Placid, New York
   Riverside, California
   Beltsville, Maryland
   - Mass propogation
   - Soma-clonal variation
   - Practical appreciation of tissue culture research to meet germplasm needs

4. Conservation of root and tuber crop germplasm workshop in New Delhi. It is suggested that specialists from several international centers be invited. The following are proposed because they are specialists in various topics listed:

- Plant Pathologist from CIAT, Cali, Colombia
- Entomologist for sweet potatoes from IITA, Ibadan, Nigeria
- Tissue Culture Specialist from CIP, Lima, Peru

Several general topics for the workshop are suggested:

- Tissue culture preservation of potatoes, cassava, and other crops
- Germplasm collections and their utilization in root and tuber crop development
- Biomass production in cassava
- Worldwide pests and pathogenes of quarantine importance of cassava
- Quarantine significance of worldwide sweet potatoes viruses

5. <u>International workshop on the use of serological testing in the certification and quarantine concepts (New Delhi)</u>

1. Invited serological testing experts
2. Invited quarantine scientists with serological programs
3. NBPGR scientists and collaborators
4. Any scientist wishing to attend
5. Commercial firms to set up exhibits and demonstrations

May be co-sponsored by an international plant protection society or a national professional society.
Fall of 1989 - New Delhi

6. International Workshop on Virus Indexing Methodology (New Delhi)

1. Listed scientists to review methods for virus indexing
2. Could be divided into separate sessions for:

a) Tropical vegetatively propagated fruit crops
b) Tropical vegetatively propagated root crops
c) Seed-borne pathogens
d) Temperate fruit crops
e) Potato
f) Ornamental

7. Underutilized plants workshop, New Delhi or USA locations like Arizona, Peoria, Illinois or other:

- Discussions could be held on various underutilized crops under development evaluation, such as Amaranth, Cuphea, Jojoba, *Cakile maritima*, *C.edentale*, and others.

Specialists from the USA who are suggested for the workshop are Dr. James Duke, Dr. Robert Perdue, and Dr. G.A. White, all botanists at Beltsville, Maryland and Dr. Bert Princen, Biochemist, of the Northern Utilization Lab., Peoria, Illinois.

8. Proposed budget for Workshops:

In order to simplify budgeting for workshops, an average number of participants will be estimated from both sides, as well as an average number of invited scientists. Cost estimates for workshops in the U.S. are separate from the cost of holding them in India. It is expected that ICAR might help reimburse expenses of Indian scientists for workshops held in India.

a. For four workshops held in U.S.A. which are estimated to last 3-1/2 to 4 days:

Indian scientist travel (7 days)			
Travel	2,500		
Per diem	700 (100/da)		
	3,200 x 5	16,000 x 4	64,000
U.S. scientist travel (4 days)			
Travel	600		
Per diem	400 (100/da)		
	1,000 x 5	5,000 x 4	20,000
Invited scientist travel (5 days)			
Travel	900		
Per diem	500 (100/da)		
	1,400 x 2	2,800 x 4	11,200

b. For three workshops held in India which are also estimated to last 3-1/2 to 4 days:

Indian scientist travel (4 days)			
Travel and per diem may be supported by ICAR			
U.S. scientist travel (4 days)			
Travel	2,500		
Per diem	500 (100/da)		
	3,000 x 5	15,000 x 3	45,000
Invited scientist travel (5 days)			
Travel	2,500		
Per diem	500 (100/da)		
	3,000 x 2	6,000 x 3	18,000

c. Contingency for honoraria
7 workshops x 2 for each = 14 scientists
14 x 200/day = 2,800 x 7 days 20,000 x 3 60,000

SUB-TOTAL 218,200

VII. Benefits for Indo/U.S. Agriculture

The umbrella objective of the sub-project, as previously stated, is to strengthen the National Plant Germplasm System in India by providing technical and material support in an India/United States joint venture for the benefit of both countries. The project supports and enhances germplasm exploration, evaluation, documentation, conservation and plant health activities mostly in India. However, scientists from both countries can partake of the fruits of this scientific labor to benefit agriculture in general, and farmers and consumers in particular.

1. Exploration for, and exchange of, genetic resources between India and the United States provides the genetic fiber that strengthens the agricultural fabric of each country. Each country possesses genetic variation that may be useful to the other. In some cases the variation was developed under biotic and abiotic stresses that are similar in each country, while in others cases, the variation was developed under different stresses. Depending on their breeding goals, scientists can take advantage of a wide spectrum of stress-induced variation. On one hand, India is rich in variation of the type developed in centers of diversity and in land races developed by farmers over centuries of agriculture. On the other hand, the United States is rich in the variation found in advanced breeders' lines and in new or improved commercially successful varieties.

