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POTATO RESEARCH IN INDIA

Report of the 1988 External Review

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Report of the 1988 External Review

ICAR

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FOREWORD

Potato research in India has completed more than 50 years. Organised potato research, which started in 1935 gained impetus with the establishment of a Central Potato Research Institute (CPRI) in 1949. CPRI's headquarters, originally at Patna, were subsequently shifted to Shimla. Since then, considerable strengthening has taken place by establishing several regional stations and launching the All India Coordinated Potato Improvement Project. Potato research has primarily been carried out under the aegis of the Indian Council of Agricultural Research (ICAR). The significant increase in potato production in the country is due largely to the contributions made by the CPRI.

In the last 50 years, significant developments have taken place, including the release of a large number of varieties, development of seed production technology, and standardisation of agrotechniques and plant protection measures. These developments have made their mark on potato production in India. In the last 23 years, the area has increased by 333%, production by 738%, and yield by 250%. However, the present level of per capita consumption is far below that of many potato-producing countries. The requirement of potato estimated for the year 2000 by the National Commission on Agriculture is of the order of 30 million tonnes; demand is likely to go even beyond this level. If India is to meet the growing demand for potato, it has to revamp its research programmes and development strategies.

During my last visit to the International Potato Centre (CIP) at Lima, Peru in December 1987, I had the opportunity of in-depth discussion of potato research and development with the Director General of CIP, Dr. R. L. Sawyer. During the discussion it emerged that it would be useful at this stage to review the efforts being made in India and to suggest ways to strengthen them. Dr. Sawyer offered to sponsor a team of competent potato scientists who could carry out this job if India so desired. I am glad that my discussions with Dr. Sawyer have borne fruits and a team consisting of eminent potato scientists drawn from CIP, other international organisations, and from within India has conducted a detailed review of the research programmes, seed production, linkages, and infrastructural needs of potato research in the country. There are still several lacunae in potato research and I am sure that the recommendations made in this report will go a long way toward filling the gaps so identified.

I would like to convey my thanks to Dr. R. L. Sawyer, for agreeing to sponsor the visit of the team. The team has thoroughly scrutinised the programmes and has come up with very useful recommendations on all aspects. I can ensure that these recommendations shall be implemented by the council in letter and spirit.

N. S. Randhawa

N. S. RANDHAWA
Director General, ICAR
and Secretary, Department of
Agricultural Research and
Education, New Delhi

Dated, 26.11.88

ABBREVIATIONS AND ACRONYMS

AICPIP	All India Coordinated Potato Improvement Project
CIP	International Potato Centre
CPRI	Central Potato Research Institute
CPRS	Central Potato Research Station
DNA	Deoxyribonucleic acid
ELISA	Enzyme-linked immunosorbent assay
g	gramme
ha	hectare
IARI	Indian Agricultural Research Institute
IBPGR	International Board for Plant Genetic Resources
ICAR	Indian Council of Agricultural Research
IPM	Integrated pest management
ISEM	Immunosorbent electron microscopy
kg	kilogramme
m	metre
MLO	Mycoplasma-like organisms
MP	Madhya Pradesh
NASH	Nucleic acid spot hybridisation
NSC	National Seeds Corporation
PLRV	Potato leafroll virus
PSTV	Potato spindle tuber viroid
PTM	Potato tuber moth
PVS	Potato virus S
PVX	Potato virus X
PVY	Potato virus Y
Rs	Rupees
SAU	State Agricultural University
t	tonne
TPS	True potato seed
UP	Uttar Pradesh

EXECUTIVE SUMMARY

- In May 1988, the Indian Council of Agricultural Research (ICAR) convened a six-man team of specialists to review potato research and development in India. ICAR provided the terms of reference.

- Since its iniciation in 1935, potato research in India has expanded to include a Central Potato Research Institute (CPRI), headquartered at Shimla and 12 regional stations with a combined staff of 600.

- An All India Coordinated Potato Improvement Project (AICPIP), established in 1971, has expanded to conduct and coordinate potato research under different environments at 24 locations that cover diverse ecological environments.

- Over the past 40 years, largely as a result of research and providing improved seed to farmers, India's potato production has grown rapidly and now ranks fifth worldwide. The value of the Indian potato crop per unit of land exceeds that of cereals by over 300%.

- Defined breeding targets should be established in accordance with perceived needs for potato improvement. Development of virus-resistant varieties should be a long-term goal, as it would greatly aid seed production while reducing virus degeneration in the field.

- Keeping records of races of the late blight fungus and breeding for "major gene" resistance should be terminated. Field or general resistance should be the goal, as it is more sustainable and permits good yields.

- Because of rapid advances in biotechnology, monitoring of progress in the field by CPRI is encouraged. However, significant investments in biotechnology facilities is discouraged. Access to costly, sophisticated facilities and specialised personnel may be obtained through research contracts with institutions involved in biotechnology research in India.

- The calibre of research in the Plant Physiology and Biochemistry Division is exemplary. This Division should initiate collaborative research with Genetics to assist in screening for high yield levels. A closer interaction with the tissue culture laboratory is also recommended.

- In keeping with current work and future priorities, the name of the Division of Crop and Soil Sciences should be changed to "Agronomy." The Review Panel outlined areas of future concentration, stressing the need for innovative research on true potato seed (TPS) and biofertilisers, and the need for economic analysis to derive appropriate farmer recommendations from experimental results.

- Material in the seed programme, all parental breeding lines and in vitro germplasm should be tested for potato spindle tuber viroid (PSTV), using the nucleic acid spot hybridisation (NASH) test.

- The ecology of the bacterium causing bacterial wilt (brown rot) and the epidemiology of the disease under Indian conditions should receive priority attention over less important bacterial pathogens.

- To reduce reliance on pesticides, it is urged that an integrated pest management (IPM) programme be introduced. The economic importance of specific insects should be carefully assessed and research priorities should be set for solving different problems in accordance with their importance and the prospects for solving them.

- A more intensive research programme on nematodes is recommended.

- Consolidation of the Division of Social Sciences is encouraged, to assist technical research by providing information on constraints to potato production and use, by developing strategies for disseminating technology to farmers, and by assessing impact. Training and communications are essential complements to socioeconomic research. CPRI is encouraged to strengthen work in these areas.

- Meeting future needs for quality seed may require legal redefinition of "breeders' seed" and a restructuring of the Seed Production Division. It is recommended that this Division be renamed, "Seed Research and Production." The Seed Production Division at CPRI should concentrate on seed research aimed at providing disease-free elite material. In addition to the NSC and state government farms, the private sector should be encouraged to produce and distribute quality seed.

- Micropropagation of PSTV-and virus-free basic stocks and maintenance of strict health standards during all stages of seed multiplication are desirable medium-term goals.

- A four-stage seed multiplication scheme is suggested to reduce the time and resources spent on seed multiplication.

- An immediate program for bulk production of TPS should be initiated immediately.

- CPRI should encourage the private sector to expand its role in seed multiplication and distribution.

- Stronger linkage with the International Potato Centre is encouraged. It would be of mutual advantage particularly in the social sciences and in technical research involving true potato seed (TPS), crop productivity, and heat tolerance. The broad scope of CPRI research could also benefit many Asian potato programmes. For this reason, expanded network activities, like training and exchange of scientists and germplasm, are strongly encouraged.

- Whereas the headquarters facilities in Shimla served CPRI well in the early days, the Panel believes that CPRI's overall effectiveness could be improved by shifting headquarters to Modipuram, located nearer to major potato production and seed multiplication areas in the plains. Shimla should be maintained for breeding and seed production for the hills.

- Immediate attention should be given to consolidating the Division of Post-Harvest Technology.

- A matrix organisation with Divisions supporting integrated problem-solving "thrusts" is recommended to improve interdisciplinary cooperation and research output.

- Inadequate staff and equipment seem to be limiting quality research at several regional stations. Consideration should be given to reducing the number of CPRI stations and improving the excellence of the remainder.

1. INTRODUCTION

Since its inception in 1935, organised potato research in India has achieved significant results. Twenty-five new potato varieties have been released, several of which are widely grown. A scientifically-based seed production system has been developed that has facilitated rapid diffusion of improved varieties and dramatic expansion of the potato crop in the north Indian plains. Appropriate agronomic practices have been developed for the country's major agro-ecological zones. As a result, since the early 1960s, potato production has increased as rapidly as any major food crop in India. With an annual harvest of 12 million tons from 800,000 ha, India is now the world's fifth largest potato producing country.

In keeping with its forward-looking stance and the tradition of planning for agricultural development, the Government of India is not content to rest on the laurels of its past achievements in potato research. Looking forward to the year 2000 and beyond, in early 1988 the Indian Council of Agricultural Research (ICAR) decided to review the research and seed programmes of the Central Potato Research Institute (CPRI) and collaborating institutions. In addition to reviewing current programmes, a main goal was to evaluate ideas to meet future needs, and to propose changes in organisation, priorities, and strategies to ensure that the potato crop continues to play a dynamic role in the country's agricultural development. In light of the fixed crop land base, small and declining farm size, and low average per capita income, India's continuing population growth is a source of concern to agricultural policy makers. For this reason, there is keen interest in expanding production and use of crops like potatoes that are highly efficient in converting nutrients and water into nutritious food.

To conduct the Review of Potato Research in India, ICAR requested that CIP sponsor the visit of a six-man team:

K.L. Chadha
Deputy Director General (Horticulture)
ICAR, New Delhi

Y. R. Mehta
former General Manager, National Seeds Corporation and Teamleader for the Quinquennial Review of CPRI, 1984
New Delhi, India

O. T. Page
Director of Research Emeritus
CIP, Lima, Peru

D. E. Horton
Head of Social Science Department
CIP, Lima, Peru

L. C. Sikka
Potato Specialist, CIP Region VI, New Delhi, India.
(former Chief of CPRI Seed Production Division and Project Co-ordinator, (Potato))

M. L. Upadhya
Regional Director, CIP Region VI,
New Delhi, India

It is noteworthy that this was the first commodity review in which ICAR requested an International Agricultural Research Centre to provide team members.

The terms of reference for the review were:

- To evaluate the extent of contribution made by CPRI in the field of potato research and development in India.

- To evaluate scientific relevance and soundness of the technologies developed and recommended, and their contribution to solving specific problems in different agro-climatic regions of India.

- To review if the current programmes and priorities of potato research are in tune with the country's requirements for the year 2000 and beyond.

- To identify future priorities of CPRI in relation to present and/or future needs for potato research and development with specific proposals for manpower deployment, infrastructural development, and training needs.

- To look into the present responsibilities of the Institute for the breeders' seed programme and into possible improvements/modifications to ensure adequate production of seed potato in the region.

- To assess the extent to which the Institute has collaborated with different countries and International Organisations, to analyse benefits accrued from such collaborations, and to suggest steps for improvement in this area.

- To suggest development of linkages with countries of South and South-East Asia towards balanced development of production and utilisation of potato in the region.

- To make any other recommendation relevant to potato research and development in India.

The review process began in March 1988, when copies of recent CPRI reports were sent to team members. From May 16 to 31, the team visited research sites, heard formal presentations, and interacted with scientists at ICAR headquarters in New Delhi, CPRI headquarters in Shimla, and at research stations at Rajgurunagar and Shillong (Annexes 1 and 2).

During its work, the team reviewed over 40 publications including annual reports, research highlights, research projects, technical and extension bulletins, and impact studies (Annex 9). Additionally, CPRI and AICPIP provided the team with two specially prepared reports, and the Director of CPRI provided three overview documents. The review panel also benefited from the reports of the Quinquennial Reviews of CPRI and AICPIP that were submitted in 1984 and 1985.

The review panel would like to thank CPRI's Director and staff for providing the excellent documentation, presentations, and frank discussions on which the present report is based. The team would also like to thank Mariella Altet and Aravind Babu for text processing and Garry Robertson for editing.

2. POTATO RESEARCH IN INDIA

2.1 Potato in the Indian Economy

Potato is believed to have been introduced into India in the late sixteenth century, most probably by the Portuguese or the Spaniards. The first accounts of potato in India in modern times are the observations made by Terry of his travels through India in 1615-1617. Terry, the chief chaplain to the representative of the English East India Company to the Mughal Courts, observed that during his travels, he saw "in the northern most parts... every where good roots as carrots, potatoes...".

Linguistic and botanical evidence suggests that potato could have been introduced into India directly from South America across the Pacific Ocean. Potato is known as aalu in Hindustani, the dominant language of the country. Kachaalu (Colocasia esculenta: Araceae) has been recorded from India in 1598. If kachaalu was known in 1598, it is probable that aalu was known in India even earlier. Until the 1930s and 1940s the dominant potato varieties, Phulwa and Darjeeling Red Round, showed predominantly andigena characters.

In the late eighteenth and nineteenth centuries, potatoes were frequently brought into India by the British, who grew them as a curiosity in their backyards. As potato became adapted to local conditions and became popular, seed potatoes were imported on a large scale until the beginning of the Second World War. These were chiefly from the UK, Italy, the Netherlands, and also from Burma. Seed potato imports ceased in the 1950s. Old accounts of British officers serving in India show that some of them carried out simple agronomic trials.

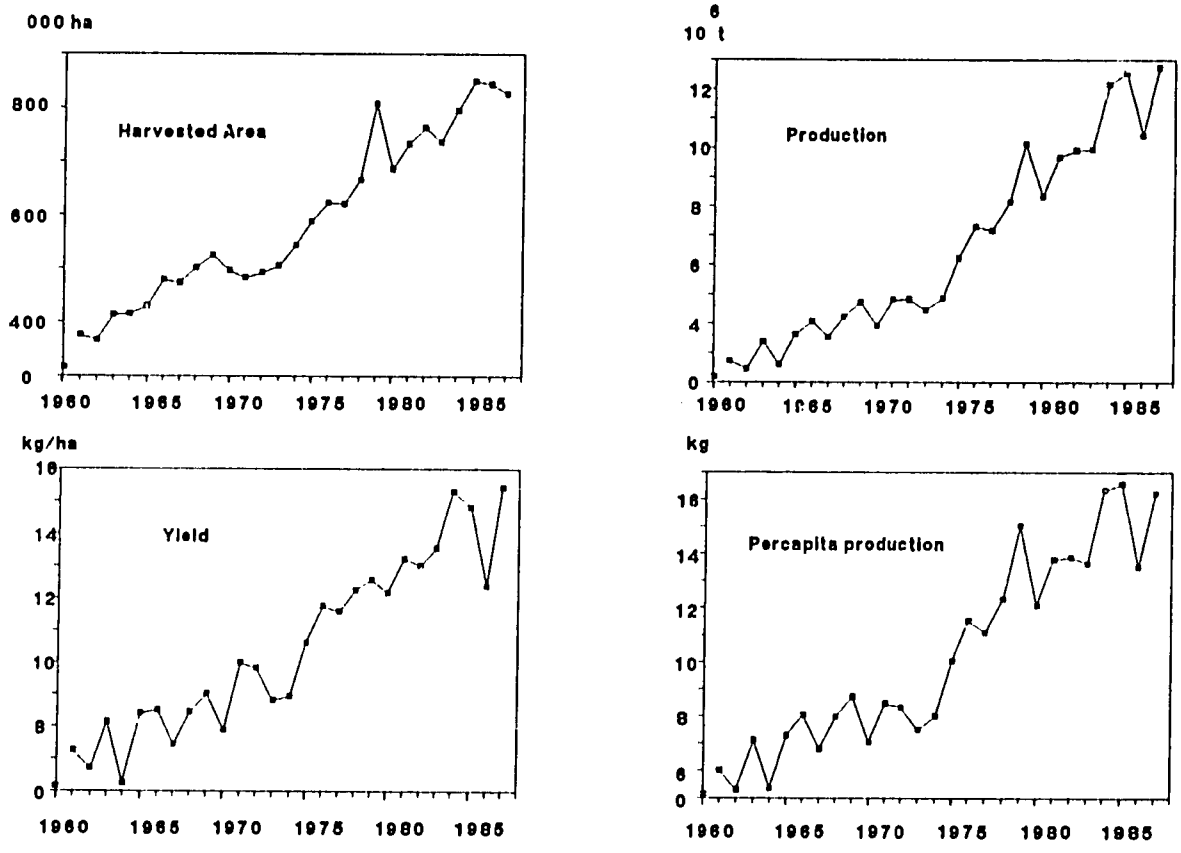
Systematic research on potato was started in 1917 with the establishment of a research station in Nanjanad (the Nilgiri hills of south India). Early studies related to introduction and selection of varieties for high yield and other agronomic attributes. Accounts of British officers in the 19th century show that the potato crop steadily degenerated when grown in the plains of India, and noted the advantages of using hill-grown seed for raising the crop in the plains.

