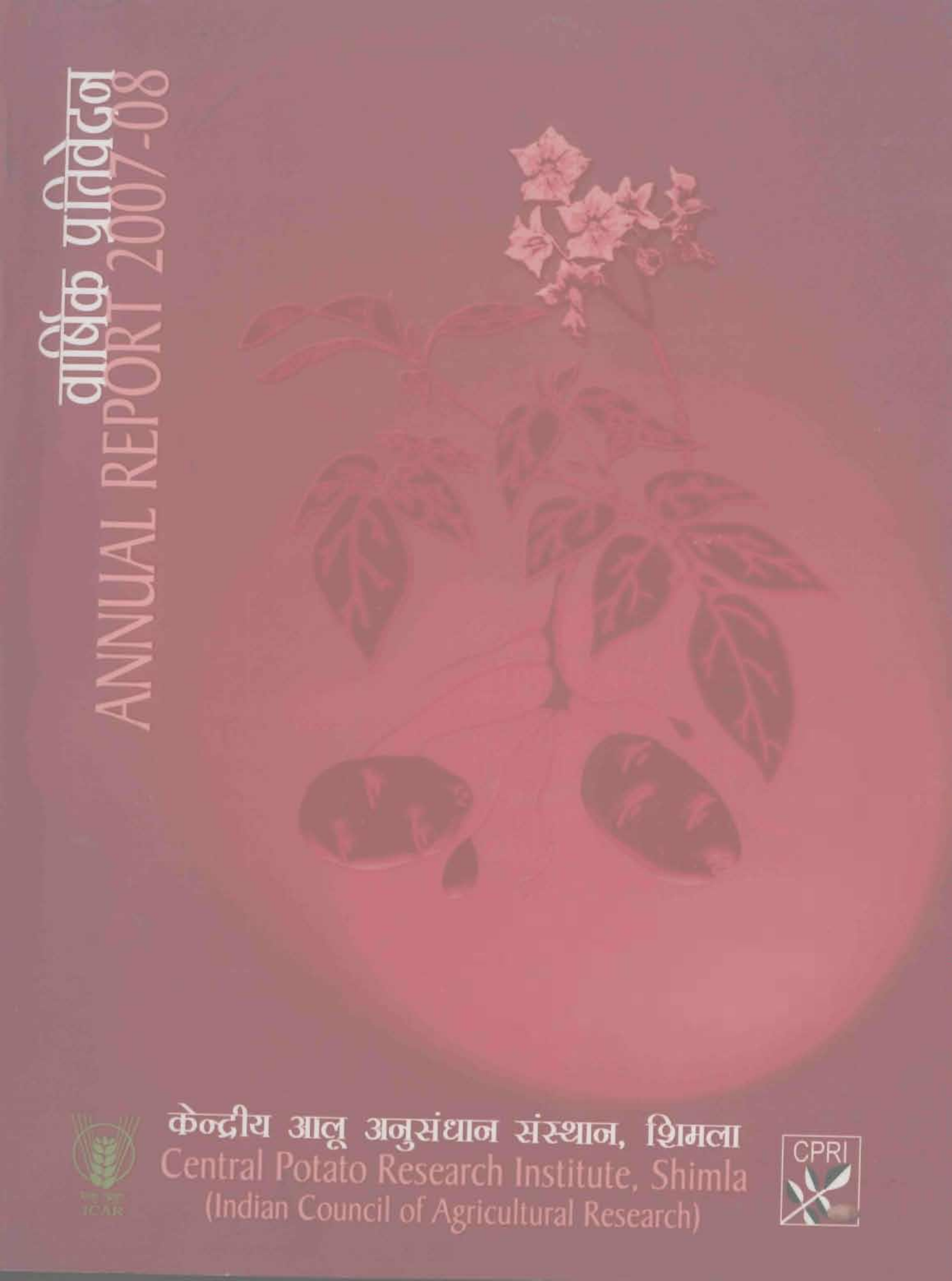
वार्षिक प्रतिवेदन
ANNUAL REPORT 2007-08



केन्द्रीय आलू अनुसंधान संस्थान, शिमला
Central Potato Research Institute, Shimla
(Indian Council of Agricultural Research)