2. Enhancement and expansion of advanced evaluation and of documentation activities in India will also benefit the agriculture of both countries. Catalogs which tabulate the characteristics of germplasm including tolerance or resistance to abiotic and biotic stresses as well as other characteristics such as the concentration and type of useful compounds can be developed under the sub-project. These catalogs can be exchanged between scientists in India and the United States. Breeders will be able to request only those accessions that directly relate to their own breeding goals. As a result, they will not be saddled with the task of evaluating large numbers of accessions to delimit those few that are of use in their own breeding programs.

3. Improvement, in India, in mid-term and long-term storage facilities for germplasm will benefit both countries by insuring that irreplaceable collected and evaluated germplasm will not be lost. Duplication of the storage of particularly valuable lines in both countries is insurance against loss due to equipment failure or human error.

4. Basic and applied research conducted in India particularly on cryopreservation and the long term effects of storage on genetic stability will have direct application to the germplasm resource activities conducted in both countries.

5. Development of a Center of Excellence in diagnostics and research leading to the identification of causes of several diseases in India will not only facilitate the control of these agents in India but will guide U.S. quarantine officials in setting safeguards to protect U.S. agriculture. Identification of agents found in imported germplasm will lead to better safeguards.

6. Any efforts made to exclude exotic pests from India not only significantly benefits India but also benefits the United States. Exclusion of those pests from India, which are also not known to occur in the United States, makes India a safer place from which to import various articles to the United States.

7. Scientists from both countries will be able to exchange ideas and participate in workshops, meetings or discussions. In addition, they can observe the use of special purpose laboratory equipment and the design of laboratories, phytosanitary procedures and stations. India would bring to this liaison, a rich background of experience in tropical and subtropical crops which are of interest in the southern States, Hawaii and U.S. territories and possessions (Guam, Virgin Islands, Puerto Rico). The U.S. would bring a similar background in northern temperate crops.

8. One of the weak points in the quarantine defence by one country against the entry of pests from another country is not having enough information about exotic pests. Much information is in the scientific literature but much more is in the unpublished data of scientists and quarantine officers. Both countries can benefit from an exchange of quarantine officers which will lead to an efficient exchange of biological data about the life cycle, host range, epidemiology, control, methods of detection, etc. Perhaps, mutually compatable information storage and retrieval systems could be developed although such systems have not yet been initiated by either quarantine service.

9. Spin-offs from the development of germplasm and plant health procedures may have application to the seed and nursery industry in India and the United States by providing a nucleus of plant material free of exotic pests and substantially free of domestic pests under certification programs. Certification programs developed for tropical and subtropical crops would be of interest to the United States.

VIII. MONITORING AND EVALUATION

It is suggested that a preliminary meeting of the review team be held as soon as possible after approval of funding for the subproject. The purpose of this meeting will be to initiate plans for the first year and set up goals for implementation. If funding is approved quickly this meeting could be held in conjunction with a national germplasm symposium already planned for Delhi in March of 1987.

The composition of the initial review team would include the following: Dr. R.S. Paroda, Director, NBPGR; Dr. W.H. Skrdla; Dr. R.P. Kahn; Dr. E.E. Roos; and Dr. M. Smith, USAID.

Periodically (not greater than 1 yr intervals) a review should be held to assess the progress of the subproject. The same review team members mentioned above would participate. In addition, various outside reviewers would be invited from time to time to give a broader scope to the review effort. These reviewers might involve some of the consultants listed under Section IX.

Representatves from disciplines such as cryobiology and tissue culture as well as the U.S. Plant Introduction Officer and leader of the U.S. national plant germplasm systems are recommended for inclusion in the annual reviews. The frequency of reviews will depend upon the rate of progress, but more frequent reviews (8-10 month intervals) may be necessary. Also as various aspects of the subproject may develop at different rates, the reviews may need to be held separately for the respective elements (conservation vs. quarantine aspects, for example).

Another aspect of the review and monitoring process would be biennial national symposia to be held in the third and fifth years of the project. These symposia would focus attention on the accomplishments of the subproject and should be documented in a proceedings of each symposium.

Expenses associated with review process:

Review team members (Skrdla, Kahn, Roos) travel and other expenses per review	20,000
Outside reviewers (two per review)	12,000
	32,000
	x 5
	160,000
Biennial National symposium costs to include printing of proceedings 2 x 25,000	50,000
TOTAL	210,000

IX. CONSULTANTS

U.S. Technical Assistance

A. Plant Introduction Officer to develop mutual exploration, exchange, and evaluation procedures for plant germplasm. This has a high priority and should be effected as soon as possible after subproject is implemented.

1st year	2 weeks	9,000
2nd year	2 weeks	9,000
3rd year	1 week	8,000
4th year	1 week	8,000
5th year	1 week	8,000
		42,000

B. Leader U.S. National Plant Germplasm System, to acquaint him with the subproject and to develop collaboration and U.S. administrative procedures for fulfilling subproject objectives from the U.S. side. His visit should coincide with that of the USDA Plant Introduction Officer.