Organised research was started in April 1935 when the then Imperial (now, Indian) Agricultural Research Institute (IARI), opened a research station for potato breeding in the northern hills of Shimla (elevation 2100 m). The station was transferred to CPRI when it was set up in 1949.

Research in the 1930s showed that potato varieties being grown in India could be classified into 16 "native" varieties (for which no European equivalent varieties could be identified) and 38 European varieties, of which 28 were commonly cultivated at that time.

At present, India ranks fourth in the world in area and fifth in production of potatoes. During 1986-87, the area under potato in India was about 825,000 ha and the production was 13 million tonnes. The yield was 15 t/ha and the per capita availability was 16 kg (Figure 1, Tables A.3.1 and A.3.2). By way of comparison, world average yield was 15 t/ha and per capita availability was 63 kg in 1986.

Figure 1. Area, production, yield, and per capita availability of potato in India, 1960/87



2.2 Potato Cultivation

More than three-fourths of the Indian potato crop is grown in the plains under irrigation during the short-day winter months from October to February. About 10% of the area is grown in the plateau region without irrigation during the rainy season from July to October. The crop is grown under long-day conditions in less than 10% of the area, mostly in the mountainous regions of north, northeast, and south India.

About 10,000 ha of potatoes are grown in the Nilgiri hills of south India (latitude 11 North; altitude 1400-2500 m). Three crops of potato are grown each year, and potatoes can be seen in this region throughout the year. Many farmers raise two consecutive crops of potato in the same field, and it is possible to raise even three crops of potato in the same field in one year. This is a unique situation.

Most potatoes are grown as a winter crop between other crops like rice, wheat, maize, onion, jowar (Sorghum), berseem (Trifolium), and cucurbitaceous vegetables and fruits.

2.3 Utilisation

Potato is the most ubiquitous vegetable of the country. Small quantities are processed for use in snacks and breakfast foods. Though no accurate figures are available, this use probably does not exceed 5% of total production. In the last three years, there has been considerable interest in preparing processed potatoes for both internal use and exports (primarily potato chips, french fries and potato flour).

2.4 Projection to the Year 2000

Over the last quarter century, India's population has increased substantially and now stands at about 816 million. By the year 2000, total population is expected to reach one billion. As production and marketing methods have been improved, potato prices have fallen and consumption has increased from about 5 kg in 1970 to 10 kg annually at present. To maintain the present level of consumption per head, total potato production must expand by about 30%, to 14 million tonnes, by the year 2000. If per capita consumption is to continue increasing as it has in the past, total potato production must increase even more. Based on the past trends, we project that consumption by the year 2000 will average about 14 kg per head and total production will be about 20 million tonnes.

The National Commission on Agriculture set up by the Goverment of India has proposed that by 2000, the area under potato should be increased to 1.5 million hectares and yield to 20 t/ha giving a total production of 30 million tonnes annually. Increasing the area under potato will call for certain policy decisions and infrastructural development that do not come within the purview of CPRI. However, with the existing varieties and technologies, the team does not see any difficulty in achieving a national yield level of 20 t/ha.

2.5 Potato Research

Potato research in India is carried out by CPRI and regional stations located throughout the country. Since 1971 the research effort has been strengthened under the aegis of AICPIP; several agriculture universities also participate. The organisation, research priorities, and achievements of CPRI and AICPIP are summarised below.

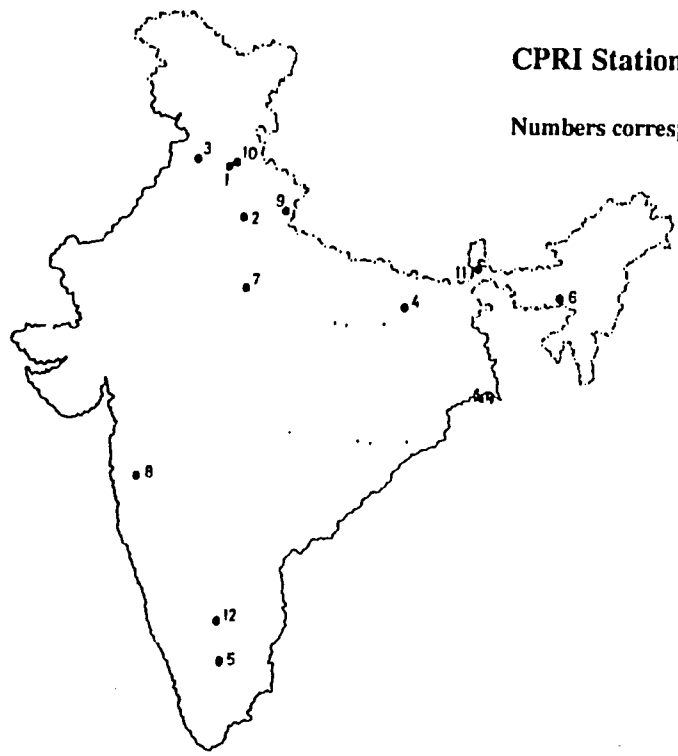
2.5.1 Central Potato Research Institute

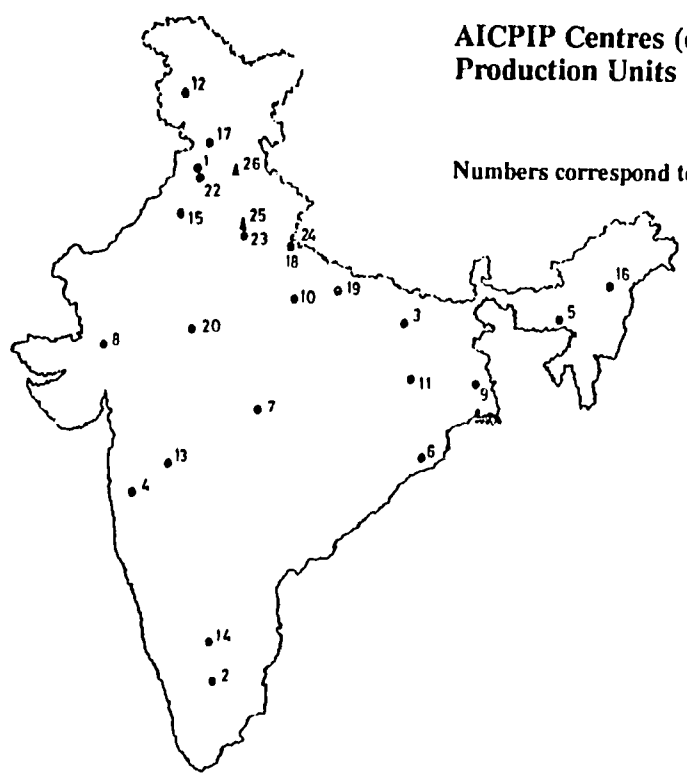
Organisation. CPRI was established under the Ministry of Agriculture and Irrigation, Government of India, in 1949 at Patna with three research stations at Kufri, Shimla and Bhowali. In 1956, the headquarters were shifted to Shimla in pursuance of the recommendations made by an expert committee. In 1966, the Institute was transferred to ICAR. At present, CPRI has 12 stations located in 10 states (Figure 2).

Mandate. The Charter of the Institute includes:

- Breeding and selection of high-yielding and disease-resistant cultivars suited to different agro-climatic conditions of the country
- Determining optimum cultivation practices in relation to the soil-cultivar-climate complex and investigations on problems connected with dormancy and storage

Figure 2. Location of CPRI stations, AICPIP centres, and seed production units





- Surveying, identifying, and investigating major potato diseases and pests and devising their control measures

- Building stocks of disease-free nucleus or breeders' seed for supply to seed corporations, State Agriculture/Horticulture Departments, and others for further multiplication and distribution to growers

- Training personnel in different aspects of potato cultivation and dissemination of new technology

Staff & Budget. The Institute's work is carried out in seven Divisions: Genetics (35 sanctioned scientists), Crop Physiology and Biochemistry (28), Crop and Soil Science (37), Plant Pathology (38), Entomology and Nematology (18), Seed Production (32), and Social Sciences (20).

The sanctioned manpower at headquarters and regional stations includes: 210 scientific, 200 technical, 55 auxiliary, 142 administrative, and 280 supporting staff. However, the number of positions filled at the end of 1987 was much smaller: 126 scientific, 93 technical, 45 auxiliary, 110 administrative and 223 supporting (Table A.4.1).

Achievements. The accomplishments of potato research in India can be conveniently summarised by decade.

From the mid-1940s to the mid-1950s: The Ministry of Agriculture and Irrigation established CPRI in 1949 at Patna. CPRI took over the breeding and seed production stations at Shimla, Kufri, and Bhowali from the IARI. Stations were set up at Jalandhar (Punjab), Ootacamund (Tamil Nadu), Rajgurunagar (Maharashtra), Babugarh, and Mukteswar (UP). The area under potato increased by an average annual rate of 2.8%, production increased by 1.7% and yield decreased by 1.1%.

From the mid-1950s to the mid-1960s: Stations were set up at Darjeeling (West Bengal) and Shillong (Meghalaya). Seven cultivars were released: Kufri Kisan, Kufri Kuber, Kufri Kumar, Kufri Kundan, Kufri Red, Kufri Safed, and Kufri Neela. The main potato-growing areas were surveyed to determine the status and build-up of aphid population. A technique was developed for producing healthy seed potatoes in the Indo-Gangetic plains, popularly known as "seed plot technique," it is now practised widely. Major potato-growing areas were surveyed to identify the major diseases and pests, and control measures were developed for them. A scientific seed production programme was initiated in 1966 involving the use of tuber indexing and serological techniques. Work was initiated to develop fertilizer and agronomic recommendations for the different zones of India. The area under potato increased by an annual compound growth rate of 4.4%, production by 6.6%, and yield by 2.1%. These growth rates exceeded the corresponding ones for wheat and rice.

From the mid-1960s to the mid-1970s: A station was established at Modipuram (UP) in lieu of Babugarh (UP). Thirteen cultivars were released, of which Kufri Chandramukhi, Kufri Sindhuri, and Kufri Jyoti became the most widely grown potato cultivars in the country. The crop registered an annual compound growth rate of 2.8% in area, 6.3% in production, and 3.5% in yield. In all these aspects, the gains registered by potato were more than those of wheat and rice.

Since the mid-1970s: CPRI stations were set up at Gwalior (MP), and Kodaikanal (Tamil Nadu). Five cultivars were released, the most recent being Kufri Swarna, which is the first cultivar released in a Third World country possessing combined resistance to cyst nematodes and late blight.

It was released for cultivation in the south Indian hills. In 1984, the research programme set new priorities, initiated research in certain frontier areas, and began modernising seed production techniques by introducing methods such as enzyme-linked immunosorbent assay (ELISA), micropropagation, and in-vitro tuberlet production. Eighteen priority programmes, including 10 thrust areas, were identified in 1987. The area under potatoes has increased on average by 2.2% per year, production by 4.4%, and yield by 2.2%.

2.5.2 All India Coordinated Potato Improvement Project

Organisation. AICPIP was initiated in 1971 to coordinate potato research under different agro-climatic conditions. The Project has its headquarters at CPRI, Shimla and operates at 21 centres that evaluate the performance of genotypes developed at CPRI under diverse agro-climatic situations. In addition, useful information relevant to potato growers is provided on various aspects of agronomy, pathology, and entomology.

Mandate. The AICPIP carries out research to increase potato productivity in the country as a whole. Its present research priorities are: to develop improved cultivars suitable for cultivation under different agro-climatic regimes of the country; to develop appropriate agronomic practices, determine optimum fertilizer requirements and identify profitable potato-based cropping systems; to develop suitable plant protection measures; to identify suitable areas for disease-free seed production; and to carry out post-harvest studies.

Staff & Budget. The Project Central Unit has five sanctioned posts for scientists and three for assistants. Of these, two scientific and one technical posts are filled. Each of the two seed preparation units has sanctioned posts for 4 scientists and 4 assistants; only one position in each category are presently filled (Table A.4.7).

The project budget, excluding ICAR-based centres, during recent Plan periods has been: Fourth Plan: Rs 1.6 million; Fifth Plan: Rs 5.0 million; Sixth Plan: Rs 7.7 million; Seventh Plan: Rs 10.1 million. Seventy five percent of this expenditure is borne by the ICAR; the remaining 25% is borne by participating universities.

Achievements. Some 20 research activities include studies on: germplasm evaluation for resistance to pests or diseases in "hot-spots"; selection of improved hybrids under hill and plains conditions; fertilizer needs of the potato crop; evaluation of potato-based crop rotations; intercropping with potato; inter-relation of seed rate, seed tuber size, and cut vs whole tubers; efficacy of different herbicides in controlling weeds; sulphur nutrition of potato; role of micronutrients applied through soil and foliage; agronomy of raising a potato crop through TPS; storage of potato in diffused light; survey for incidence and intensity of late blight, collection of isolates, and control; control of common scab; control of brown rot through cultural practices and crop rotations; rate of degeneration due to virus diseases in different potato varieties; surveillance of potato aphids and incidence of virus diseases; survey on intensity of potato tuber moth (PTM) and evaluation of efficacy of natural repellents; key pests of regional importance; and survey of plant parasitic nematodes associated with the potato crop. Recommendations have been developed for the control and management of important diseases and pests, and for growing potatoes in different ecological zones. Two Seed Preparation Units have been set up at Kufri and Modipuram for supplying seed of uniform quality to all AICPIP centres. Eight "Packages of Practices" have been brought out by the Institute in collaboration with AICPIP for growing potatoes in distinct zones.

2.6 Meeting Future Needs

Keeping in view the country's projected needs for potatoes in the year 2000, a well thought-out action plan is needed by ICAR and cooperating agricultural universities. The team has examined alternatives for expanding potato production. In view of the scarcity of cropland, priority clearly must be on increasing yields rather than expanding the seeded area. Needed are improved production technologies that are suited to the needs of small holders in marginal areas, and that reduce production costs per unit of output. Improved varieties, low-cost quality seed, and improved pest management and cultural practices are needed for many areas where yields are still low and unit production costs are high. Improved storage and processing are needed to reduce post-harvest losses and marketing costs, and to ensure delivery of quality potato products to consumers.

The research programmes of the Institute, their impact, and their future priorities have been evaluated. Findings are highlighted elsewhere in the report. Despite great progress over the years in production and distribution of quality seed, this input continues to be the costliest input in potato production. The limited supply and high cost of quality seed continues to be a major production constraint. Hence, application of modern seed technology and improvement in seed distribution systems could contribute significantly to potato improvement.

CPRI plays a strategic role in India's potato research and development, but its resources are limited. Success in future advances will require that CPRI tap the resources of other institutions both for research and for the dissemination of results.

3. RESEARCH ACHIEVEMENTS, IMPACT, AND FUTURE PRIORITIES

3.1 Introduction

This section and the next review the achievements, impact, and priorities of CPRI's divisions. CPRI's research divisions, projects, and staff are listed in Annex 6. Due to the importance of the Seed Production Division, both as an employer of Institute resources and as a source of impact at the farm level, this division is treated separately in Section 4. Although the Post-Harvest Division has been sanctioned, since it is not yet operational it has not been reviewed. Some post-harvest work is dealt with in the review of the Plant Physiology and Biochemistry Division.

3.2 Genetics and Plant Breeding

Breeding and seed production have been the focus of CPRI's successful potato improvement programme. Development of a seed system for the plains opened the way for use of new varieties which were adapted to the conditions of specific localities. The new varieties, in turn, raised farm yields, particularly in the irrigated northern plains of India. Nevertheless, some areas still have average yields of less than 10 t/ha. Meeting the needs of small farmers in marginal areas, who do not have access to cold storage and who cannot afford costly certified seed, still presents a significant challenge for breeders. An equally important challenge is to identify varieties that meet the requirements of the steadily growing processing industry.