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Editorial Board	:	SK Pandey, KC Sud, PM Govindakrishnan and SK Chakrabarti
Compilation & Production	:	Avnish Atrey
Photographs	:	DC Chandel, BS Latwal and Sham Sunder
Secretarial Assistance	:	Joginder Thakur and Sandeep Verma
Hindi Translation	:	Praveen Chandla and RS Kapoor

Published By: SK Pandey, Director, Central Potato Research Institute, Shimla - 171001 (HP)
Ph: 0177-2625073, 2624830 Fax: 0177-2624460 Email: dircpri@sancharnet.in
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New Delhi - 110028 Ph.: 25891449, 9811053617 E-mail: pawannanda2000@yahoo.co.in

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Preface

It is heartening to note that agricultural situation in the country took a better turn in the very first year of XI plan and is presently growing at the targeted 4% rate. The potato crop also showed an impressive growth over the last year. Our estimate based on remote sensing and GIS suggested an overall increase of 6.6% in potato acreage and 10% in production over last year. What is more satisfying is that in spite of a big jump in production, no threatening price collapse has been reported so far. It shows coming to maturity of the potato sector in the country.

Potato production and consumption is accelerating in most of the developing countries including India primarily because of increasing industrialization and participation of women in the job market. In fact, potato production in developing countries surpassed that of developed countries for the first time in the year 2006. This trend is expected to continue for years to come. The Food and Agricultural Organization (FAO) of the United Nations has recognized the potential role of potato in global food security and declared the year 2008 as the International Year of Potato. Potato is only the second crop after rice, which has been given that status by FAO. The role of potato in ensuring food and nutritional security of the country has been recognized well in advance by the National Agricultural Research System. What is still lacking is an appropriate policy support by the Government to encourage it to come to its blooming. The institute has already prepared a draft policy guidelines for appropriate development of the potato sector in India that can act as a primer for extensive deliberation. The R&D status of potato in India is well acclaimed throughout the world. Provided innovative policy support is given, the crop can bring prosperity and alleviate poverty in rural India.

During the year 2007-08, being the first year of the XI five year plan, many new initiatives were started based on analysis of critical gaps and thrust areas at the completion of X plan last year. The institute for the first time released an early-bulking variety that can give as high as 26 MT/ha yield within 60 days. Several other early-bulking hybrids are also in the pipeline that may eventually increase the area under potato by increasing the paddy-potato-wheat cropping system. Similarly, to fulfill the increasing demand of French Fry sector, a promising hybrid, MP/98-71 has been identified that can be released as a variety. It was also demonstrated that potato cultivation could be extended even to Goa with the availability of the heat tolerant variety Kufri Surya. The institute is nurturing a break through technology for conferring late blight durable resistance through genetic engineering. Successful exploitation of this technology may take care of a nagging disease problem in near future. Similarly, we are confident of tackling the debilitating problem of cold-induced sweetening in potato tubers through modern biotechnology. After a long and exhaustive trial, scientists in the Division of Crop Production have come out with packages for eco-friendly and remunerative management of natural resources with respect to potato cultivation. It came out that in many parts of Punjab farmers are practically wasting phosphorus fertilizer, since the available P in those soils is already above the threshold level. Another promising technology that can revolutionize on-farm potato storage for 3-4 months without sprouting and rottage has been perfected during the year. In the area of seed production, we are gradually replacing nucleus tuber seed stock with that of tissue culture raised material and we are confident that the target of 100% Breeders' seed production through tissue culture raised nucleus material will be achieved much before the targeted date of 2012. Besides, several other technological innovations were made in the area of crop production, plant protection, post harvest technology, and seed technology that would make potato cultivation a remunerative venture for Indian farmers. All the above achievements are described briefly in this report. In pursuance of our earlier commitment, the language of this report has been kept simple and narrative for better understanding of our diverse stakeholders.