1st year	2 weeks	9,000
2nd year	1 week	8,000
One additional visit during years 3 to 5, the timing to be mutually determined.	1 week	8,000
		25,000

C. Computer Specialist for both hardware and software. This has very early priority after the implementation of the subproject

1st year	8 weeks	20,000
2nd year	4 weeks	15,000
3rd year	4 weeks	15,000
4th year	2 weeks	9,000
5th year	2 weeks	9,000
		68,000

D.	Visit of Greenhouse Engineer to work with quarantine expert and Indian engineer and quarantine expert.		
	1st year	8 weeks	20,000
	2nd year	4 weeks	15,000
	3rd year	2 weeks	9,000
	4th year	2 weeks	9,000
	5th year	2 weeks	9,000
			62,000
E.	Visit of one or more plant quarantine experts to work with NBPGR at the 4 quarantine station location 6 wks per year for five years, depending on the establishment of quarantine facilities		
	1st year	8 weeks	20,000
	2nd year	6 weeks	18,000
	3rd year	4 weeks	15,000
	4th year	4 weeks	15,000
	5th year	4 weeks	15,000
			83,000
F.	Cryogenics Consultant for main station at New Delhi and possibly two or three outlying stations.		
	1st year	4 weeks	15,000
	2nd year	2 weeks	9,000
	3rd year	2 weeks	9,000
	4th year	2 weeks	9,000
	5th year	2 weeks	9,000
			51,000
G.	Plant Quarantine Information Specialists to work with NBPGR (includes local travel)	2 months	20,000
	2nd year	2 months	20,000
	4th year	2 weeks	10,000
			50,000
H.	Contingency for service contracts and training of technicians for maintenance of laboratory and other equipment provided by this subproject		100,000
	SUB-TOTAL		481,000

X. ANTICIPATED ACHIEVEMENTS WHEN SUBPROJECT IS FULLY IMPLEMENTED

A. A fully operational, effective, and efficient National Plant Germplasm Network. Exotic and indigenous plant germplasm will be systematically collected, exchanged with the U.S. and other countries, evaluated, catalogued, and made freely available to plant scientists worldwide. This will not only benefit India and the U.S. but also the entire world.

B. Safe and secure medium and long term storage of indigenous and exotic germplasm collections of seed will be developed. They will be preserved under conditions that will minimize genetic drift and loss of genetic diversity.

C. Significant improvement in techniques and capability to propagate and maintain clonal germplasm for extended periods of time. Research in India on tissue culture shows that it is feasible to propagate and store vegetatively propogated stock as plantlets in laboratory cultures. This subproject should provide the means for refinement of culture techniques, provide for mass production of plantlets, the proper conditions for holding them, and for providing facilities for duplicate storage of germplasm as plantlet collections at NBPGR Headquarters.

D. A highly trained scientific staff will be in place at headquarters and at outlying locations for genetic resources activities, plant quarantine activities and for basic and applied research activities. This will have been accomplished through scientist travel in the U.S., use of consultants from the U.S., attendance at special training courses in the U.S. and India, and through national and international workshops.

E. A significant reduction in the risk of introducing pests and pathogens in imported high risk germplasm is anticipated.

F. Effective and efficient computer network for germplasm resources. Fifteen to twenty microcomputer with disks will be divided among the activities responsible for germplasm conservation and evaluation to help develop a centrally coordinated program from NBPGR headquarters.

G. Improved health status of stored germplasm.

H. Facilitate the movement of seed in and out of India to provide for more rapid and timely exchange of plant germplasm between India, the U.S., and other countries.

I. Development of Centers of Excellence in research on:

1. Diagnosis of obscure pathogens at NBPGR headquarters
2. Tissue culture applications to plant germplasm activities .
3. Identification and characterization of medicinal, aromatic, and other compounds.
4. Cryopreservation of germplasm

XI. LONG RANGE NEEDS

A. Expansion of Storage Facilities

At the end of the 5 year period covered in this subproject, storage space for about 200,000 accessions in the base collection will have been provided. However, this is about equal to the current seed inventory in the working collections. If all of these samples in fact been transferred to the base collection, then capacity will have been reached. It is necessary to think beyond 5 years when additional storage capacity in both the base and working collections will be needed. As already stated in Section IVC an ultimate storage capacity of 400,000 to 500,000 (double that proposed in this report) will be needed. Space for these additional facilities should be set aside at the start of the project to avoid separating the storage units in the future.

B. Duplication of the Base Collection

Security from catastrophic events is often difficult to ensure. One method is to use the base collection as a backup to the working collection. That is the system proposed for both India and the United States, however, in the international community germplasm should be readily available to all users.