Achievements. Since systematic potato research was established in India in 1935, a successful breeding programme has been developed. In the early days, emphasis was on collecting germplasm for direct introduction and to provide a base for future potato improvement. Today, the collection has grown to over 1800 accessions including varietal/parental tuberosa, andigena, and a number of wild and semi-cultivated species.

Another step leading to varietal improvement in India was development of the "Seed Plot Technique" which allowed varieties to be selected and multiplied under low-disease conditions in the plains. Breeding was focussed on developing varieties adapted to climatic and edaphic conditions in five major zones and five areas with special disease and pest stress problems. Through the efforts of ICAR, potato breeding now includes CPRI and the supporting AICPIP with 21 centres nationwide.

CPRI's collection includes accessions of 33 Solanum species with resistance to diseases and pests along with other desirable attributes. As a result of continued breeding and selection, 25 Kufri varieties have been released over the years (Annex 7). Eight promising hybrids possessing improved late blight resistance are now in AICPIP multilocational trials. A new hybrid, SE/I-1307, with superior late blight resistance has now been developed after 14 years of research. Another hybrid S5/C-562 possessing resistance to late blight and adaption to the conditions of the north eastern Indian hills, is soon to be released. The latest achievement is the release of Kufri Swarna, which is resistant to late blight and cyst nematodes. This variety was selected from more than 2000 genotypes. Already, three hybrids superior to Kufri Swarna are in advanced stages of evaluation.

Impact. At present, due largely to use of improved varieties and seed, India ranks fifth among the 106 potato growing countries of the world. Success is attributable largely to the release of Kufri varieties from a relatively low level, potato production in India has increased 300% in the last 20 years.

Strong emphasis on adaptability to specific climatic zones has encouraged farmers to invest in potatoes. Among the Kufri cultivars, Kufri Jyoti and Kufri Chandramukhi have been specially successful. Kufri Sindhuri has been released officially in Bangladesh and Nepal, and Kufri Chandramukhi is now a main variety in Afghanistan.

Future Priorities for Germplasm. About four-fifths of CPRI's tuberosa accessions have already been converned to in vitro storage. This priority activity should be continued with duplicates held at a second location. Use of descriptors developed by the International Board for Plant Genetic Resources (IBPGR), would facilitate computer management of the collection. A systematic purging of any in vitro accessions proven PSTV positive by the NASH test should also be an immediate priority. Assistance in this task could be provided by CIP. The pace of freeing accessions of viruses needs to be accelerated.

The maintemance of more than one accession of the same genotype is expensive and usually unnecessary. Identification of duplicate genotypes by polyacrylamide gel electrophoresis has been suggested. A more reliable identification of duplicate genotypes is by constriction enzyme analysis of deoxyribonucleid acid (DNA).

Future Priorities for Breeding Improved Cultivars. Improvement of varieties adapted to agroclimatic zones is the basic thrust of six current projects. CPRI breeders have defined broad varietal parameters required for four zones as well as three north India hill sub-zones and three special problem areas. In 1987, multilocation trials with 19 hybrids and varieties were conducted at 39 locations in six states covering three agro-climatic zones.

To alleviate the burdensome logistics of multilocation trials, a computer prediction model could be used to determine the optimum number and location of variety trials. Seven to 10 locations would appear to be adequate to evaluate climatic adaptability.

Incorporation of single-gene virus resistance prior to selection for potato leafroll virus (PLRV) resistance could be developed through a vigorous seedling screening programme which eliminates susceptibles at an initial stage. Similarly, seedlings from parental lines free of "major genes" could be screened en masse for generalised field resistance to late blight. Combinations of resistances might then be screened in controlled environment chambers mimicking climatic conditions prevailing in specific zones. Conversely, in the short run, TPS of resistant lines could be sent for selection to the 10 agro-climatic zones, subzones, and special problem areas.

Future Priorities for True Potato Seed (TPS). A major problem associated with TPS is the availability of seed. One approach would be to locate a site which favors flowering and berry production under natural conditions. Selection of parental lines which ensure homogenity of offspring is essential. Inherent in the heterozygosity of TPS is genetic variation which might enhance resistance to diseases and pests. Because TPS can be stored for a number of years with little reduction in germinability, TPS could provide an emergency seed source for Indian potato production provided basic production technology has been sorted out beforehand. Recently, the Weizmann Institute in Israel has succeeded in confering male sterility in female parents eliminating the need for field emasculation. Hand emasculation in the field has already been used in quantity production of TPS in areas with abundant labor. It is envisaged that production of TPS on commercial scale will be undertaken by public or private-sector seed companies.

Future Priorities for In Vitro Techniques. CPRI has already assessed the value of in vitro technology and is using the methodology in the preservation of germplasm, in vitro tuberisation, virus elimination, and rapid multiplication. The high failure rate in another culture activity is probably

associated with genes-controlling "tissue culturability." CIP has several hundred pollen-derived plantlets available from a range of potato genotypes.

Despite the general practical usefulness of in vitro technology, there is a need to further exploit the methodology in breeding. This requires knowledge and equipment to synthesise artificial nucleotide sequences and to insert synthetic sequences into potato genomes. Such modified genotypes are directly useful in normal breeding procedures.

It is strongly urged that research be undertaken to improve potatoes through a genetic engineering approach. Coordination might be through tissue culture specialists, physiologists, biochemists, and their counterparts at the Biotech Institute. The transfer of pest, virus, and bacterial resistance as well as viroid inhibition is being examined at CIP.

Future Priorities for Processing Varieties. Potato processing is a growth industry. In order to tap the potential, varieties must meet processor's requirements for dry matter, reducing sugars, size, shape, and storage properties. Some work has been done in India to understand processors' requirements and assess the quality of existing varieties, but little has been done to breed new varieties for processing. These areas merit greater attention in the future.

3.3 Plant Physiology and Biochemistry

The inception of a Plant Physiology Unit in 1954 and the addition of a of biochemistry post in 1964 were followed by the creation of a combined Crop Physiology and Biochemistry Division in 1978. Current research priorities include: photosynthesis and crop productivity, storage physiology, and biochemistry; heat tolerance; post-harvest technology; and, studies on potato root systems.

Achievements. Significant advances have been made in: breaking and regulating tuber dormancy; studying cultivar response to day length; studying inter-relationship between dry matter, specific gravity, and sugar-accumulation in stored potatoes; identification of processing cultivars; technique for storing ware and seed potatoes; effects of fertilizer on quality; screening for heat tolerance; and, photosynthesis in potato.

Impact. It is difficult to directly assess impact in terms of practical farmer benefit from basic physiological and biochemical research. The impact is indirect as supporting of other areas of CPRI research. It is felt that closer interaction between the Division and CIP could be of mutual benefit, particularly in the areas of passive cooling r . ware potato storages, drought stress, and heat stress.

Future Priorities. The Division has clearly defined its priorities. Collaborative research with the Genetics and Plant Breeding Division is underway in the application of photosynthetic measurements in the development of high yielding lines. Short term priorities include a study of the relationship between photosynthesic capacity and productivity, carbohydrate interconversions in stored tubers, heat resistance in potato, and, potato micro-ecology. In the longer term, to the year 2000, emphasis will be on seed physiology, nitrogen uptake and metabolism, crop modeling and simulation, and, carbohydrate translocation and tuberisation.

3.4 Crop and Soil Science

The Division of Crop and Soil Science, which began functioning in 1972, currently includes agronomists, soil scientists, and agricultural engineers. Previously, biochemists, economists, statisticians and extension specialists were also included.

Achievements. A substantial body of practically oriented agronomic research has been conducted on the dosage, placement, form, timing, yield responses, residual effects, and interactions of nitrogen-, phosphorus-, and potassium-bearing fertilizers. The effects on yield of farm yard manure and green manure crops have also been studied. The result is a series of fertilizer recommendations for India's diverse potato-growing zones. Work on micronutrients has been initiated.

The fertilizer requirements of potato-based cropping systems continue to be examined in the plains of Jalandhar, Patna, and Rajgurunagar and in the hills at Shimla and Shillong, as well as under AICPIP.

Management practices have been identified that maximise yields and minimise the wastage of irrigation water and the leaching of nutrients in the plains, where nearly 90% of the potato crop is grown.

Recommendations have been developed for control of the principal weeds through manual weeding and the use of herbicides. Evaluation of new herbicides for major production zones in the hills and plains is a continuing activity. The effects on yield of different planting dates, seed size, and spacing have been studied, and recommendations have been developed for different varieties and production zones. Guidelines have also been drawn up for management of cold-stored seed and for use of cut-seed tubers. Experiments at Patna and Rajgurunagar have shown that potatoes can be grown beneficially as multiple-crops or intercrops with wheat and sugarcane.

A few farm implements, including an automatic potato planter, have been designed. Some implements have been manufactured by private firms with some design modifications.

Impact. The Division has contributed significantly over the years to the development of sound agronomic practices that have helped farmers capitalise on the yield potential of improved varieties and seed. Through widespread adoption of improved management practices, farmers increase their yields and income significantly.

Future Priorities. The division's work has been sound and practically oriented. However, present research activities differ little from activities that have already been undertaken for several years. During discussions, the following were identified as high-priority areas for future work:

- selection of potential new cultivars under low fertility conditions
- use of bio-fertilizers, including mycorrhiza
- development of appropriate agronomic management practices including irrigation, for modern potato production systems

The review panel noted with some concern that virtually all agronomic research is being conducted on research stations and that little economic analysis is used to derive farmer recommendations from experimental results. Most research on fertilization and agronomy of ware potato production should be on representative farms. Moreover, the aim should be to determine recommendations for potato-based cropping systems, not for the potato crop in isolation. Some basic research on soil physics and fertility and nutrient utilisation could also be undertaken.

It is recognised that expanding on-farm research would require more funds for travel, per diems, and field assistants. However, it is felt that these expenditures would generate a high return in terms of better adapted technologies.

The Division should focus on innovative research and on the development of methods that can be used by other institutions, e.g., the state agricultural universities, for conducting location-specific research and for developing recommendations for farmers. Economic analysis and farmer participation should be encouraged to ensure that recommendations meet farmers' needs and will be widely adopted.

The comparative advantage of the Division in designing new farm implements is questionable. Before proceeding further in this area, the practical value and utilisation of equipment already developed should be evaluated.

3.5 Plant Pathology

At present, 36 scientists are assigned to 10 locations. Ten of the scientists are in Shimla. Of 31 activities listed by the Division, 13 are concerned with bacteria, 9 with fungi, 7 with viruses and 2 with mycoplasma-like organisms (MLOs).

Achievements. The late blight pathogen, Phytophthora infestans was found to survive in a latent form in tubers in cold stores. A late blight forecasting system has been developed to warn farmers in the Shimla hills through All India Radio. Although 84 races of P.infestans have been recorded, non-race specific resistance was best in Kufri Badshah and Kufri Jyoti.

A total of 11 tuber-borne fungal pathogens have been identified. A practical control consisting of submerging tubers for 30 minutes in 3% boric acid has been widely tested. A two to three year rotation for field control of soil borne inoculum was reported. Specific measures for control of charcoal rot and leaf spot diseases have been devised.

Eight publications on bacterial wilt caused by Pseudomonas solanacearum attest to the efforts to control this serious disease. Of practical interest, it was found that the bacteria do not survive at an altitude above 2000 m. The longevity of the pathogen in soil, its invasion of tubers through lenticels, its symptomless survival in carrier weeds in the field, the use of chemical control measures, and rotation crops have been identified. Five reports dealt with incidental bacteria of which soft rot forms are of significant importance.

Achievements relating to viruses are concerned primarily with their identification by antisera, immunosorbent electron microscopy (ISEM) and ELISA. Methods were developed to eliminate viruses from germplasm by chemo-and thermo-therapy, and viral degeneration was noted specially in the variety Kufri Jyoti. Indexing of 16,000 tubers for the production of breeders' seed and serological testing of all stages in seed production annually are valuable contributions. Vectors of diseases caused by MLOs were identified, as were associations of mycoplasmas with purple top, witches broom, hairy sprout, and several other diseases.

Impact. The recommendation to harvest potatoes before soil temperatures reach 28-30°C is a simple, environmentally sound approach to control charcoal rot. The influence of temperature as a control factor is evident in the suppression of bacterial wilt above 2000 m. The bacteria do not survive where the mean monthly temperature remains above 40°C and the soil receives no water for at least 45 days.

The success of any seed potato program depends upon the health of the seed. Indexing tubers for breeders' seed production by ELISA and ISEM, and test by serology at all stages in seed production is essential for ensuring a healthy crop. The control of degenerative viruses and other tuber diseases is essential for the success of the seed program.

The detection of economically important organisms in material in quarantine secures the borders of a country to many unwanted diseases. The identification of new pathogens in routine screening in the field often prevents more serious problems that could result from uncontrolled spread of, e.g., potato wart. Testing of seedling progenies of new crosses assists the breeder in his selection of disease-resistant parental lines. The wart-immune, blight-resistant Kufri Jyoti variety has had a substantial impact on Indian potato production.

Future Priorities. During the past 40 years, pathologists have catalogued races of the late blight fungus, Phytophthora infestans, seeking major gene resistance. CPRI pathologists have recorded over 80 races of the fungus. But each new host resistance gene has been overcome by the pathogen, which appears to have infinite variation.

Another approach to late blight resistance does not rely on cataloguing fungal races. Field resistance, or so called minor gene or horizontal resistance, may not be absolute resistance, but it is sustainable and allows good yields in spite of a few blight lesions.

Solanum demissium genes in tuberosum material have given rise to major gene resistance in most breeding lines. Breeders should abandon parental tuberosum X demissum crosses despite useful characteristics including low levels of horizontal blight resistance. After more than 40 years of failure with major gene resistance, it is time for a new direction in breeding for late blight resistance.

After late blight, the next most important disease is bacterial wilt. It is urged that the study of the ecology of the causal bacterium as well as epidemiology of the wilt disease be given priority over a number of less important pathogens.

The potato spindle tuber disease, so named bacause of the shape of tubers of plants infected with the causal viroid, is a very serious disease of potatoes. Referred to as PSTV, the pathogen differs from a virus in the lack of a protein sheath. Viroids also differ from viruses in that they cannot be detected by serology, cannot be eliminated by meristem culture, and they pass freely into both tuber and true seed. While preparations can be made to view PSTV with the electron microscope, this is not a practical approach to identification. The NASH test, which can detect PSTV at the picogram (trillionth of a gram) level, is useful for identification of the viroid. Because of the difficulty of preparing the radioactive-labelled complementary nucleic acid template material, the method adopted is to spot up to 100 spamples of sap from test plants onto a membrane. The membrane is then sent to a laboratory (e.g. CIP) which can assess the sap samples and indicate those plants infected with PSTV. It is essential to test a wide spectrum of parental lines as well as in vitro germplasm accessions, since PSTV is readily transferred mechanically in the field.

About 30 virus diseases are of varying importance in different potato-growing areas. Combinations of potato virus X (PVX), potato virus Y (PVY) and PLRV are commonly encountered. With the recent knowledge that PLRV resistance can be broken by subsequent infection by PVX or PVY, it is essential to develop combined resistance to PVX and PVY before incorporating PLRV resistance. Since PVX and PVY resistance are inherited simply (i.e., single gene resistance) an early start in breeding for PVX and PVY resistance is encouraged.

3.6 Entomology and Nematology

Entomological research was initiated at CPRI in 1949. Since then, entomologists have surveyed pest incidence in major potato growing areas, tested chemical control measures, and searched for alternative means of controlling insects and nematodes.

Achievements. Early insect surveys established the presence of aphids, leaf hoppers, cutworms, and defoliating caterpillars in all potato-growing areas. Potato tuber moths were found to be confined to five states while Epilachna beetles, white grubs and Myllocerus weevils were found to be more serious in the hills.