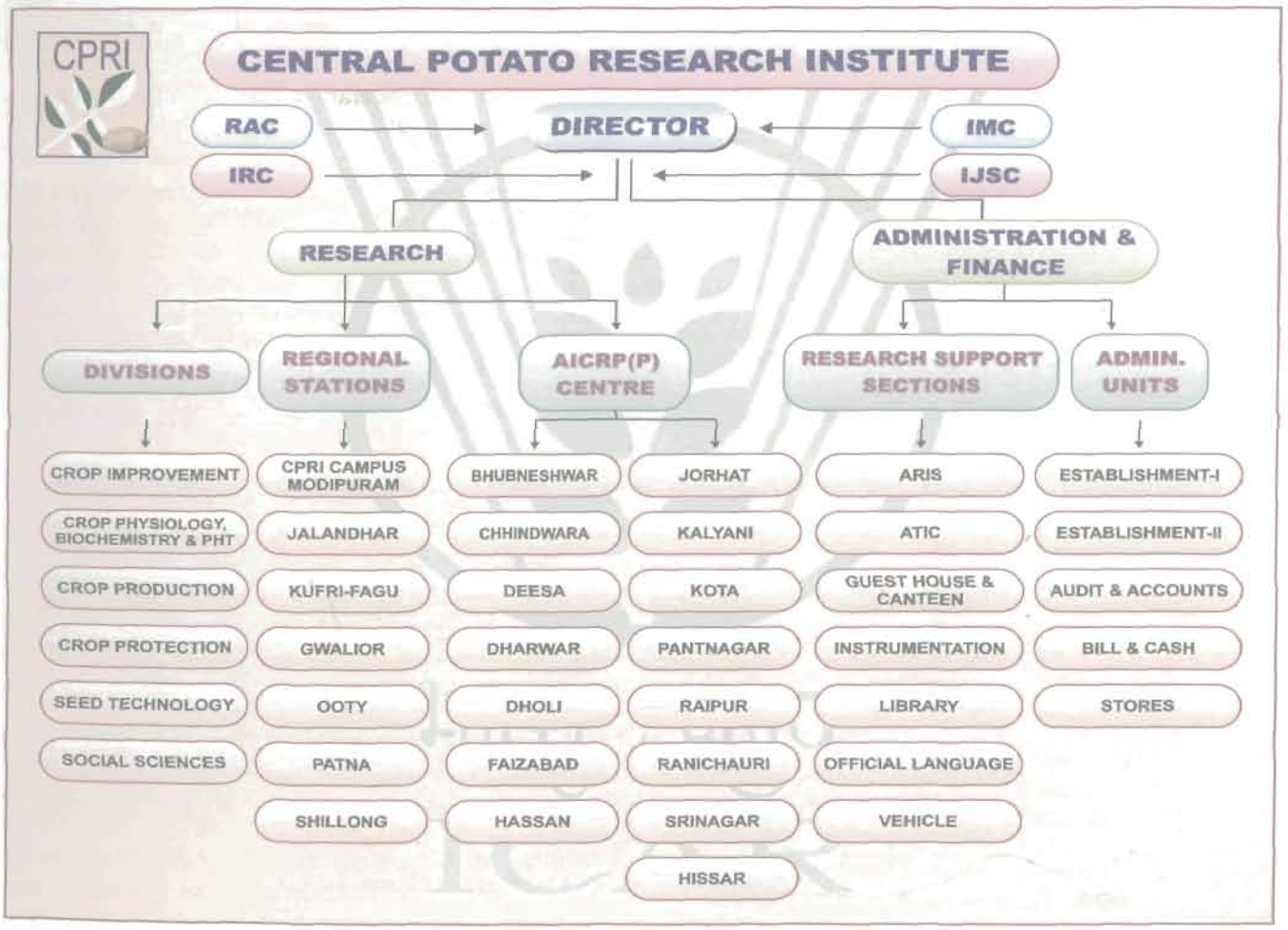
I shall be failing in my duty if I do not thank my staff for carrying out the various research activities as per plan and bringing out the results reflected in this report. I would like to thank all Heads of the Divisions as well as Stations including the Joint Director, CPRIC, Modipuram and Project Coordinator, AICRP (Potato) for compilation and timely submission of their respective reports. Thanks are also due to Drs. K.C. Sud, J.P. Singh, P.M. Govidakrishnan, and S.K. Chakrabarti for making this report crisp and comprehensive. Though every effort has been made to keep the report error free, yet comments from the readers will be valuable to us.

(SK Pandey)

Introduction

The Central Potato Research Institute (CPRI) was established under the Ministry of Agriculture, Government of India, in August 1949 at Patna. The headquarters of the Institute was shifted to Shimla in 1956. The CPRI is situated in the heart of Shimla city, near Bemloi, which is approximately 4 kms from Shimla Bus Stand and 6 kms from Shimla Railway Station on the National Highway No. 21. The seat of the Institute is at an altitude of 2,000 metres above mean sea level and has wet temperate climate. The Institute was transferred to the Indian Council of Agricultural Research (ICAR) in April 1966.