The International Board for Plant Genetic Resources has put forth the concept of duplication of base collections at one or more regional base centers. This is another way of providing security for germplasm accessions. Alternatively the base collection could be duplicated, in small seed quantities, at an alternative location, Shimla for example, to provide an additional level of security.

C. Utilization of Genetic Engineering (Molecular Biology)

1. Initiate research on techniques and development of procedures for germplasm enhancement such as transferring valuable genes from wild to cultivated species.

2. Expansion of pathogen detection activities by use of molecular probes.

D. Relationship with private industry

Foster cooperative relationship with private industry in plant genetic resources activities like acquisition, evaluation, utilization, and quarantine.

XII. FINANCIAL PLAN, BASED ON A 5-YEAR PERIOD

A. Equipment, Headquarters, NBPGR

1.	Gene Bank	681,600	
2.	Gene Bank equipment	815,000	
3.	Evaluation, Issapur, Main Station	1,330,000	
4.	Collection & Exploration	25,000	
	SUB-TOTAL		2,851,600

B. Equipment, Regional Stations and Institutions

1.	Outlying Stations (13) 204,500 x 13	2,658,500	
2.	Base Centers (5)	125,000	
3.	NBPGR Regional Centre Jodhpur	397,000	
4.	Central Potato Research Center, Shimla	100,000	
5.	National Research Center for Spices, Calicut	115,000	
6.	Central Tuber Crops Research Institute, Trivandrum	113,000	
7.	Sugarcane Breeding Institute, Coimbatore	333,000	
8.	Central Plantation Crops Research Institute, Kasargod	93,000	
9.	Indian Horticultural Research Institute, Bangalore	343,500	
	SUB-TOTAL		4,278,000

C. Plant Quarantine

1.	Equipment	1,261,600	
2.	Phytosanitory Plant Growing & Storage Equipment	1,125,000	
3.	Supplement for imported glasshouse		
	a. Plant Quarantine Station	1,000,000	
	b. Outlying Stations for Isolation of plants	900,000	
	SUB-TOTAL		4,286,600

D. Training

1. NBPGR Headquarters		
a. Senior staff	91,500	
b. Scientists	360,000	
2. Outlying Stations	402,000	
3. Graduate Training	342,000	
4. Plant Quarantine	721,000	
SUB-TOTAL		1,916,500

E. Basic & Applied Research (Delhi)

1. Cryogenic Equipment	115,000	
2. Tissue Culture	100,000	
3. Germination Testing	40,000	
4. Salvaging infected and infested germplasm	38,000	
SUB-TOTAL		293,000

F. Joint Plant Explorations

1. Collecting in U.S.	144,000	
2. Collecting in India	120,000	
SUB-TOTAL		264,000

G. Special Fund for Germplasm Exchange

1. India (per year)	10,000	
2. U.S.A.(per year)	10,000	
SUB-TOTAL	20,000 x 5	100,000

H. Workshops

1. 4 in U.S.A.	95,000	
2. 3 in India	63,000	
3. Contingency for honoraria	60,000	
SUB-TOTAL		218,000

I. Biennial National Symposia

1. Review teams	160,000	
2. Symposium costs, including printing of proceedings	50,000	
SUB-TOTAL		210,000

J. Consultants from U.S.

1. U.S. Plant Introduction Officer	42,000	
2. Leader, National Plant Germplasm System	25,000	
3. Computer Specialist	68,000	
4. Greenhouse Engineer	62,000	
5. Plant Quarantine Expert	83,000	
6. Cryogenics Consultant	51,000	
7. Plant Quarantine Information Specialist	50,000	
SUB-TOTAL		381,000

K. Contingency for Service Contracts for Sophisticated Laboratory and other equipments 100,000

SUB-TOTAL	100,000
GRAND TOTAL	14,898,700

L. Financial Plan Summary

1. Equipment, Headquarters NBPGR	2,851,600
2. Equipment, Regional Stations and Institutes	4,228,000
3. Plant Quarantine	4,286,600
4. Training	1,916,500
5. Basic and Applied Research, Delhi	293,000
6. Joint Plant Explorations	264,000
7. Special Fund for Germplasm Exchange	100,000
8. Workshops	218,000
9. Biennial National Symposia	210,000
10. Consultants from U.S.	381,000
11. Contingency for service contracts	100,000
GRAND TOTAL	14,898,700

XIII. GUIDELINES FOR EXPENDING SUBPROJECT FUNDS

Before a schedule for expending funds can be developed in a meaningful manner, the total funds available under the project must be determined. If approved funds are less than requested funds, then priorities must be set so that low priority items can be red-lined. Because of the wide spectrum of NBPGR activities and those of its germplasm resource collaborators, the Design Team believes that the setting of biological priorities is the responsibility of NBPGR with advice from subproject monitoring and evaluation specialists.