Aphids are significant vectors of virus pathogens. The population dynamics of five aphids have been studied under different agro-climatic conditions. This knowledge makes it possible to raise potatoes free from virus diseases in the plains during low aphid population periods. Similarly, leaf hoppers are vectors of mycoplasmas and also cause direct damage by sucking sap from the leaves. Both aphids and leaf hoppers may be controlled in commercial crops by direct application of systemic insecticides.

Five species of cutworms and two species of white grubs have been identified as economically important pests. Occurring in the eastern and western Indo-Gangetic plains at different times, cutworms are controlled by drenching foliage and soil with chlorpyrifos (Dursban, Larsban). White grubs render tubers unfit for marketing by gauging deep circular holes. Insecticide application at hilling has been found effective in controlling them.

Two species of Epilachna beetles, four species of leaf-eating caterpillars, broad mites, and Myllocerus weevil are frequent pests for which specific chemical controls have been developed. The potato tuber moth, Phthorimaea operculella, is the most destructive pest of the potato in tropical regions. It is a serious pest in the states of Maharashtra, Meghalaya, Himachal Pradesh, Karnataka, and southern Madhya Pradesh. Considerable biometric information has been gathered to aid in its control. Insecticides have been found effective in the field. Dried leaves of Lantana and Eucalyptus layered over tubers in farmers' stores provide an effective barrier to PTM invasion of stored tubers. Five exotic species of parasites were reared and released in fields at the Central Potato Research Station (CPRS), Rajgurunagar. Although verified in the field after release, the parasites did not become established.

The occurrence of root-knot nematodes was first recorded from Shimla in 1951. Three species of the root-knot nematode which attack potatoes have been identified as Meloidogyne incognita, M. hapla and M. Javanica. Now found in ten states, these pests originally from South America caused damage which reduces both crop yield and quality. Through crop rotation with cereals and by soil application of nematicides, suitable practical control can be achieved.

Two species of cyst nematodes, Globodera pallida and G. rostochiensis are found in the hills of Tamil Nadu. They cause stunted growth and inhibit nutrient utilisation by the host. Control is through long-term rotation involving cereals and legumes and by the application of nematicides.

Impact. Chemical controls have been developed for all the major species of insect pests of the potato in India. This does not always imply complete or even adequate control. Control may be hampered by poor timing of application, stage of insect development, and also by the gradual build-up of insect resistance to specific chemicals. Nevertheless, a basic control programme is available.

Several approaches to biological control have been tried. While the repellency of Lantana and Eucalyptus leaves is an effective barrier to PTM invasion of stored potatoes, early attempt at field

control by parasitic insects was unsuccessful. Timing of planting and harvesting to avoid high aphid populations has been successful in reducing the incidence of virus disease spread by aphids.

It is questionable whether sufficient control of movement of nematode-infested tubers can be exercised to prevent further spread of these destructive pests. At present some control of both root-knot and cyst nematodes can be achieved through crop rotation. Both pests are also controlled by application of Aldicarb (Temik) or Carbofuran (Furadan). The variety Kufri Swarna is reported to be resistant to Globodera nematodes.

Future Priorities. Chemical control of insect pests is often successful in the short run, but due to the build-up of resistance, it is frequently necessary to change the insecticides. It is common for multiple resistance to occur in insects over the long run.

The modern approach is to develop an Integrated Pest Management (IPM) programme, hopefully to minimise the use of insecticides. While IPM may be successful, in theory and even under experimental field conditions, it often entails a complex programme based on biometric data that are not available to a small farmer. Despite the drawbacks of IPM, every attempt should be made to reduce the use of costly and often persistent insecticides. Insecticide trials and assessment of crop losses, population dynamics, and spread of pests, may be greatly aided by appropriate computer facilities and programmes.

Both root knot and cyst nematodes are serious pests, and their spread is usually controlled by quarantine in the international seed trade. Within India, a concerted effort should be made to control spread of nematodes by seed tubers. A more thorough research program to control nematodes is urged.

3.7 Social Sciences

The Division of Social Sciences was created in 1986. For this reason, the following sections refer primarily to the work of statisticians, agricultural economists, and extension specialists who worked previously in other divisions.

Achievements. Although agricultural statisticians were originally brought in to provide statistical support to projects in the research divisions, they have conducted original research on experimental design and on methods to forecaste yields and estimate yield reductions caused by insects and diseases. A method for forecasting potato prices is being developed. Research results were documented in a series of publications from 1965 to 1983, no statistical publications have been issued since then (Annex 9).

Extension specialists have contributed significantly to the diffusion of the Institute's research results, by editing numerous research and extension bulletins and by conducting demonstrations at the farm level. Since the mid-1970's, they have been directly involved with the transfer of technology within the framework of three India-wide programmes titled: "Lab to Land," "Operational Research," and "Tribal Development." Early work in these programmes centered on demonstration of recommended technologies in farmers' fields and on-the-spot guidance by scientists. Recently a research component has been added to determine the levels of farmer adoption; work has also been inititated to determine the causes of persistent low yields in Bihar and Himachal Pradesh.

The incidence of brown rot disease and potato tuber moth, and their management by farmers are being examined. The feasibility of farm- level TPS tuberlet production is now being studied. In a study of small-farm decision-making, the role of women was found to be specially important in post-

harvest operations and marketing. This information is useful information for planning and implementing extension programmes.

Extension specialists have contributed to human resource development in India and other South Asian countries by organising three annual CPRI courses: one on modern methods of potato production, and the other two on seed production and certification. Since 1986, numerous extension bulletins have been published on recommended practices for table and seed potato production in India's principal growing regions.

Research in agricultural economics, initiated in 1977, has included studies of production practices, costs, and yields of local and improved cultivars in Farrukhabad district of Uttar Pradesh; the production and marketing of seed potatoes in Himachal Pradesh; compilation of country-wide statistics on potato production, area, and yields; and the impact of a project in Bihar and Himachal Pradesh. When economics was part of the Division of Crop and Soil Sciences, it contributed to the establishment of recommendations for fertiliser and agronomic practices. The results of economics research are now being published.

Impact. The main functions of the Division of Social Sciences are to provide: socio-economic information and analysis that is directly useful in guiding the Institute's priorities; statistical support in design, analysis, and evaluation of research experiments and surveys; and training and communication support to ensure adequate diffusion of the Institute's research results.

The Division's main impact on potato production is achieved through partnerships with the Institute's biological research scientists and extension specialists who benefit from CPRI's training and communications programmes.

Concerning agricultural statistics (biometrics), the Institute's needs appear to have been adequately met until around 1980. However, since that time, there has been relatively little innovative work, particularly in relation to computerised statistical analysis.

The Division is to be congratulated for its numerous recent publications on extension and for the experimentation with diffusion of technical information from scientists to farmers via radio programmes. The usefulness and impact of CPRI's extension bulletins could probably be enhanced if they were more solidly grounded in the Institute's research results, and if they were more detailed and thought provoking. CPRI should consider the principal audience for its bulletins to be researchers, educators, and extension agents in agricultural support institutions, not farmers.

Future Priorities. The Review Panel commends CPRI management for creating the Division of Social Sciences and supports the increasing emphasis placed on socioeconomic research, vis a vis public relations and transfer of technology.

The Panel is concerned about the multiple responsibilities of the Social Science Division, relative to its resources. The Division has broad responsibilities for socioeconomic research, providing statistical support for other divisions, organising training courses, transfering technology, and handling public relations. It has enthusiastic leadership and has started a number of promising activities. However, its staffing and resources are limited. To ensure the Division's viability and a high contribution to CPRI's programmes, its role within CPRI needs to be clarified, its focus sharpened, and its disciplinary composition reconsidered. Clear priorities need to be established and viable implementation strategies worked out.

The Review Panel believes that, to the extent feasible, the Division should focus on three complementary areas: socioeconomic research, training, and communications. Management should

consider transferring responsibility for agricultural statistics to a "Support Division" which would serve research throughout CPRI.

Research should be structured around a few central themes, in which the Division establishes itself as a center of excellence within India and internationally. Such themes could be:

- Constraints to potato production and use
- Strategies for disseminating information on potatoes
- Impact of potato programmes

Social scientists should also become involve in the Institute's principal research thrusts, like breeding new varieties and seed production and distribution.

In order to meet the country's needs for training and communications as well as for socio-economic research, it is imperative that the number of sanctioned positions in the social sciences be increased, and that vacant posts be quickly filled with highly qualified individuals. Priority should be on recruiting a senior economist and a senior statistician. It may be desirable to include other social science disciplines like anthropology, rural sociology, and home economics.

The Division should establish and maintain contacts with social scientists in key universities and research institutes throughout the country and abroad. By so doing, it could better keep abreast of advances in applied social sciences and also stimulate useful research and training in other institutions.

Fieldwork, including off-station surveys and experiments, and analysis of large data sets are essential ingredients of social science research. Unfortunately, resources for them are scarce within the ICAR system. The Review Panel believes that additional resources for fieldwork and data processing could significantly inhance the contribution of the Social Sciences Division to the Institute's overall programme.

3.8 Conclusions

Since its inception in 1949, CPRI has come up of age, growing in headquarters and regional station facilities. Research programmes have evolved, with breeding and seed production the two most significant activities. As a result, while India used to import seed potatoes, it now has 25 of its own varieties, adapted to different regions of the country, and produces its own seed. The Institute has also made significant strides in acquiring and evaluating germplasm from abroad.

The Crop and Soil Sciences Division has developed fertiliser recommendations for various agro-climatic regions. Through sustained efforts of CPRI nematologists, nematode-resistant varieties have been developed. The Social Sciences Division, a new concept in the Institute, has introduced several innovative programmes adequately justifying its establishment.

But many goals are still distant. The gap between present production and future needs beyond the year 2000 calls for aggressive potato research, both for commercial and subsistence farming. It calls for an all-out effort on seed production and distribution, and for potato-based cropping systems research. TPS might be the answer for remote areas where quality seed tubers are unavailable or too costly for small farmers.

More than ever before, an inter-disciplinary approach has become necessary. Interaction between disciplines needs to be stressed by the Institute in developing future research projects. The time has arrived when CPRI must shed some projects and involve Agricultural Universities in tackling

region-specific problems. Although the Institute has reasonably good facilities, other facilities could still be added.

The panel noted the inadequacy of staffing and laboratory facilities at the regional stations. The panel feels that a viable regional station with reasonable facilities and a full complement of staff capable of tackling research problems are needed to give confidence to growers in a region.

4. SEED PRODUCTION

4.1 Introduction

The change from traditional seed production in the hills to modern seed production in the plains is one of the greatest breakthroughs in potato production in India. As a result, seed production has become decentralised and there are now two independent seed channels with most emphasis on production in the plains.

Development of the "seed plot technique" for multiplying seed in the plains during periods of low aphid population, has revolutionised potato production in India. Beginning in 1965, there has been a steady expansion of the area and yield of potatoes in the plains, where more than 90% of the country's potatoes are now grown.

4.2 Achievements

Production of breeder's seed has been one of the major activities of CPRI and is currently estimated to involve the largest share of the Institute's resources.

The Seed Production Division maintains two independent seed systems, one in the hills and one in the plains. In the hills, most breeders' seed is produced in Kufri and Fagu at an altitude of more than 2,300 m. Seed is also produced at Mukteswar, Shillong and Ooty hill stations for distribution in their respective states. It cannot be supplied to other states due to disease and quarantine restrictions (Annex 8).

Most of the breeders' seed is produced in the northern plains at the Modipuram, Jalandhar, Gwalior and Patna research stations. Aphid-transmitted virus diseases are not a problem in the cool, moist climates of the high hills. Bacterial wilt is also absent in Kufri and Fagu.

In the breeder's seed programme, indexed tubers of improved varieties are multiplied four times in the field. In stage I, individual plants are tested serologically for PVX and PVS and are inspected visually for PVY and PLRV. In stage II, tubers harvested from each healthy stage I plant are planted in a unit row. If any plant in the row is found to have virus symptoms, the entire row is discarded. In stages III and IV, plants with virus symptoms are eliminated based largely on field inspection. Some serological testing is also done.

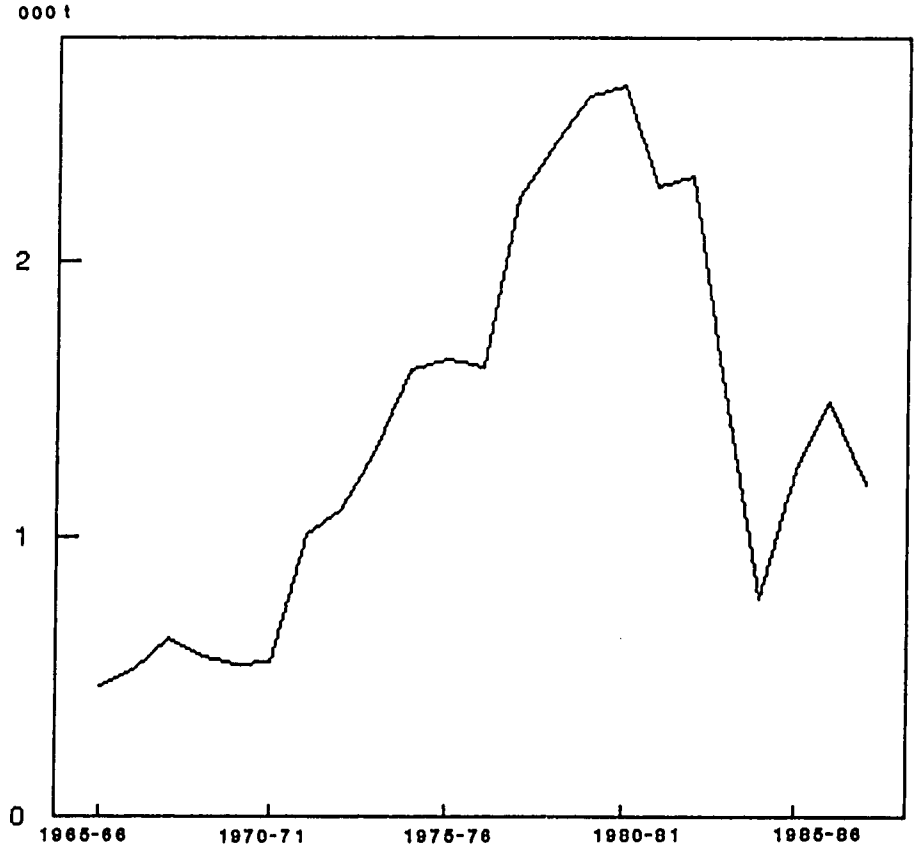
In the plains, planting and harvesting are scheduled to minimise exposure to aphids and reduce transmission of PVY and PLRV. Important elements of the system include starting with pathogen-tested (indexed) stocks, rouging before aphids appear in the crop, cutting haulms before aphid populations reach critical levels and checking regrowth. Aphid dynamic studies have shown that Myzus persicae, the principal insect vector, is practically absent from October to December. The seed-producing aras are also free from potentially devastating soil-borne diseases like brown rot and from serious insect pests like the potato tuber moth.

Of the 25 improved Kufri varieties, CPRI is currently producing sizeable amounts of breeders' seed for six: Kufri Chandramukhi, Kufri Badshah, Kufri Bahar, Kufri Sindhuri and Kufri Lalima for the plains and Kufri Jyoti for both hills and plains. (Table A.8.2).

About three-quarters of the breeders' seed is supplied to state governments for further multiplication and production of foundation seed on state government farms (Table A.8.3). Until the mid 1980's a sizeable amount went to the National Seeds Corporation for multiplication by contract seed growers; since then the quantity has declined. The goal is for breeders' seed to be multiplied twice to produce foundation seed and once more to produce certified seed to supply to private growers. However, breeder's seed is usually multiplied less than twice before going to private farmers.

From an initial volume of 460 t in 1965/66, the supply of breeders' seed increased to a maximum of 2,600 t around 1980. Since then, it has declined to an average of 1,300 t from 1985 to 1988 (Figure 3, Table A.8.4).

Figure 3. Amount of breeders' seed distributed in India 1965/66-1987/88



Assuming that breeders' seed is multiplied twice at a rate of eight to one, the annual production of 1,300 t of breeders' seed would result in 104,000 t of certified seed available for planting in 1991/92. At a conservatively estimated seed rate of 2 t/ha, this represents less than 10% of the seed currently planted.