Initially, the CPRI had 3 research stations at Shimla, Kufri, and Bhowali. With the expansion of potato cultivation in major potato growing regions of the country, new stations have been created since its inception in 1949. Presently, it has one campus at Modipuram (UP) and 6 regional research stations in different potato growing areas of the country. These are located in Kufri-Fagu (HP), Jalandhar (Punjab), Gwalior (MP), Patna (Bihar), Shillong (Meghalaya), and Ootacamund (Tamil Nadu). The All India Coordinated Research Project on Potato started in 1971 also has its Hqrs. at Shimla and 21 centres located in SAU's and CPRI Stations. The Institute work is being carried out by a team of dedicated potato scientists ably supported by Technical, Administrative & Supporting Staff. The organization of the Institute is as under:



Achievements

The Central Potato Research Institute (CPRI) is a nonprofit scientific institution under the Indian Council of Agricultural Research, working exclusively on potato. The institute has played a key role in popularizing potato cultivation and utilization under sub-tropical agroecosystem. We believe that potato can play an important role in food and nutritional security of India, while helping the rural poor to rise out of poverty. The institute focuses all its energy to make that belief becomes a reality.

- To undertake basic and strategic research for developing technologies to enhance productivity and utilization of potato.
- To produce disease-free basic seed of notified varieties developed by the Institute.
- To act as a national repository of scientific information relevant to potato.
- To provide leadership and co-ordinate network research with state agricultural universities for generating location and variety specific technologies and for solving area-specific problems of potato production.
- To collaborate with national and international agencies in achieving the above objectives.
- To act as a centre of training in research methodologies and technology for upgrading scientific manpower in modern technologies for potato production.
- To provide consultancy in potato research and development.

Work of the Institute is being carried out by the six Divisions; Crop Improvement, Crop Protection, Crop Production, Crop Physiology & Post Harvest Technology, Seed Technology and Social Sciences under 21 well defined research programmes. In addition to regular research programmes, 18 externally funded research projects sponsored by the ICAR, NATP, CSIR, DBT and Mini Mission-1 are also under operation. Production of Breeders' seed is being done by the Institute under a Revolving Fund Scheme.

Achievements

- Established a germplasm collection consisting of around 3,000 accessions.
- Released 45 high yielding varieties suitable for cultivation under diverse agro-climatic conditions of the country. These varieties occupy about 95% of the total potato growing area of the country.
- Developed the "Seed Plot Technique" and established a national disease-free seed production programme for hills and plains.
- Standardized techniques for micro-propagation, *in vitro* microtuber production and rapid multiplication.
- Produced transgenic potatoes with durable resistance to late blight, reduced cold-induced sweetening, bacterial wilt tolerance, and better protein quality.
- Developed technology for raising commercial crop using true potato seed (TPS).
- Developed recommendations for fertilizer application and other cultural practices of potato for diverse agro-climates of the country.
- Identified profitable potato-based cropping systems for different agro-climatic zones of the country.
- Developed agricultural implements, including an oscillating tray type potato grader, fertilizer applicator-cum-line marker, potato culti-ridger, soil crust brakers, granular insecticide applicator, two/four row automatic potato planter, culti-ridger and potato digger.
- Developed late blight forecasting systems for the hills as well as for plains.

- Developed integrated package of practices for management of late blight, bacterial wilt, viruses, and soil- and tuber-borne diseases. Identified sources of resistance to major diseases.
- Developed modified ELISA procedures and immunosorbent electron microscopic techniques for detection of potato viruses.
- Conducted aphid surveys that led to the identification of low aphid periods for growing seed potatoes.
- Carried out basic studies on photosynthesis.
- Developed methods of screening for high thermo-period resistance and used them to select heat tolerant lines.
- Established relationship between tuber dry matter content and specific gravity for different cultivars in five agro-climatic zones, and identified areas for producing high dry matter potatoes suitable for processing. Studied sugar accumulation in potatoes stored at different temperatures and identified genotypes that accumulated less reducing sugars.
- Demonstrated the efficiency of chemical control of sprouting during non-refrigerated storage and the feasibility of on-farm storage of potatoes in an insulated potato store equipped with passive evaporative cooling.
- Transferred potato technology under Lab-to-Land, ORP, TAD and other programmes, like "Potato School on Air".
- Collected country-wide statistics on potato production, area, yields and prices. Prepared annual Quick National Outlook Surveys for estimating potato production and prices.
- Conducted training programmes on modern methods of potato production and seed certification, apart from Farmers, *Melas*, etc.