The Design Team recommends, in general, that at least 60 percent of the funds be committed during the first two years - rather than spending an equal amount each year (i.e. 20% per year). Many events are sequential. Consequently, certain events must be scheduled early in the program in order to allow for development of succeeding events.

The Design Team further recommends that expensive sophisticated equipment not be acquired until there is assurance that (1) the laboratory in which the equipment is to be used is in place (2) personnel have been trained or are in training and (3) contractual arrangements have been made or are being made to service the equipment in accordance with the manufacturer's schedule not only to keep warranties valid but for safety of equipment operators and extending the useful life of such equipment.

As a guideline, for expenditures over the five-year period, the Design Team suggests the following scheduling for some major items as a guideline pending assignment of priorities.

	YEAR 1	2	3	4	5
A. WORKSHOPS					
#1 U.S.	Plan	Conduct	Follow-up		
#2 India	Plan	Conduct	Follow-up		
#3 U.S.		Plan	Conduct	Follow-up	
#4 India		Plan	Conduct	Follow-up	
#5 U.S. or India		Plan	Conduct	Follow-up	
#6 India			Plan	Conduct	Follow-up
#7 U.S.			Plan	Conduct	Follow-up
B. CONSULTANTS					
1. Cryogenics	4 wks	2 wks	2 wks	2 wks	2 wks
2. Glasshouse Engineer	8 wks	4 wks	2 wks	2 wks	2 wks
3. Plant Introduction Officer	2 wks	2 wks	1 wk	1 wk	1 wk
4. U.S. National Germplasm Leader	2 wks	1 wk		1 wk	
5. Information Specialist		2 mos		2 wks	
6. Computer Specialist	8 wks	4 wks	4 wks	2 wks	2 wks
7. Plant Quarantine Experts	8 wks	6 wks	4 wks	4 wks	4 wks

	YEAR 1	2	3	4	5
C. Post doctoral etc Post doctoral researach, seed treatment, U.S. 15 months		X	X		
D. Equipment					
1. Basic & applied research	20%	60%	20%		
2. Gene Bank	30%	50%	20%		
3. Evaluation	100%				
4. Collection & Exploration	100%				
5. Outlying Stations	40%	40%	20%		
6. Plant Quarantine Stations					
Priority 1	60%	20%	20%		
Priority 2	50%	25%	25%		
Priority 3	40%	30%	30%		
Priority 4	0	30%	60%	10%	
7. Physanitary Plant Growing or Storage Equipment					
Priority 1	80%	20%			
Priority 2	20%	60%	20%		
Priority 3	20%	40%	40%		
Priority 4	0	30%	40%	30%	
8. Isolation Glasshouses and Screenhouse at locations other than Plant Quarantine Stations					
Priority 1 + 2	100%				
Priority 3 + 4		100%			
Priority 5 + 6			100%		

	YEAR 1	2	3	4	5
E. TRAINING					
1. NBPGR Headquarters	100%				
2. NBPGR senior staff	100%				
3. NBPGR scientists	30%	40%	30%		
4. Outlying Stations		30%	40%	30%	
5. Graduate Training (6)		2	2	2	
6. Plant Quarantine Stations					
Priority 1	30%	50%	20%		
Priority 2		40%	40%	20%	
Priority 3		20%	40%	40%	
Priority 4		20%	30%	50%	
7. Information Specialist		100%			
8. Train-the-trainer					
Pesticide			100%		
9. Plant Quarantine		100%			
Plant Quarantine Program Manager	50%	50%			
F. PROCURE AND INSTAL SEED STORAGE MODULES					
Delhi - 4 medium-term units			2	2	
Delhi - 4 long-term units			2	2	
13 locations - medium-term units	5	8			
G. CONSTRUCT GENE BANK BUILDING	Plan	Construct			
H. Plant Exploration (The utilization plan should be flexible, however, in order to accommodate special opportunities that may arise)	20%	20%	20%	20%	20%

Germplasm collections maintained by various ICAR Institutes/Coordinated Project/Centres