The Seed Production Division differs from the other Divisions in two respects. First, while other Divisions have a clear research mission, the Seed Division has a dual mission: research and seed production. Second, the headquarters staff are drawn from other Divisions on a part-time basis. Whereas initially the Seed Production Division had strong leadership, a clear identity, and a highly

committed staff, this has eroded over time. The Review Panel believes that this may limit the effectiveness and impact of the seed program.

The system for producing quality breeders' seed is sometimes referred to as "foolproof." However, this is not the case. In 1985, glasshouse tests of nuclear stocks showed that 29.4% of the samples of Kufri Chandramukhi from Fagu were infected with PVX. In Patna in 1986, 19.6% and 6.5% of stage I and stage II samples, respectively, were found to be PVX- and PVS-infected. The same year, in Patna 18% and 12% of plants in stages III and IV, respectively, showed mild mosaic symptom. In 1983, government farms in three states refused to accept breeders' seed from CPRI because of problems with soil-borne diseases. Clearly, visual inspection in the field for virus infection is inadequate to ensure quality seed.

4.3 Impact

As noted at the beginning of this section, the seed plot technique and the seed programme have had a significant impact both on the area sown and on yield of potatoes in India. In combination with the release of improved varieties, seed multiplication is the primary vehicle through which CPRI has achieved an impact at the farm level.

The seed programme is not, however, without its limitations. Most breeders' seed is being distributed to six state governments in areas of primary seed production: Uttar Pradesh, Himachal Pradesh, Madhya Pradesh, Bihar, Haryana and Punjab. A present concern is how to improve the distribution of seed to other states so that a greater number of growers can benefit from the breeding and seed programmes of CPRI.

4.4 Priorities and Options

The priorities of the Seed Production Division are:

- Expand production of quality seed
- Collaborate with State Agricultural Universities to expand the capacity to produce breeders' seed
- Utilise in vitro and rapid multiplication techniques to reduce field multiplication
- Establish more effective virus testing facilities at all stations where breeders' seed is multiplied.

In general, the Review Panel concurs with these priorities. There is an apparent need to expand quality seed production, to devolve responsibility for production of breeders' seed, to modernise seed production, and to upgrade virus testing. In order to highlight some of the issues involved and the options available to researchers and policy makers, future priorities will be discussed under the following headings:

- Volume of breeders' seed
- Seed research vs seed production
- Role of CPRI and other institutions.

4.5 Volume of Breeders' Seed

In India, the breeder of a new variety is responsible for supplying each year a small amount of seed, true-to-variety and disease-free for further multiplication. This concept, originally developed for the cereals, is also applied to potatoes. At present, the harvest of the fourth multiplication stage on CPRI stations is defined as breeders' seed. Over the last decade, the amount supplied has ranged from 780 t to more than 2,600 t. Producing this amount of quality seed represents a substantial burden to CPRI in terms of the personnel, facilities, and financial resources needed for large-scale field multiplication and inspection, laboratory testing, storage, handling, and distribution. While breeders' seed is the most tangible product of CPRI's research, its production may distract from the Institute's central research mission.

The burdensome aspect of supplying breeders' seed stems from the number of multiplications and the quantity of tubers involved, currently about 1,300 t annually. Two options available for reducing the burden on CPRI would be to limit the number of multiplications or the total volume produced.

4.6 Seed Research vs Seed Production

CPRI must play two distinct roles to meet the country's needs for seed potatoes: conduct research needed to improve seed technology, and produce more breeders' seed. These roles imply two distinct processes which require different personnel, approaches, and facilities, and have different outputs: information in the first case, quality seed in the second.

The Review Panel believes that CPRI's overall effectiveness could be improved if seed work was concentrated in a single Seed Production Division with two distinct, but closely related, units: a Seed Research Unit and a Seed Production Unit. The Head of the Division should be a senior (S-4 or S-5) researcher. The Seed Research Unit should be staffed by a core of scientists including a virologist, a general pathologist, an entomologist, and a tissue culture specialist. The Seed Production Unit should be staffed primarily by well-qualified and well-trained technicians.

4.7 Roles of CPRI and other Institutions

At present, CPRI conducts research on seed, produces breeders' seed, participates in the inspection and quality control for foundation seed, and provides training and encouragement for other public institutions and private firms to multiply quality seed. While the Review Panel feels that these roles are appropriate, CPRI should emphasise seed research and training and de-emphasise direct involvement in production and inspection. In this regard, the Panel would not recommend the purchase of additional farmland or significant investments in facilities for field multiplication.

To date, all breeders' seed has been produced by CPRI and most of this has been supplied to state government farms for further multiplication. A significant proportion has also gone to NSC. At present, state agricultural universities are being encouraged to participate in the production of breeders' seed. Based on experience in other countries, as well as the recent Indo-US review of the agricultural universities, the Review Panel doubts that the universities can be counted on to develop a strong role in seed multiplication. The comparative advantage of the agricultural universities is in teaching and research, not in seed production and distribution, which requires well organised field operations, technical expertise, and financial management.

The NSC and state government farms have played key roles in the production of foundation seed. Recently, however, some questions have arisen concerning their effectiveness. Quality control appears to be slipping.

The Review Panel did not had the opportunity to interact directly with current representatives of the NSC and state governments, or to discuss this issue with private farmers. However, based on local observations and on experience in other countries (both developed and developing), the Panel believes that the private sector could be encouraged to play a larger role in production and marketing of quality seed potatoes.

5. LINKAGES

CPRI's overall goal is to remove the principal constraints in potato production and utilisation in India. To achieve this goal, CPRI must work with, and through, many other institutions in India and abroad.

5.1 International Linkages

On a global basis, potato is one of the world's leading food crops, occupying fourth place in importance after rice, wheat, and maize. In Europe and North America, where potato is a major staple food, potato research has received considerable attention for many years. In view of the potato's growing importance in developing countries, CIP was established in 1972 with headquarters in Peru, the center of origin of the potato. Gradually many countries of Latin America, Asia, and Africa are developing centres of potato research expertise.

In this context, CPRI can benefit from linkages with CIP, with Europe and North America, and with institutions in developing countries. All would benefit from an improved exchange of information and genetic materials.

5.1.1 International Potato Centre

A Memorandum of Agreement for scientific and technical cooperation for potato improvement was signed on 17 November, 1976. An amendment, dated 2 December 1987, now includes sweet potato. On 15 May 1987 the first work plan for collaborative research was developed for 1988 and 1989; it includes the following priorities:

- Evaluation of potato germplasm for resistance and tolerance to biotic and abiotic stresses
- Research on potato production from TPS
- Adaptation of the potato to warm environments
- Research on post-harvest technology with emphasis on potato storage and processing.

During 1988 and 1989, ICAR/CIP are to organise two general production courses and five advanced training courses. CIP is to supply CPRI with pathogen-free germplasm; in turn, CPRI will make germplasm and breeding lines available for CIP's use and distribution. Five joint workshops are planned:

- Processing and marketing of processed potato products. April 1988
- True Potato Seed. January 1989
- Seed and ware potato storage. May, 1989
- Potato marketing. September 1989
- Potato in warm and humid tropics. December 1989

CIP has been involved with CPRI since 1986, in research on TPS at CPRS, Modipuram. CIP collaborates with AICPIP in testing advance hybrid TPS populations in multilocation trials and in perfecting the TPS technology for potato production. Results of the last three years' trials clearly support the view that TPS technology is a viable alternative for potato production under Indian agro-climatic conditions; that three of the hybrid TPS populations gave equal or higher yields than local varieties. A limited number of on-farm trials conducted during 1987-88 season in the plains have confirmed the results of trials at AICPIP centres.

CPRI is conducting independent research on TPS at CPRS, Patna. The Review Panel feels that closer collaboration between CIP and CPRI could improve the effectiveness of TPS research, and that consolidation of results would give a boost to TPS technology for on-farm adoption. Collaboration would also help in perfecting the technology for commercial production of hybrid TPS and for working out the economics of TPS production.

As stated earlier, the major problem associated with TPS is the availability of seed. ICAR should encourage public or private sector seed companies to produce hybrid TPS commercially.

The Review Panel has gone through the TPS research plans of CIP's Region VI office and feels that the following components could form the basis of a joint CPRI/CIP research project from 1988-89 for the next three years:

- Breeding for the selection of female parental lines from the Tuberosum group and male lines from the Andigena group, keeping blooming/berry set under short days and field tolerance to late blight as the basic features

- Using the top-cross method for testing general combining abilities

- Evaluating selected parental lines for specific combining ability and TPS characteristics, and carrying out preliminary assessment of yield, foliage, and tuber uniformity of progenies

- Producing 50 to 100 g of selected TPS hybrid combinations for conducting AICPIP trials using transplanting and seedling tubers for raising a commercial potato crop

- Conducting yield trials up to the third or fourth generation for assessing yield losses during subsequent tuber generations.

- Conducting on-farm trials using transplanting and seedling tubers as propagules for the ware crop

- Evaluating TPS technology in intercropping with sugarcane.

- Perfecting technology for commercial production of hybrid TPS and working out the economics of TPS production.

The combined research efforts of CPRI and CIP could generate valuable information and parental material which could be used by countries of South and South East Asia. CPRI could play a leading role in technology transfer to these countries.

Similarly, ICAR/CPRI has expertise in the fields of post-harvest handling of potatoes and control of pests and diseases. The Review Panel feels that research projects in these two areas could

be initiated between ICAR/CPRI and CIP for the generation of viable technologies which would benefit not only Indian growers, but potato farmers throughout South and South East Asia.

Recent studies have shown that IPM could provide long-term control of the pests and minimise the use of insecticides, specially persistant ones. CPRI and CIP could develop collaborative project in this area.

The Division of Social Sciences should also develop active linkages with CIP specially in prioritiy areas: constraints to potato production and use, strategies for disseminating new potato technologies and impact assessment.

5.1.2 Other Institutions

In the 1950's and 1960's, CPRI collaborated with the Scottish Society of Plant Breeding, and through this programme received breeding material with field resistance to late blight and immunity to wart. One of India's leading varieties, Kufri Jyoti, was developed from this material. The supply of genetic material was suspended due, perhaps, to the discovery of spindle tuber viroid. Since the material has now been totally checked for PSTV, CPRI should again develop a cooperative programme to receive it. Similarly, it would be worthwhile to develop a collaborative programme with Cambridge University for breeding varieties resistant to cyst nematodes.

It would be useful to establish linkages with the national potato programmes of neighboring countries in order to survey diseases and pests, to strengthen breeding for resistances, and to improve quality seed production and distribution. This would be in the national interest because pests and diseases, such as cyst nematodes, brown rot, and wart, sometimes enter India on potatoes from neighboring countries.

5.2 Internal Linkages

CPRI conducts most of India's potato research and produces breeders' seed. Previously, this was essential due to the limited capacity of other institutions. Since State Agricultural Universities (SAUs) and other institutions have strengthened their research capabilities, it is important that CPRI strengthen its linkages with them to optimise the potato research effort and to ensure a wide dissemination of results. Moreover, various agencies both in the public and private sector could be usefully engaged in seed production.

Universities. SAUs have been established in potato-growing areas. Several have been involved with AICPIP in regional surveys and in testing advanced lines, agronomic practices, and pest management systems. In the Review Panel's view, this valuable work should be continued. Because of the improved research capabilities of SAUs, CPRI should encourage them to do more basic research on potatoes, in addition to regional surveys and testing.

Rather than investing in costly, sophisticated facilities for genetic engineering, CPRI should link with other institutions with facilities to do this work. In any case, CPRI will need a biotechnology unit with highly trained staff.

The role of SAUs in seed production remains controversial. Universities have a comparative advantage in research and training rather than in production per se. Hence, routine aspects of seed multiplication may be better handled by semi-public, cooperative, or private enterprises than by universities.

ICAR may wish to provide resources and incentives for SAUs to conduct research on topics that support local seed production scheemes. These may include tissue culture, rapid multiplication techniques, TPS, and virus diseases.

An area of great potential importance is collaboration with the departments of agricultural economics of SAUs in socioeconomic studies. A good place to start would be with surveys of farmers' preferences for varieties and the existing "informal" seed systems.

National Seeds Corporation, State Farms Corporation, and State Departments of Agriculture. These organisations have been involved for several years in the production of foundation and certified seed and its delivery to farmers. In light of current doubts concerning their effectiveness and role in seed multiplication, an impartial study of existing programmes and options for the future would be useful.

5.3 Training and Communications

If CPRI moves towards greater decentralisation and transfer responsibilities for a portion of its basic research and most of its location-specific research and seed production to other institutions, it will be necessary to place greater emphasis on training and communications. As CPRI sets its priorities and strategies, appropriate training and communications activities should be included to provide collaborating organisations with the information they need to carry out their missions. The Review Panel believes that CPRI's training and publications should be directed towards researchers and those responsible for extension rather than directly toward farmers. Little value is seen in continuing the Institute's series of technology package extension bulletins..

6. ORGANISATIONAL ISSUES

This section discusses a number of organisational issues that influence the performance of CPRI and its contributions to potato production and use in India.

6.1 Location of CPRI Headquarters

CPRI was set up at Patna in 1949. Headquarters were moved to Shimla in 1957. The Shimla location has several disadvantages. The most obvious one being its growing conditions differ sharply from those of India's principal potato-growing areas in the plains. Additionally, Shimla has a harsh, cold winter, when the productivity of office and laboratory work declines. Housing is scarce and living costs are high.

The two main reasons for identifying Shimla as the headquarters were the natural advantage of hills for isolation and low aphid population, and flowering needed for hybridization. An additional reason was that the northern hills were an important production zone for both ware and seed potatoes. Since the development of the seed plot technique, it is now possible for several regions of India to produce healthy seed potatoes. At present, over 80% of the area and production of ware and seed potatoes comes from the Indo-Gangetic plains, with UP accounting for more than 40%.

Taking these factors into consideration, it seems clear that CPRI's headquarters should be moved to a more representative site in the plains. The issue is not <u>if</u> the headquarters should be moved but <u>when</u> it would be feasible and to <u>where</u>. Modipuram in UP would seem to be the ideal location for CPRI's headquarters because of its central location, research facilities, and experience with seed production. The Shimla research station should be maintained for breeding and seed production in the hills.

6.2 Regional Centres

Greater decentralisation is needed for the benefits of potato research to reach farmers and consumers more broadly. However, the Review Panel believes that decentralisation should not be sought through a proliferation of CPRI's resources, acquisition of more land, or setting up more breeders' seed farms. Instead, CPRI should reduce the number of research centres while upgrading personnel and facilities to ensure that each operates as a viable research unit. At present, some of the centers (e.g., Rajgurunagar) are so poorly staffed and equipped that they cannot be expected to conduct quality research.

6.3 Manpower

The total sanctioned scientific manpower of CPRI seems to be adequate. However, an increase in the ratio of technicians to scientists would be useful, as would be an increase in the ratio of senior to junior scientists.

The relatively large proportion of sanctioned positions that are presently unfilled is a cause of concern. Every effort should be made to fill all sanctioned positions as soon as possible. As a stop gap measure, ad-hoc research projects may be needed to implement the Review Panel's recommendations.

Critical vacancies in genetics, agronomy, social sciences, biochemistry, and post-harvest technology need to be filled immediately.

In assessing the resources and needs of the Divisions, it would appear that the number of scientists assigned to work on post-harvest technology and social sciences should be increased relative to those assigned to the pathology and soil science.

The number of technicians needs to be increased generally. This need is particularly urgent in the Seed Production Division, where seed production requires a considerable amount of technical manpower. More technicians are also essential for AICPIP, and for the Divisions of Social Science and Crop and Soil Science to implement needed on-farm research.

Regional stations need to have a minimum number of scientists, perhaps five, and at least as many technicians to provide the critical mass needed to maintain a viable research unit.

6.4 Research Organisation and Programmes

At present, CPRI's research is organised around 42 projects in eight Divisions. Eighteen research thrusts have been proposed to provide a structure for interdisciplinary teamwork. The research divisions appear to be soundly structured and have served CPRI well over the years. However, some problems exist. The Division of Post-Harvest Technology is presently not functioning, and efforts should be made to reactivate this potentially important Division.

The Seed Production Division, perhaps CPRI's most important one, appears to be suffering from weak leadership and an "identity crisis." Seen as essentially a production unit, it is an unattractive institutional locus for CPRI scientists and only 16 are devoting 50% of their time as "borrowed" scientific manpower from other Divisions. This is clearly not an ideal situation. The Review Panel feels strongly that the Seed Production Division should be consolidated with its own scientific staff and technicians. Scientists should provide overall leadership and conduct innovative seed research and technicians should be principally responsible for seed multiplication.

The Social Sciences Division, CPRI's newest, seems to be somewhat of a "catch all" for miscellaneous disciplines, rather than a coherent operational unit. The Review Panel believes that this Division should concentrate on economics, extension, training, and communications to ensure a more productive research and service agenda.

The role of Thrusts in CPRI's research organisation and the relation between thrust projects and Divisions is unclear. The Review Panel believes that before going further with the establishment of Thrusts, CPRI should think carefully through its management needs, if necessary with the assistance of an external management expert. If Thrusts are implemented, they should be structured as coherent teams to produce essential product services. A possible list of Thrusts follows:

- Assessment of potato technology needs in India
- Collection, maintenance, and assessment of germplasm
- Development of improved varieties adapted to local growing conditions and uses
- Production and distribution of quality breeders' seed
- Modernisation of seed systems

- Management of major diseases caused by viruses, viroids, fungi, and bacteria
- Management of the principal insect and nematode pests
- Improvement of agronomic management in major production zones
- Improvement of potato marketing and post-harvest technology
- Dissemination of research results (training and information service).

6.5 Seed Programme

Seed production issues, already mentioned several times, are critical for CPRI's future. Key questions include: How much seed to produce? Who should produce it? How should it be produced? How should it be distributed?

Providing definitive answers goes beyond the scope of this report. Nevertheless, the Review Panel has reached some tentative conclusions. The most important is the need for an in-depth study of existing seed systems in major potato-producing areas. It should be carried out by an interdisciplinary team that brings both biological and socioeconomic expertise to bear on this complex topic.

Concerning the quantity of seed to be produced, it is frequently noted that CPRI is currently producing only about 25% of the country's requirement for breeders' seed, the implication being that more should be produced. The Review Panel believes that CPRI should produce less, not more, basic seed, which would later be multiplied by other public and private organisations. Whereas it is generally assumed that breeders', foundation, and certified seed should be produced by government organisations, experiences in many countries indicate that the public good can best be met by transfering a greater role for seed production to the private sector with appropriate legal standards.

Great strides have recently been made in seed production technology for vegetatively propagated crops. Use of in vitro propagation, TPS, and a range of rapid multiplication techniques have come into practical application in a number of countries during the past decade. CPRI needs to modernise its seed production methods by reviewing recent international experience, testing promising methods, and tailoring them to fit local needs and resources.

Little progress has been made in improving seed distribution methods. Government agencies are notoriously poor at marketing a costly, perishable and bulky commodity of variable quality, like seed potatoes. This highlights the need for the suggested study of existing seed systems and for exploring means of involving the private sector more extensively in seed production and marketing.

6.6 Information, Training, and Communications

CPRI has a long and productive history in these areas. The institute possesses the foremost collection of potato literature in India and numerous publications have been issued, particularly in recent years. Well-organised courses have been conducted for many years.

Increasing decentralisation and devolution of responsibility to other institutions for research and seed programmes will require even more emphasis on information, training, and communications. CPRI could play a pivotal role by disseminating abstracts of research publications to potato researchers throughout India, and even more widely in Asia. More specialised training will be needed to

modernise seed production, breeding, virus testing, and other priority research areas in various collaborating institutions.

Communication systems need to be modernised considerably to facilitate the rapid exchange of research information among scientists, and with policy makers and those responsible for seed multiplication and agricultural extension. Publications should be directed toward these groups rather than directly toward farmers.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 General

- In May 1988, ICAR convened a six-man team of specialists to review potato research and development in India. ICAR provided the terms of reference. CIP sponsored the visit of the team.

- Since its initiation in 1935, potato research in India has expanded to include CPRI, headquartered at Shimla, and 12 regional stations with a combined staff of 600.

- The AICPIP, established in 1971, has expanded to conduct and coordinate potato research at 24 locations, covering diverse ecological environments.

- Over the years, CPRI has released 25 cultivars for different agro-climatic zones. At present, eight are multiplied in seed production programmes.

- Over the past 40 years, largely as a result of research and providing improved seed to farmers, India's potato production has grown rapidly and now ranks fifth worldwide. The value of the Indian potato crop per unit of land exceeds that of cereals by over 300%.

- Defined breeding targets should be established in accordance with perceived needs for potato improvement. Development of virus-resistant varieties should be a long-term goal, as they would greatly aid seed production while reducing virus degeneration in the field.

- Recording races of the late blight fungus and breeding for major gene resistance should be terminated. Field or general resistance should be the goal as it is more sustainable and permits good yields.

- Because of rapid advances in biotechnology, CPRI is encouraged to monitor progress in this field. However, significant investments in biotechnology facilities are discouraged. Access to costly, sophisticated facilities and specialised personnel may be obtained through research contracts with institutions involved in biotechnology research in India.

- The calibre of research in the Crop Physiology and Biochemistry Division is exemplary. This Division should initiate collaborative research with Genetics to assist in screening for high yield levels. A closer interaction with the tissue culture laboratory is also recommended.

- In keeping with current work and future priorities, the name of the Division of Crop and Soil Science should be changed to Agronomy. Future work should focus on innovative research on true potato seed (TPS) and biofertilisers, and economic analysis to derive appropriate farmer recommendations from experimental results.

- In the seed programme, all parental breeding material and in vitro germplasm should be tested for PSTV, using the NASH test.

- The ecology of the bacterium causing bacterial wilt (brown rot) and the epidemiology of the disease under Indian conditions should receive priority attention over less important bacterial pathogens.

- To reduce reliance on pesticides, it is urged that an integrated pest management (IPM) programme be introduced. The economic importance of specific insects should be carefully assessed, and research priorities should be set for solving different problems in accordance with their importance and the prospects for solving them.

- A more intensive research programme on nematodes is recommended.

- Consolidation of the Division of Social Sciences could assist technical research by providing information on constraints to expanded potato production and use, by developing strategies disseminating information, and by assessing impact. Training and communications are essential complements to socioeconomic research. CPRI is encouraged to strengthen work in these areas.

- Meeting future needs for quality seed may require legal redefinition of "breeders' seed" and a restructuring of the Seed Production Division. It is recommended that the Division be renamed "Seed Research and Production Division," and that it include two units: "Seed Research Unit" and "Seed Production Unit."

- Micropropagation of PSTV- and virus-free basic stocks and maintenance of strict health standards during all stages of seed multiplication are desirable medium-term goals.

- A four-stage multiplication scheme for seed is suggested to reduce time and resources spent on seed multiplication.

- An immediate programme for bulk production of TPS is called for.

- Greater involvement of the private sector for seed multiplication and distribution should be sought.

- Stronger linkage with CIP is encouraged, particularly in the social sciences and in research involving TPS, crop productivity, and heat tolerance. The broad scope of CPRI research could also benefit many Asian potato programmes. For this reason, expanded network activities in training and exchange of scientists and germplasm are strongly encouraged.

- Whereas the headquarters facilities in Shimla served CPRI well in the early years, the Panel believes that CPRI's overall effectiveness could be improved by shifting headquarters to Modipuram, located nearer to major potato production and seed multiplication areas in the plains. Shimla should be maintained for breeding and seed production for the hills.

- Immediate attention should be given to activating the Division of Post-Harvest Technology.

- A matrix organisation with Divisions supporting integrated problem-solving "thrusts" is recommended to improve interdisciplinary cooperation and research output.

- Inadequate staff and equipment seem to be limiting quality research at several regional stations. Consideration should be given to reducing the number of CPRI stations and to improving the excellence of the remainder.

- The Seed Production Division at CPRI should concentrate on seed research aimed at providing disease-free elite material. In addition to NSC and state government farms, the private sector should also be encouraged to produce quality seed.

7.2 Research Priorities

- **Genetics and Plant Breeding.** All in vitro cultivars must be made PSTV-free. The IBPGR has developed descriptors for potatoes. Based on these, computer management of a PSTV-free in vitro germplasm collection, preferably maintained at duplicate locations, should be a short-term (3- to 5-year) objective.

- There is a need to breed varieties to meet processors' requirements. A population approach to breeding, permitting mass screening at the seedling stage for specific characters, is recommended.

- Selection for climatic and edaphic adaptation might efficiently be limited to no more than seven environmentally distinct zones. Attention should be directed to analysis of CPRI data and to modelling to predict the fit of clones to particular areas of the country. This would save a great deal of field testing.

- TPS is a promising method of propagating potatoes specially by small farmers. A practical and immediate resolution of bulk production of TPS is desirable to complement traditional seed tuber production.

- Exploitation of in vitro technology is encouraged through associations of CPRI scientists and their counterparts at an Indian Biotechnology Institute with the objective of modifying potato genomes through genetic engineering. If this is not possible, part of the work may be done in CPRI by acquiring some equipment and employing trained scientists.

- **Crop Physiology and Biochemistry.** The Division has clearly defined priorities. Collaborative research in the application of photosynthetic measurements for the development of high yielding lines is proposed with the Genetics Division.

- It is recommended that studies on the role of enzymes in carbohydrate metabolism be used in conjuntion with the selection of parental lines for processing quality.

- A closer interaction between plant physiology, biochemistry, and tissue culture is recommended.

- **Crop and Soil Science.** The work of the Division has resulted in a series of recommendations. The Division's name should be changed to Agronomy, which is in keeping with the work currently being undertaken and the priorities for the future, including statistical (biometric) research.

- The Division should publish detailed research bulletins reporting results of its work on fertilisation, seed planting, irrigation, weed control, and related agronomic management practices. These bulletins should present practical findings and recommendations for seed and ware crops. They should also serve as examples of good research design, analysis and presentation. This writing should mark the end of the Division's direct involvement in this traditional area of research. The future strategy should be to encourage SAUs and other regionally based Institutions to carry out location-specific work.

- The Division's future research on conventional seed and ware potato production should be to establish the agronomic requirements of India's major potato-based cropping systems.

- Greater attention should be paid to non-conventional research areas, like selection of potential new cultivars under low-fertility conditions, studying nutrient metabolism, use of bio-fertilisers, and developing appropriate agronomic management systems for rapid multiplication and TPS.

- **Plant Pathology**. It is strongly recommended that tuberosum or andigena material free of "major" genes be identified for use as new parental material in breeding for late blight resistance. Monitoring of P.infestans races should be terminated.

- A request should be made to CIP for NASH kits sufficient to examine several hundred samples of important breeding lines and in vitro germplasm for PSTV. Testing should commence as soon as possible in 1988 to eliminate any PSTV-infested material.

- Bacteriological research in the Division should concentrate on studies leading to effective control of brown rot (bacterial wilt) at the earliest opportunity.

- Pathologists cooperating with breeders should be encouraged to help in developing breeding lines incorporating PVX and PVY resistances prior to attempting multigenic FLRV resistance. PVX and PVY resistance could be incorporated into new Kufri cultivars within the next 2 to 3 years with subsequent incorporation of good levels of PLRV resistance by 1993. ELISA kits should be prepared locally and the latest methods should be developed for antiserum production.

- **Entomology and Nematology**. Though several scientists are working on aphids, research output is small. The programme needs to be overhauled. Research should be initiated to study the ecology and determine causes of resurgence of new pests like white grubs and Heliothus spp.

- An improved experimental programme of IPM should be undertaken to provide comprehensive control of potato tuber moth. The proposed IPM programme would place emphasis on innovative use of pheromones in both population studies and mating confusion techniques.

- Good field plot design and computer-assisted analysis is recommended as an important component of modern IPM programmes.

- Present research effort does not reflect the importance of nematodes in damaging the potato crop. Both root-knot and cyst nematodes are serious pest, and prevention of their spread requires stringent control measures. A more intensive research programme is recommended.

- **Social Sciences**. The Review Panel commends CPRI for establishing this Division, and recommends that it focus on three complementary areas: socioeconomic research, training, and communications. It is recommended that direct responsibility for statistics be transferred to the Division of Agronomy.

- CPRI has the potential to exercise a leading role in socioeconomic research applied to the potato. Realising this potential will require that research be strengthened within a clear framework with a few central themes, such as constraints to potato production and use, strategies for disseminating new potato technology, and impact assessment.

- In conjunction with this socio-economic research programme, members of the Division should become involved in interdisciplinary teams working on CPRI's priority Thrusts, such as

breeding new varieties, seed production (including in vitro systems and TPS), and post-harvest technology.

- In order to keep abreast with applied socioeconomic research and to stimulate research and training that is relevant to potato improvement, the Division should develop linkages with leading universities and research institutes in India and abroad.

7.3 Seed Production

- One of the most important functions of CPRI is to produce seed. The seed plot technique has revolutionised seed production. The responsibility of the Institute should be limited to disease indexing by the currently most reliable methods, in vitro and screenhouse multiplications, and minimal field multiplication.

- Field roguing should be carried out by trained technicians. Virus indexing is essential to guarantee high seed quality.

- A Division of Seed Research and Production is proposed under the direction of a single senior scientist at S-4 or S-5 level. This Division would implement a four-stage multiplication scheme (see Flow Chart for Seed Production).

- Through use of the proposed multiplication scheme CPRI could reduce the time and resources needed for field multiplication. Cutting the number of field multiplications would also reduce exposure of planting material to diseases and raise the quality of breeders' and certified seed.

Flow Chart for Seed Production

Present Scheme	Proposed Stage	Activity	Seed Class
First	I	In vitro laboratory multiplication to meet demand for virus-free plantlets and/or micro tubers	PRE-BASIC
	II	Screenhouse multiplication of plantlets and micro tubers to produce small tubers	BASIC I
Second		10 g tubers for field multiplication	BASIC II, (Breeders' seed)
Third-Fourth	III	Multiplication of Basic II seed by private/public agencies for 2 seasons	FOUNDATION I & II
Fifth		Production of Certified Seed from Foundation II by private growers	CERTIFIED
Sixth		Certified seed planted by growers	

Only Stage I would be produced by CPRI.
All of Stage III cycles would involve three field inspections during each growing season and post-harvest tests for viruses.

- The Division of Seed Research and Production should have a virologist, a general pathologist and, an entomologist to oversee disease and pest control in the present Stage III; a tissue culture specialist for in vitro multiplication; and, technicians to carry out the present Stages II and III. The virologist and general pathologist would also be responsible for screenhouse and field inspection during Stage III.

- The term "breeders' seed," which is not recognized internationally, should be replaced by international recognised terms such as "pre-elite" and "elite I and II" or "pre-basic" and "basic I and II."

7.4 Linkages and Technology Transfer

- The Review Panel encourages CPRI to look upon the SAUs and other research institutions as sources of expertise and facilities for basic research needed on potato (e.g., biotechnology, biochemistry, plant-water relationship).

- CPRI's research and extension bulletins should be written for researchers and extension specialists, not for farmers. CPRI should reduce involvement in extension to a few well-selected programmes designed to help Institute management and scientists understand and overcome the major obstacles to greater dissemination of research results.

- One of the principal linkages between CPRI, other institutions, and farmers is through seed. Given the importance of seed multiplication and distribution, the extent of public and private sector involvement, and the lack of organised information on the topic, the Review Panel proposes that a comprehensive study be conducted of seed potato multiplication and distribution in India.

- Discussions on seed production usually focus on the role of CPRI, NSC, agricultural universities, the State Farm Corporation of India, and other public sector institutions. The Panel recommended that CPRI explore ways of expanding the role of the private sector in seed multiplication and distribution.

- CPRI scientists should be encouraged to publish results of their work in international journals. To facilitate this, special funding may be required.

- AICPIP is seen as a potentially useful vehicle for diagnosing local problems, for testing potential solutions, and disseminating information to farmers. More technicians and additional resources for transportation are required for conducting on-farm research. Improved methods are needed in three areas, field-level diagnostic studies, prior to implementing field trials; analysis of results of field surveys and trials; and design of field trials on farms, rather than on research stations. Greater involvement of social scientists and statisticians would be useful for developing needed technologies.