Institutes/Centres	Crop-diversity maintained
Central Rice Research Institute, Cuttack	Rice (15,740)
Directorate of wheat, IARI, New Delhi	Wheat (16,000)
Project Coordinator, Sorghum, Hyderabad	1000 lines with P.C.
Project Coordinator, Barley, Karnal	Barley (8,000)
Project Coordinator, Millets, Puna	Finger millet (4480), Kodo millet(1095), Foxtail millet 1905 & 2491) at Nandyal, Proso millet (581, 1169 at Dholi), Barnard millet (882, 985 at Vivekananda Parvatiya Krishi Anusandhan Shala, Almora).
Central Potato Research Institute, Shimla	Solanum tuberosum: tuberosum types 626 andigenu types, 228 (tubers), semi-wild and wild tuberiferous Solanum spp. 191.
Central Tuber Crops Research Institute, Trivandrum	Cassava(1214), Sweet potato(494), Dioscorea esculenta(96), D. alata(208), D. rotundata(370), taro/Colocasia(180), Xanthosoma(65), Elephant foot yam(80), Yam bean(11), Coleus(20), Winged bean(25)
Project Coordinator (Tuber crops) CTCRI, Regional Centres, Bhubaneswar	Cassava(267), Sweet potato(100), Colocasia(14), Elephant foot yam(21), Dioscorea alata(30), D. esculenta & others(6)
Rajendra Agri. Univ. Campus, Dholi	Sweet potato (468), Colocasia(40), Pachyrhizus/Sweet yam(37), Cassava(11), Winged bean(28) and others (31).
Andhra Pradesh Agricultural University, Rajendra nagar, Hyderabad	Cassava(38), Sweet potato(53), Colocasia (21), others(10).
Tamil Nadu Agricultural University, Coimbatore	Cassava(109), Sweet potato(65), Colocasia (8), Elephant foot yam(10), Coleus(10), Dioscorea alata & other spp. (19).

Assam Agricultural University Jorhat	Cassava(25), Sweet potato(30), Colocasia(12), Amorphophallus & Dioscorea spp. (12).
Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani	Cassava(12), Sweet potato(42), Colocasia(11), Sweet yam(11), Dioscorea, Amorphophallus & others (12).
Kerala Agricultural Univ., Trichur	Cassava(72), Sweet potato(31), Colocasia(8), Dioscorea spp. (14), others (7).
University of Agricultural Sciences, Bangalore, Station, Ullal, Karnataka	Cassava(11), Sweet potato (38), Colocasia(6),
Konkan Krishi Vidyapeeth Dapoli	Cassava(16), Sweet potato(55), Colocasia(10), Elephant foot yam(14), Dioscorea alata & D. bulbifera (19).
ICAR, Research Complex, Shillong	Cassava(10), Sweet potato(14), Colocasia(10), Dioscorea(6).
Central Plantation Crops Research Institute, Kasargod.	Coconut (94)
CPCRI Station, Vittal	Arecanut(72), Cashew (248), Cacao(48)
CPCRI Station, Anadmans	Coconut (24)
CPCRI Station, Shantigodu	Cashew (150)
CPCRI Station, Paleda	OildPalm (7)
CPCRI Station, Calicut	Nutmeg(301), Black Pepper(260), Ginger (127), Turmeric (180), Cloves(152), Cinnamon(166)
CPCRI Station, Apangala	Cardamom (210), Greater Cardamom(14).
Indian Institute of Horticultural Research, Bangalore	(a) Fruit crops: Banana(172), Citrus (71), Grapes(636), Mango(120), Pineapple (25), Papaya(20), Pomegranate(38), guava(19), Water melon(49), Muskmelon(191), Annona spp. (13) and others (20) (b) Vegetable crops: Amaranth(53), Bitter gourd(84), Bottlegourd(166), Cucumber(9), Pumpkin(72), other Cucubits(8), Brinjal(70), Tomato(9000), Cabbage(53), Capsicum (854), Carrot(188), Cauliflower(77), Radesh(26), Cowpea(150), Dolichos(223), Garden pea(300), French bean(34), Limabean(30), Okra(26), Winged bean(116), Onion(171), Garlic(36), Others(11). (c) Medicinal plants : Ostharanthus roseus(11) Jasminum (39), Patchouli(12), Solanum spp.(10), Dioscorea & others (8). (d) Ornamental plants : Bougainvillea(119), Chrysanthemum (180), Gladiolus (120), Hemerocallis(34), Hippeastrum(89), Orchids (102), Roses(464), China aster(21)