- CPRI should obtain systematic information on the principal yield constraints in each area to serve as a basis for setting priorities for research and extension.

7.5 Organisational Issues

- ICAR should seriously consider moving CPRI headquarters from Shimla to a more accessible and representative location in the plains. With development of the seed plot technique in the plains, nearly 90% of India's potatoes --both ware and seed-- are now grown there. Given its central location, facilities, and track record in seed production, Modipuram research station is the most logical site for the new headquarters of CPRI. The Shimla station should be retained for breeding, and Kufri and Fagu for field multiplication of seed for the hill region. These stations could also devote themselves to bulk production on TPS.

- The present deployment of staff and facilities among three regional stations and eight research centres is not ideal for pursuing CPRI's research goals, for seed production, or for technology transfer. The Review Panel recommends that stations with less than a critical number of scientists --say five-- and inadequate research infrastructure be upgraded or closed.

- A Post-Harvest Technology Division has been approved by the ICAR, but is virtually non-functioning. Given the strategic impact of storage, processing, and other post-harvest activities on potato production and utilisation, it is recommended that CPRI give immediate attention to consolidating this Division.

- CPRI should create a Division of Seed Research and Production to ensure innovative research in seed technology and to achieve qualitative and quantitative production targets.

- The number of staff in post-harvest technology and social sciences should be increased to establish a more appropriate balance among disciplines within CPRI.

- Quarterly reporting of scientific results is excessive; the Review Panel encourages management to reduce paperwork to a minimum.

- Problem-oriented interdisciplinary teamwork should be encouraged.

- The panel endorses the establishment of "Thrusts," but cautions that 18 may be too many. The panel suggests 10 thrusts (Section 6.4)

- In order to stimulate creative scientific effort, interdisciplinary Thrust objectives should be set out as manageable projects. Each senior scientist should be responsible for at least one research project.

- Insufficient work was reported to pose disciplinary problems during the off-season. The Review Panel urges management to encourage scientists to use this period each year to analyse data, publish research findings and plan for the coming year.

- The total sanctioned manpower of CPRI is adequate. However, an increase in the ratio of technicians to scientists and of junior to senior scientists is recommended.

- From observations at Rajgurunagar and Shillong stations, both staff number and laboratory equipment are minimal, and limit quality research. Consideration should be given to reducing the number of CPRI-affiliated stations and to improving the excellence of the remainder within budget limitations.

7.6 Infrastructural Needs

- From casual observation at CPRI, Shimla, immediate attention to greenhouse repairs should be a priority.

- To facilitate adequate quarantine during multiplication of seed potatoes, well-kept screenhouses are required to exclude aphids and whiteflies.

- Improvement in the efficiency of the tissue culture laboratory at CPRI, Shimla could be achieved with more modern glassware and boxes for rapid multiplication use. The Review Panel feels that in-vitro multiplication facilities should be created at CPRS Jalandhar, Modipuram, and Patna to supply sufficient planting material to produce basic-I Stage tubers in the screenhouses. The in-vitro stocks of cultivars assigned to each region could be supplied by a central facility which would maintain and multiply tested stocks.

Annex 1. Itinerary for the Review of Potato Research in India May 16-31, 1988

16 May — **ICAR, headquarters, New Delhi**

- Meeting of the team members with Dr. N.S. Randhawa, Director General
  The following officers were also present
  - Dr. G.L. Kaul, Assistant Director General (Hort.)
  - Dr. Ramphal, Senior Scientist (Vegetables)
  - Mrs. K. Bhatnagar, Financial Advisor
  - Mr. Hazari Lal, Under Secretary, (IC Division)
- Lunch hosted by ICAR for review team and government officials

17 May — Travel to **CPRI headquarters, Shimla**

- Meeting with Dr. N.M.Nayar, Director, and with heads of divisions
- Presentation: Plant Pathology Division

18 May — **CPRI, Shimla**

- Presentation: AICPIP
  - Crop and Soil Sciences Division
  - Entomology and Nematology Division
  - Seed Production Division
- Visit **CPRS at Kufri-Fagu**

19 May — **CPRI, Shimla**

- Presentations: Genetics and Plant Breeding Division
  - Crop Physiology and Biochemistry Division
  - Social Sciences Division

20 May — **CPRI, Shimla**

- Meeting of review team to discuss strategy
- Wind up meeting with Dr. Nayar
- Travel to **New Delhi**

21 May — **New Delhi**: Report writing

22 May — **New Delhi**

- Report writing
- Travel to **Pune**

23 May — Travel to **CPRS, Rajgurunagar**

- Visit to the Station
- Visit farmer storages
- Travel to **New Delhi**

24 May — **New Delhi**: Report writing

25 May — Travel to **Guwahati and Shillong**

26 May — **CPRS, Shillong**[1]

- Visit to experiment station
- Travel to **New Delhi**

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1 Dr. Chadha not present

27 May	**New Delhi** • Report writing • Discussions in ICAR with Dr. M.V. Rao, Special Director General, ICAR, and with Dr. N.M. Nayar, Director CPRI
28 May	**New Delhi**: Report writing
29 May	**New Delhi**: Report writing and review by team.
30 May	**New Delhi**: Dinner hosted by CIP for review team and government officials.
31 May	**New Delhi**: Meeting of review team to plan final write up[2]

2 Dr. Page not present

Annex 2. Persons met by Research Review Team during Visits

Division of Crop & Soil Sciences
Dr. J.S. Grewal, Sci. S-4 & Head

Division of Social Sciences
Dr. Hira Nand, Sci. S-3 & Head
Sh. V.P. Malhotra, Sci. S-2 (Stat.) & formerly Head of the Division

Division of Plant Pathology
Dr. G.S.Shekhawat, Sci. S-3 & Head
Dr. S.M.P. Khurana, Sci. S-3
Dr. S.K. Bhattacharya, Sci. S-3

Division of Plant Physiology & Biochemistry
Dr. N.P. Sukumaran, Sci. S-3 & Head
Dr. S.C. Verma, Sci. S-3

Division of Seed Production
Dr. Sarjeet Singh, Sci. S-3 & Head

Division of Genetics & Plant Breeding
Sh. P.C. Misra, Sci. S-2 & Head

Division of Entomology & Nematology
Dr. S.S. Misra, Sci. S-2 & Head

Library
Sh. S.R. Yadava, Librarian

Coordinated Project Unit
Dr. P.C. Gaur, Sci. S-3 & Project Coordinator

CPRS Shillong
Dr. Lakshman Lal, Sci. S-2 & Scientist-in-charge
Dr. U.C. Sharma, Sci S-2 (Soil Fertility)
Sh. Surendra Ram, Sci S-1 (Pl. Path.)
Sh. Kamla Singh, Sci. S-2 (Agron.)

CPRS Rajgurunagar
Sh. D.M. Kaley, Sci. S-2 (Pl. Phy.) & Scientist-in-charge
Sh. M.N. Akhade, Sci. S-2 (Agronomy)

CPRS Kufri
Sh. V.K. Garg, Sci. S-2 (Pl. Phy.) & Scientist-in-charge

Annex 3. Potato Production Statistics

Table A.3.1: Area, production, yield, percent net cropped area and per capita availability of potato in India 1986-87

	Area (000 ha)	Net Cropped Area %	Production (000 t)	Yield (t/ha)	Per capita availability (kg/yr)
Andhra Pradesh	0.4	-	1.3	3.2	-
Arunachal Pradesh	3.0	2.5	20.7	6.9	28
Assam	56.3	2.1	337.7	6.0	14
Bihar	133.5	1.6	1334.5	10.0	17
Delhi	0.2	0.3	1.2	6.0	-
Gujarat	11.0	0.1	253.6	23.0	6
Haryana	9.0	0.2	131.5	14.6	9
Himachal Pradesh	14.3	2.5	37.8	2.6	8
Jammu & Kashmir	1.4	0.2	3.1	2.2	0
Karnataka	17.9	0.2	222.7	12.4	5
Madhya Pradesh	27.3	0.1	333.7	12.2	6
Maharashtra	11.1	0.1	51.9	4.7	1
Manipur	2.5	1.8	20.9	8.4	12
Meghalaya	17.9	9.3	149.5	8.4	96
Mizoram	0.2	0.3	0.8	4.0	1
Nagaland	1.1	0.7	6.8	6.8	7
Orissa	9.8	0.2	96.7	9.9	3
Punjab	24.6	0.6	251.5	10.2	13
Rajasthan	1.8	0.0	9.8	5.4	0
Sikkim	5.0	6.6	26.4	5.3	65
Tamil Nadu	5.0	0.1	98.6	19.8	2
Tripura	2.5	1.0	40.2	16.1	17
Uttar Pradesh	296.6	1.7	5757.9	19.4	46
West Bengal	173.1	3.1	3542.6	20.5	58
All India	**825.5**	**0.6**	**12731.4**	**15.4**	**16**

Source: Directorate of Economics & Statistics, Dept. of Agriculture & Cooperation, Ministry of Agriculture & Rural Development, Govt. of India, New Delhi.

Table A.3.2: Area, production, yield and per capita availability of potato in India 1950-51 to 1986-87

Year	Area (000 ha)	Production (000 t)	Yield (t/ha)	Per capita availability (kg/year)
1950-51	240	1660	6.9	5
1960-61	375	2719	7.2	6
1970-71	482	4807	10.0	9
1980-81	730	9670	13.3	14
1981-82	760	9910	13.0	14
1982-83	730	9960	13.5	14
1983-84	794	12152	15.3	17
1984-85	849	12571	14.8	17
1985-86	848	10696	12.6	14
1986-87	826	12731	15.4	16

Source: Directorate of Economics and Statistics, Dept. of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India, New Delhi.

Annex 4. Personnel of the CPRI and the AICPIP

This Annex contains statistics on the sanctioned personnel and filled posts of the CPRI and the AICPIP. The following abbreviations are used in the tables:

S = Sanctioned personnel
F = Filled posts
Shm = Shimla (HQ)
K/F = Kufri/Fagu
Jul = Jullundhar
Mod = Modipuram
Pat = Patna
Gwa = Gwalior
Muk = Mukteshwar
Dar = Darjeeling
Shi = Shillong
Raj = Rajgurunagar
Oot = Ootacamund
Kar = Karnataka

Table A.4.1 Total sanctioned posts and staff in position at CPRI Shimla and regional stations by category 1985-87

Category	Staff in Position 1985	1986	1987	Total Sanctioned Posts
Scientific	115	135	126	210
Technical	96	91	93	200
Administrative	106	109	110	142
Supporting	215	210	223	280
Auxiliary	47	46	45	55
Total	**579**	**591**	**597**	**897**

Table A. 4. 2. Sanctioned scientific personnel of CPRI Shimla and research stations

	Shm	Kuf	Jul	Mod	Pat	Gwa	Muk	Dar	Shi	Raj	Oot	Kar	Total
Agri. Physics (Meteorology)	2	-	-	-	-	-	-	-	-	-	-	-	2
Crop & Soil Sciences	6	1	5	7	5	-	1	1	3	2	2	-	33
Entomology & Nematology	4	-	-	5	2	-	-	-	2	1	3	1	18
Genetics	15	3	2	4	3	-	2	2	1	1	2	-	35
Instrument Eng.	2	-	-	-	-	-	-	-	-	-	-	-	2
Machinery & Power	-	-	4	-	-	-	-	-	-	-	-	-	4
Physiology & Biochemistry	8	-	5	9	1	-	-	-	-	1	-	-	24
Plant Pathology	13	1	4	4	3	2	2	1	3	2	2	1	38
Post Harvest Technology	-	-	2	-	-	-	-	-	-	-	-	-	2
Seed Production	2	3	4	6	3	5	1	-	3	1	-	4	32
Social Sciences	14	-	1	1	3	-	-	-	1	-	-	-	20
Total	66	8	27	35	20	7	6	4	13	8	9	6	210

Source: Detailed project documents EFC Memo of 7th plan. Filled posts as of April 30, 1988.

Table A. 4. 3. Sanctioned and filled posts by station: technical staff

	Shm		Jal		Pat		Mod		Shi		Raj		Oot		Kar		Gwa		Dar		Muk		Total	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
T-7	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
T-6	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	5	-
T-5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
T-4	17	6	1	2	1	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	21	10
T-II-3	20	6	6	5	5	2	6	3	3	-	1	-	2	-	2	-	2	-	1	-	1	-	49	16
T-2	19	8	11	3	7	8	13	8	3	3	3	2	4	1	3	-	7	3	2	2	2	2	74	40
T-1	11	3	7	5	3	1	5	3	2	1	2	2	2	2	2	-	3	1	1	-	1	1	39	18
Total:	74	24	25	15	16	12	26	14	9	5	6	4	8	3	7		13	4	4	2	5	3	193	85

Source: Detailed project documents EFC Memo of 7th plan. Filled posts as of April 30, 1988.

Table A. 4. 4. Sanctioned and filled posts by station: administrative staff

	Shm		Jal		Pat		Mod		Shi		Raj		Oot		Kar		Gwa		Dar		Muk		Kuf		Total	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Sr. Administrative officer	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Sr. Accounts officer	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Administrative officer	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Hindi Officer	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Asst. Accounts Officer	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Asst. Administrative officer	2	2	1	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	3
Superintendent	5	5	-	-	-	-	1	-	1	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	8	7
Assistant	7	9	2	-	2	2	2	1	1	-	1	-	-	-	-	-	1	-	-	-	-	-	1		17	12
Senior stenographer	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
Stenographer	9	6	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		10	7
Senior clerks	16	15	3	3	2	1	5	5	2	-	1	2	1	1	1	-	1	3	1	1	1	1	1	1	35	33
Junior stenographer	4	6	-	-	1	1	1	1	1	-	1	-	1	-	-	-	1	-	-	-	-	-	1		11	8
Junior Clerks	27	21	4	4	5	4	4	2	2	4	1		1	1	1		1	1	1		1		1		49	37
Total	77	68	11	9	11	8	14	9	7	5	4	2	4	3	2		4	4	2	1	2	1				

Source: Detailed project documents EFC Memo of 7th plan. Filled posts as of April 30, 1988.

Table A. 4. 5. Sanctioned and filled posts by station: support staff

	Shm		Jul		Mod		Raj		Shi		Gwa		Mut		Kuf		Oot		Kar		Dar				Total	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Grade I	29	20	20	13	31	13	13	6	10	4	8	6	31	27	9	2	15	12	10	9	1	-	4	3	181	115
Grade II	25	12	7	1	6	9	[illegible]	7	3	4	2		5	5	1	5	1	6	2	4	-	-	1	2	55	55
Grade III	16	17	4	4	4	1	2	1	4	3	2	-	5	3	2	1	1	1	2	1	-	-	2	2	44	34
Grade IV	-	8	-	2	-	2	-	-		1	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	16
Total	70	57	31	20	41	25	17	14	17	12	12	6	41	37	12	8	17	19	14	14	1	-	7	8	280	220

Source: Detailed project documents EFC Memo of 7th plan. Filled posts as of April 30, 1988.

Table A. 4. 6. Sanctioned and filled posts by station: auxiliary staff

	Shm		Jui		Pat		Mod		Shi		Raj		Oot		Kar		Gwa		Dar		Muk		Total	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Publicity officer	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	1
Project operator	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	1
Hindi translator	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Machine operator	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Driver	3	3	-	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	5	4
Jeep driver	1	1	1	1	2	1	2	1	1	1	1	1	1	1	-	-	1	1	1	1	1	1	12	10
Tractor driver	-	-	4	3	3	4	5	4	1	1	1	1	1	1	2	-	4	3	-	-	-	-	21	17
Truck-cum-jeep driver	1	-	1	1	1	1	1	2	1	-	-	-	-	-	1	-	1	2	-	-	-	-	7	6
Operator (elect.)	-	-	2	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2
Blacksmith/carpenter	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Carpenter	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Mason	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Blacksmith	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
Total	12	7	9	9	6	6	11	9	4	2	2	2	2	2	3	-	6	6	1	1	1	1	55	48

Source: Detailed project documents EFC Memo of 7th plan. Filled posts as of April 30, 1988.