110

Project Coordinator (Sunflower), Bangalore	Sunflower(644), wild *Helianthus* sp.(6)
Project Coordinator (Rapeseed-Mustard), Hissar (maintained by 15 cooperating research centres).	Brassica spp.(14,259)
Project Coordinator (Safflower), (maintained by 12 different centres).	Safflower(8240)
National Research Centre for Groundnut, Junagadh.	Groundnut(3500); *Arachis* spp. (20).
Central Institute for Cotton Research, Nagpur	*Gossypium arboreum*(1420), *G. herbaceum*(300), *G. hirsutum* (4000), *G. barbadense*(280), wild *Gossypium* spp. (27); Perennial cottons (110), H Hybrids, polyploids & others (225), land races(22).
CICR Subcentre, Coimbatore	*G. hirsutum* (2000), *G. barbadense*(280), *Gossypium* wild spp.(11), Landraces(4)
CICR Subcentre, Sirsa	*G. hirsutum*(400), *G. arboreum*(100)
Project Coordinator (Cotton)	*G. hirrutum*(3300), *G. barbadense*(205), *G. arboreum*(850), *G. herbaceum*(200)
Sugarcane Breeding Institute, Coimbatore	Sugarcane (3590) clones
Central Jobacco Research Institute, Rajamundry	Tobacco(1091) including *Nicotiana rustica*.
Project Coordinator (Medicinal & Aromatic plants), New Delhi & other centres	Opium poppy (355), Senna(40), Periwinkle(26), Rauvolfia(43), Vetiver(31), Palmarosa(63), Vetiver(31), Palmarosa(63), Isabgol(110), foxglove(17), *Geranium*(7), Patchouli(4).
Vivekananda Parvatiya Krishi Anusandhan Shala Almora	Rice (1500), Wheat (1700) Barley(260) Maize(300), Minor millets - Finger millet(3,000), Barnyard millet(900), Foxtail millet(800), Proso millet (50), Amaranths (500), Blackgram(80), Greengram (125), Horsegram(9), Soybean(55), French bean (150), Tomato(30), Chillies(20), Peas(100)
CAZRI, Jodhpur	Pomegranate(20), Jojaba(20), datepalm(15), Custard apple(8), Pearlmillet(1250), Italian millet(96), Prosomillet(64), guar(1200) methbean(1100), Mung bean(80), Horse gram(25), sesame(190), Raga(100), Brown sarson(10), groundnut(26), Pasture grasses - Lasiurus, Sentilrus

V

Germplasm collections maintained by the NBPGR

Locations	Crop diversity maintained
Headquarters New Delhi 28° 35'N & 70°12'E alt. 228m subhumid/ sub-tropical	CEREALS: Wheat(1395), Barley(740), Oats(1000); Minor MILLETS: Panicum (425); LEGUMES: Cowpea(2533), Cluster bean(3580), Fieldpea(663), Blackgram(400), Hyacinth bean(1273), Mungbean(572), Velvetbean (59), Rothbean (1087), Brinjal(442), VEGETABLES: Tomato(1750), Okra 92), Bulbous crops - Onion(1094), Garlic (680); Bottlegourd and other Cucurbits Roselle(112), Coriander(52), others(54); FRUITS: tropical: jujube & others(95), Oilseeds: Oleiferous Brassicas(2305); Safflower(1050), Sunflower(350); MEDICINAL & AROMATIC PLANTS - Catharanthus (36), Senna(20), Greengram(51), Fennel(40), Opium Poppy(317), Palmarosa(52), Vetiver (35), others (5); Underutilised: Winged bean(100), Lemongrass(102).
Regional stations Jodhpur 26°18'N & 73°E alt. 224m. semi-arid/ sub-tropical	LEGUMES: Cluster bean(3855), Rothbean(1573), Green gram (777), Black gram(81), Cowpea(495), Mungbean(48), Ricebean(100), Pigeonpea(26), Bambara groundnut(30), VEGETABLES: Okra(62), others(17); FRUITS: Pomegranate(32), Ber(29), others(13); OILSEEDS: Sesame(1085), Citrulus colocynthis (52), Industrial crops: jojoba, guayule, Euphorbia and others (24); Forage legumes/grasses etc.(60).
Akola 21°N & 77°20'E alt. 350m. sub-humid/ subtropical	PSEUDOCEREALS: Amaranthus (558); Millets: Foxtail millet (710), Finger millet(672), Barnyard millet/Echinochloa spp. (412), Proso millet(52), little millet(198), Kodo millet/ Paspalum(241); LEGUMES: Soybean(2061), Mungbean(506), Pigeonpea(1178), Hyacinth bean(545), Cowpea(276), French bean(1300), Yambean(32), Clusterbean(49); Lathyrus/Lentil (26), Lentil(20), Chickpea(49), Mungbean(30), Lablab bean (23), others(5); VEGETABLES: Okra (900), Onion(205), Garlic(282), Horticultural/Fruits crops: Grapes(60), OILSEEDS: Groundnut(398), Sesame(212), Safflower(328), Castor(87), Niger(205), Linseed(371), Others(5); FIBRE CROPS : Kenaf (53); Industrial plants (Simmondsia, Euphorbia and guayule), Lemongrass and others(62).

Best Available Document

112

Trichur
10°30'N & 16°20'E
alt. 50/110m
Humid tropical

CEREALS: Rice (1020), MILLETS: Fingermillet(221), Foxtailmillet(42), Pearlmillet(23), Kodomillet(17), LEGUMES: Cowpea(856), Greengram(64), Black gram(214), Rice bean(96), Pigeonpea(168), Broad bean(85), Horsegram(484), Winged bean(124), Tha bean(10), Bhavana(15), VEGETABLES: Okra (325), Bottlegourd(22), Lucha (39), Snakegourd(27), Bittergourd(16), Chillies(547), Tuberoses: Dioscorea alata(172), other Dioscoreas (42), Colocasia(460), Elephant foot yam(72), Arrowroot(18), Canna(6), Xanthosoma(58), Pachyrhizus(16), Fruits: Banana (126), OILSEEDS: Sesame(318), [illegible] Cocoa (640), Ginger(150), Black pepper [illegible] (79), [illegible] (35) Arecanut & others (22).

Shimla
31°N & 77°E

CEREALS AND PSEUDO CEREALS: Barley(40), Amaranthus(2291), Buckwheat(270), [illegible](9), Millets: Finger millet(76), Foxtail millet(737), Kodo millet(208), Barnyard millet(29), LEGUMES: French bean(1470), Rice bean(112), Greengram(86), Black gram(138), Broad bean(67), Limabean(17), Adzuki bean (138), Rayed bean(8), Horsegram(76), lentil(200), Lathyrus(13), VEGETABLES: Cyclanthera(18), Onion(43), Capsicums/chillies(130), tomato(61), Lettuce(5), Brassicas (131), FRUIT CROPS: apple(211), pear (32), cherry(12), plum(23), peach(36), strawberry(23), raspberry(27), pome-l granate(20), Chinese gooseberry(7), Nut crops: almond(16), Walnut(45), Pecan(10), Filbert & others(9), Spices etc.: Turmeric(14). Forages grasses/legumes: Bromus, Lolium & others (155), LEGUMES - Medicago, clover, Onobrychis, Vicia and Desmodium(112), Chicory (37), Hops (27), Ornamentals etc: Rosa(38), Gladiolus (19) and others(62).

Appendix XVI

Collections held at the Central Tuber Crops Research Institute, Trivandrum

Crop	Number of Accessions
Cassava	1214
Sweet Potato	724
Lesser Yam (Dioscorea esculenta)	96
Greater Yam (D. alata)	208
White Yam (D. rotundata)	370
Other Diascorea species	5
Taro (Colocasia escutenta)	310
Tannia (Xanthosoma sp.)	63
Elephant Foot Yam (Amophophalus)	96
Coleus (Chinese potato)	61
Yam bean (Pachyrrhizus crosus)	11
Winged bean (Psophocarpus)	1
Arrow root	1
TOTAL	3160

Appendix XVII

Cooperation between NBPGR and ICRISAT-GRU

The International Center for Research in the Semi-Arid Tropics (ICRISAT) is one of the thirteen global institutes under the algis of the Consultative Group for International Agricultural Research (CGIAR) and is located near Hyderabad. ICRISAT's Mission, simply stated, is to improve crops and farming systems in the Semi-Arid Tropics (SAT). It is located in India through authorization of the GOI and operates under procedures developed through formal agreements with the ICAR.

Five of the major crops grown in the SAT are sorghum, pearl millet, chickpea, pigeonpea, and groundnut. ICRISAT performs research on these mandate crops, but very importantly, also has the responsibility for assembly, maintenance, and evaluation of germplasm collections of them. This work is the responsibility of ICRISAT's Genetic Resources Unit (GRU), which has assembled all known available germplasm collections in the world of these crops and continues the search for others that may not yet have been found. The GRU is also responsible for exploration, evaluation, documentation (computer), and distribution of these crops and has full worldwide responsibility for them.

ICRISAT's genetic resources collections are fully secure because action collections are stored in modern seed storage modules at 4°C and 20% RH and base collections will be stored at -20°C, also in modules currently in place and being tested. The size of ICRISAT-GRU collections follow:

Sorghum	28,022	accessions
Pearl Millet	18,033	"
Chickpea	14,872	"
Pigeonpea	10,818	"
Groundnut	11,588	"
Total	83,383	"
Minor Millets (6 species)	5,097	"
Total all crops	88,480	"

For these crops, NBPGR has a cooperative relationship with ICRISAT-GRU. In 1985-86, a plan for cooperative work between NBPGR and ICRISAT-GRU was developed in the areas of joint plant explorations in India, joint evaluations of collections, and joint publications relating to this work on ICRISAT's mandate crops. The plan was approved by ICAR in January 1986 and joint evaluation and explorations were started early the same year.

In addition, to the five mandate crops, ICRISAT has had a collection of 6 species of minor millets, the assembly and evaluation of which was supported by the International Board for Plant Genetic Resources (IBPGR) because NBPGR had responsibility for seed distribution of these species within India from its own collections, ICRISAT distributed seed only to foreign requests. However, in January 1986, this policy was modified, giving full responsibility for maintenance and distribution to both NBPGR and ICRISAT. Implementation of this policy was followed by an exchange of seed between the two organizatins and now both will have equal responsibility for maintenance and distribution of seed.

These developments resulted in closer cooperation between NBPGR and ICRISAT-GRU in the assembly and evaluation of these crops, which should continue in the future. ICRISAT will continue its responsibilities toward future assembly, evaluation, documentation, conservation, and distribution of the above crop germplasm collections.