Table A. 4. 7. Manpower of the AICPIP

	Santioned	In Position
Central Project Units		
Project Coordinator	1	1
Scientist	1	1
Jr. Seed Production Officer	2	
Jr. Statistician	1	
SRA	3	1
Stenographer	1	1
Accountant	1	
Typist/Clerk	2	1
Jeep Driver	1	
Sr. Mali	1	1
Seed Preparation Units*		
Jr. Seed Preparation Officer	4	1
SRA	4	1
Sr. Mali	2	1

CPRS, Modipuram and CPRS, Kufri; numbers indicate posts at each unit.

Table A. 4. 8. Sanctioned and filled posts by Centre, AICPIP

	Scientific								Technical		Administrative		Support	
	Breeding		Agronomy		Pathology		Entomology							
	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Main Centres														
Kanpur	1	1	1	1	1	1	1	1	3	3	1	1	1	1
Dessa	1	1	1	1	1	1	1	1	3	3	1	1	1	1
Kalyani	1	1	1	1	1	1	1	1	3	3	1	1	1	1
Bhubaneswar	1	1	1	1	1	1	-	-	3	3	1	1	1	1
Ranchi	1	1	1	1	1	1	1	1	3	3	1	1	1	1
Chhindwara	1	1	1	1	1	1	1	1	3	3	1	1	1	1
Srinagar	1	1	1	1	1	1	-	-	3	2	1	1	1	1
Jalandhar	1	•	1	•	1	•	1	•	-	-	-	-	-	-
Patna	1	•	1	•	1	•	1	•	-	-	-	-	-	-
Shillong	1	•	1	•	1	•	1	•	-	-	-	-	-	-
Ooty	1	•	1	•	1	•	1	•	-	-	-	-	-	-
Rajgurunagar	1	•	1	•	1	•	1	•	-	-	-	-	-	-
Sub Centres														
Bangalore	-	-	1	1	1	-	-	-	2	1	1	1	1	1
Palampur	-	-	1	-	1	1	-	-	2	-	1	1	1	1
Port Blair	-	-	1	-	1	1			2	-	-	-	-	-
Jorhat	1	1	1	1	-	-	-	-	2	2	1	1	1	1
Hissar	1	1	1	1	1	1	-	-	3	3	1	1	1	1
Aurangabad	-	-	1	1	1	1	-	-	2	2	-	-	-	-
Kota	-	-	1	1	1	1	-	-	2	2	-	-	-	-
Faizabad	-	-	1	1	1	1	-	-	2	2	-	-	-	-
Pantnagar	1	1	1	1	1	1	-	-	3	3	1	1	1	1
Total	15		10	21	14	20	14	10	5	41	35	12	12	1212

CPRI centres; work being done by CPRI scientists.

Annex 5. Potato Research Stations and Centres

Table A. 5. 1. CPRI stations

Station		Location (Lat./Long.)	Elevation (m)	Establishment (year)	Area (ha)
1.	Shimla (HP)	31°N 77° E	2,202	1935	5.2
2.	Modipuram-Macchari (UP)	29 N°76°E	222	1971	150.6
3.	Jalandhar (Punjab)	31 N°75°E	237	1957	80.0
4.	Patna (Bihar)	25 N°85°E	53	1949	44.4
5.	Ootacamund (Tamil Nadu)	11 N°76°E	2245	1957	16.6
6.	Shillong (Meghalaya)	25 N°91°E	1,500	1959	12.8
7.	Gwalior (MP)	26°N 78°E	207	1979	179.5
8.	Rajgurunagar (Maharashtra)	18 N°73°E	559	1957	22.5
9.	Mukteswar (UP)	29 N°79°E	2,311	1957	20.0
10.	Kufri-Fagu(H.P)	32°N 77°E	2,501	1963	32.0
11.	Darjeeling (West Bengal)	27 N°88°E	2,128	1963	2.6
12.	Bangalore (Karnataka)	12°N 77°E	921	1984	-

Source: For latitude, longitude and elevation : Climatological Atlas of India Part-A. Indian Meterological Department 1981; for year of establishment and area: Report of the Quinquennial Review Team of CPRI 1985 (processed)

Table A. 5. 2. AICPIP research centres

Centre	Year of Establishment
Main Centres	
1. Jalandhar (Punjab)	1971
2. Ootacamund (Tamil Nadu)	1971
3. Patna (Bihar)	1971
4. Rajgurunagar (Maharashtra)	1971
5. Shillong (Meghalaya)	1971
6. Bhubneswar (Orissa)	1971
7. Chindwara (M. Pradesh)	1971
8. Deesa (Gujarat)	1971
9. Kalayani (West Bengal)	1971
10. Kanpur (U. Pradesh)	1971
11. Ranchi (Bihar)	1971
12. Srinagar (Kashmir)	1972
Sub-Centres	
13. Parbhani (Maharashtra)	1973
14. Bangalore (Karnataka)	1975
15. Hissar (Haryana)	1975
16. Jorhat (Assam)	1975
17. Palampur (H. Pradesh)	1975
18. Pantnagar (U. Pradesh)	1975
19. Faizabad (U. Pradesh)	1987
20. Kota (Rajasthan)	1987
21. Port Blair (Andaman Is.)	1987
Voluntary Centres	
22. Ludhiana (Punjab)	1971
23. Babugarh (U. Pradesh)	1983
24. Ranichauri (U. Pradesh)	1984
Seed Preparation Unit	
25. Modipuram (U. Pradesh)	1976
26. Kufri (H. Pradesh)	1976

Annex 6. CPRI Research Projects

Table A. 6. 1. List of CPRI research projects by division 1988

GENETICS AND PLANT BREEDING

1. Collection, conservation, evaluation and documentation of potato germplasm.
2. Breeding improved cultivars for north Indian hills.
3. Breeding improved cultivars for western Indo-Gangetic plains.
4. Breeding improved cultivars for central Indo-Gangetic plains.
5. Breeding improved cultivars for eastern Indo-Gangetic plains.
6. Evaluation of true potato seed for raising commercial crop.
7. Use of tissue culture techniques for potato improvement.

PLANT PHYSIOLOGY & BIOCHEMISTRY

1. Identification of potato genotypes with high and low net photosynthetic rates and establishment of correlation between photosynthetic rates and tuber yield.
2. Selection of heat tolerant genotypes and morphophysiological characters associated with heat tolerance.
3. Growth and development studies on potato root systems.
4. Physiological determinents of keeping quality in potatoes under non-refrigerated storage.
5. Role of growth regulators and enzymes in carbohydrate interconversions in stored potatoes.

CROP & SOIL SCIENCES

1. Soil and plant tests for fertilizer recommendations to potato.
2. Evaluation of potato based cropping systems.
3. Nitrogen nutrition of potato.
4. Phosphorous and potassium nutrition of potato.
5. Water optimization and requirement of potato crop.
6. Design and development of an automatic potato planter.
7. Performance evaluation of selected farm equipment/machines for potato production under the farmer-use conditions.
8. Level of mechanisation for potato cultivation in Punjab.

PLANT PATHOLOGY

1. Latency and management of Pseudomonas solanacearum.
2. Epidemiology and control of Phytophthora infestans causing late blight of potato.
3. Survey, epidemiology and management of soil and tuber-borne pathogens of potatoes.
4. Mycorrhiza in potato.
5. Ecology and management of wart disease of potato in north Bengal hills.
6. Detection and diagnostic techniques for viruses.
7. Aetiology and control of marginal flavescence and thin/hairy sprout diseases of potato.
8. Utilization of electron microscopy in potato research.
9. Quarantine service for the introduction and export of potato germplasm.
10. Surveillance and control of potato diseases.

cont.

Table A.6.1. List of research projects by division 1988 (cont.)

SEED PRODUCTION

1. Production of nucleus and breeder's seed stocks of potato.
2. Development of agronomic practices for seed potato production.
3. Epidemiology of potato viruses: establish critical levels of aphid vectors and rate of degeneration of potato cultivars.

SOCIAL SCIENCES

1. Transfer of technology on potato based farming system - its differential adoption, adaptability and constraints analysis.
2. Development of sampling methodology for surveys and the estimation of yield losses.
3. Economics and marketing of potato in Himachal Pradesh.

ENTOMOLOGY & NEMATOLOGY

1. Biology of Mysus persicae and other aphids transmitting potato virus diseases.
2. Ecology of potato pests and their natural enemies.
3. Bionomics and management of potato tubermoth.
4. Assessment of crop losses due to major potato insect pests.
5. Distribution, biology & management of nematode pests.
6. Surveillance and management of potato pests.

POST-HARVEST TECHNOLOGY

1. Determinants of keeping quality in potatoes under storage.

Table A. 6. 2. Number of CPRI research projects and scientists by divisions

Division	1985 - 86	Projects terminated in 1987	approved in 1987	1987-88	Scientists 31/12/87
Genetics	8	1	0	7	24
Physiology & Biochemistry	6	6	4	4	17
Crop & Soil Sciences	8	4	4	8	20
Plant Pathology	11	2	1	10	39
Entomology & Nematology	7	1	0	6	13
Seed Production	3	0	0	3	1
Social Sciences	1	1	3	3	8
Post-harvest Technology	1	1	1	1	0
Total	**45**	**16**	**13**	**40**	**122**

Annex 7. Kufri Varieties Released by CPRI

1958	1963-67	1968	1971-85
Kisan	Neela ('63)	Alankar	Muthu ('71)
Kuber	Sindhuri ('67)	Chamatkar	Lauvkar ('72)
Kumar		Chandramukhi	Dewa ('73)
Kudan		Jeevan	Badshah ('79)
Red		Jyoti	Bahar ('80)
Safed		Khasigaro	Lalima ('82)
		Naveen	Sherpa ('83)
		Neelamani	Swarna ('85)
		Sheetman	

Annex 8. Production and Distribution of Breeders' Seed

Table A. 8. 1. Production of breeders' seed by stage and station 1985/86 (t)

Station*	Production Stage I	II	III	IV
Hills 1986				
Kufri-Fagu	5.7	30.0	23.6	89.0
Plains 1985/86				
Machhari	4.9	16.3	93.5	606.7
Jalandhar	3.7	17.9	48.3	206.7
Gwalior	4.0	5.0	15.5	334.3
Patna	1.7	5.2	28.6	79.2
Subtotal	14.3	44.4	185.9	1,226.9
Total	**20.0**	**74.4**	**209.5**	**1,315.9**

Source: CPRI, Annual Scientific Report, 1986 (Shimla, 1988)

* Seed is also produced at the Ooty (42.8t), Mukteswar (26.3t) and Shillong (11.6t) hill stations; it is distributed only within these states because of disease problems and quarantine restrictions.

Table A. 8. 2. Breeders' seed distributed for further multiplication from plains and hills 1985/86 (t)

	From plains	From hills	Total
K.Chandramukhi	1	414	415
K.Badshah	0	315	315
K.Jyoti	112	86	198
K.Bahar	0	133	133
K.Sindhuri	0	132	132
K.Lalima	0	43	43
Others	1	3	4
Total	**114**	**1,126**	**1,240**

Source: CPRI Annual Scientific Report, 1986 (Shimla, 1988)

Table A. 8. 3. Breeders' seed distributed to different states and organisations by source 1985/86 (t)

	Plains	Kufri-Fagu	Total
State Governments			
Uttar Pradesh	353	20	373
Himachal Pradesh	72	40	112
Madhya Pradesh	105	0	105
Bihar	98	0	98
Haryana	71	0	71
Punjab	44	0	44
Jammu & Kashmir	15	10	25
West Bengal	22	0	22
Orissa	14	0	14
Karnataka	12	0	12
Arunachal Pradesh	3	8	11
Tamil Nadu	0	10	10
Tripura	7	0	7
Others	0	13	13
Subtotal	816	101	917
National Seeds Corp	196	0	196
SFCI	38	0	38
Private growers	58	9	67
CPRI stations	7	4	11
GB University	10	0	10
Subtotal	309	13	322
Total	**1,125**	**114**	**1,239**

Source : CPRI Annual Scientific Report 1986, (Shimla 1988)

Table A. 8. 4. Total amount of breeders' seed distributed 1965-1988 (t)

Year	Quantity	Year	Quantity
1965-66	462	1975-76	1,642
1966-67	527	1976-77	1,612
1967-68	641	1977-78	2,228
1968-69	569	1978-79	2,426
1969-70	544	1979-80	2,590
1970-71	553	1980-81	2,627
1971-72	1,014	1981-82	2,269
1972-73	1,096	1982-83	2,302
1973-74	1,322	1983-84	1,531
1974-75	1,608	1984-85	780
		1985-86	1,239
		1986-87	1,489
		1987-88	1,190

Low production due to late blight epidemic.

Annex 9. Major Publications of CPRI

Title	Author/Editor	Year of Publication	Type	No. of Pages
Potato in Karnataka	AV Gadewar and TP Trivedi	1988 (in press)	Technical Bulletin	46
Wart Diseases of Potato	PH Singh, SG Phadtare and GS Shekhawat	1988 (in press)	Technical Bulletin	30
Potato Tuber Moth with Special Reference to India	BT Raj	1988 (in press)	Technical Bulletin	29
Alu ki sudhari Kheti	Edit. Hira Nand & JP Sharma	1987	Extension Bulletin	113
Coping up with Drought in Potato Cultivation	Edit. NM Nayar, JS Grewal and SC Verma	1987	Extension Bulletin	5
Potato in Himachal Pradesh	Edit. KS K Prasad & NP Sukumaran	1986	Technical Bulletin	76
A Potato Store Run on Passive Evaporative Cooling	HN Kaul & NP Sukumaran	1984	Technical Bulletin	14
Potato Cultivars Released by the Central Potato Research Institute	PC Misra, PC Gaur & NM Nayar	1984	Technical Bulletin	26
Catalogue of Potato Germplasm Collection Group Tuberosum	PC Gaur, PC Misra & NM Nayar	1984	Technical Bulletin	38
Selection Procedure in Potato Breeding	PC Gaur, PC Misra & NM Nayar	1984	Technical Bulletin	6
Potato Production, Storage and Utilization	Edit. BB Nagaich	1983	Monograph	536
Potato in Developing Countries	Edit. BB Nagaich, PC Gaur, GS Shekhawat & SC Verma	1982	Proceedings	426
Investigation on Purple Top Roll and Witch's Broom disease of the Potato	BB Nagaich et al.	1978	Technical Bulletin	48
Recent Technology in Potato Improvement and Production	Edit. BB Nagaich	1977	Monograph	308
Utilization of Haploids in the Breeding and Genetics of Potato	Hari Kishore et. al.	1976	Technical Bulletin	64
Breeding Potato varieties resistant to Charcoal Rot	MD Upadhya, CL Khushu, SK Bhattacharya & Sheo Raj	1976	Technical Bulletin	31
Breeding Potato Varieties resistant to Brown rot	MD Upadhya	1976	Technical Bulletin	24
Investigations on Hairy Sprout diseases of potato	BB Nagaich et al	1973	Technical Bulletin	36
Heriditary variation in the ability of Myzus persicae to transmit potato leaf roll and virus Y	BB Nagaich, KD Verma & GC Upreti	1970	Technical Bulletin	22
Potato Cultivation in Kashmir, Problems and Prospects	Pushkarnath	1966	Technical Bulletin	23
Potato Cultivation in Mysore, Problems and Prospects	Pushkarnath	1966	Technical Bulletin	26
Potato Cultivation in Ceylon, Potentialities and Prospects	Pushkarnath	1966	Technical Bulletin	44
Potato in India	CPRI, Simla	1971,1977 & 1982	Technical Bulletin	50
Potato in India, Varieties	Pushkarnath	1964	Monograph	493
Package of Practices for table and Seed potato production in: i) North Western Hills v) Western Indo-Gangetic Plain ii) North Eastern Hills vi) Central Indo-Gangetic Plain iii)Uttar Pradesh Hills vii) Eastern Indo-Gangetic Plain iv) Nilgiri Hills viii)Plateau region	CPRI, Simla	1984 1985 1986 1987	Extension Bulletin	