Staff & Finance

The Institute has 690 sanctioned staff strength comprising of 109 Scientists, 207 Technical, 122 Administrative and 211 supporting staff. The staff position as on 31.03.2007 was 92 Scientific, 189 Technical, 113 Administrative and 175 Supporting staff. The expenditure of the Institute for the year (Plan & Non-Plan & others) was Rs 298.01 million and receipts Rs. 46.10 million including RFS. The CPRI generated about 16% of its total budget from its own resources i.e. from the sale of seed, farm produce, Revolving Fund Scheme, consultancy, etc. The Revolving Fund Scheme sanctioned in 1991 by the ICAR with seed money of Rs. 40.0 lakhs now generates revenue to the tune of Rs. 155.6 lakh per year and the scheme has been most successful and widely acclaimed. During the year, 11 scientists and 2 administrative officers were transferred from CPRI to other institutes beside 15 staff members retired. Shri AK Singh, Sr. Administrative officer joined the Institute.

Facilities

The Institute has 521 ha land for laying experiments and undertaking breeders seed production distributed over 15 units. CPRI Library is the second largest Potato Library in the world. Besides, the institute has well-equiped ARIS cell, ATIC, museum, auditorium, conference hall, committee room at the Hqrs. and similar facilities have been provided at the regional stations. Institute is fully equipped to organize training programmes with AV aids, hostel, etc. A separate administrative building has been completed during the year. In addition, new pathology laboratory and two additional rooms for library have been made functional.

The institute created state-of-the-art laboratories for conducting basic and strategic research in the field of biotechnology, genetics & plant breeding, plant protection, soil science & agronomy, plant physiology, biochemistry & post harvest technology. CPRI is the first plant science research institute in India to introduce ELISA in 1984 and ISEM in 1987 for plant virus diagnosis. The virus diagnosis laboratory is now equipped with automated ELISA system, PCR and NASH facilities. Because of its unique record in the field of virus diagnosis, this laboratory has been notified by the Govt. of India as a referral laboratory for potato virus diagnosis and detection.

The biotechnology laboratory of the institute inaugurated by Prof. V.L. Chopra, Ex. DG, ICAR in 1992, has all the modern facilities for transgenic research, DNA finger printing, molecular breeding, micro propagation and cryo conservation. A new laboratory has been created for undertaking basic research on cell biology and somatic cell genetics. The radio-tracer laboratory has been created in 1996 for carrying out basic research on nutrients dynamics in soil and plant system. The institute has well equipped fungal pathology laboratory that has world class facility for basic and applied research on late blight pathogen. Besides, the institute also has good laboratories for plant physiology & post harvest technology related works.

Research Achivement

- Germplasm collection was augmented by adding cultivated and wild species from Peru, Korea and USA, thereby raising the total collection to more than 3,000 accessions.
- Released the early-bulking variety Kufri Khayati (J.93-86) for Indian plains, medium maturing late blight resistant variety Kufr Girdhari (SM/93-237) for Indian hills, Kufri Sadabahar (MS/93-1344) for Uttar Pradesh; and the processing variety Kufri Himsona (MP/97-644) for hills.
- Identified the advanced hybrid MP/98-71 suitable for making French Fries. The hybrid may become the first ever variety from India suitable for making French Fry.
- Promising hybrids of Kufri Bahar/Kufri Jyoti x RB-transgenic Katahdin identified. RB-transgenic lines of Kufri Bahar and Kufri Jyoti were confirmed to have RB gene integration.
- Putative transgenic lines of Kufri Jyoti and Kufri Chipsona-1 with reduced cold induced sweetening developed. Binary vectors carrying the *CP* gene of PVY in sense, antisense and non-translatable orientations as well as *replicase* gene of ToLCNDV in antisense, sense, and hairpin-loop orientations designed.
- Phenotypic characterization of androgenic dihaploids was done. Their ploidy was confirmed by the nDNA 2C values and chromosome analysis. An improved reproducible protocol was optimized for protoplast isolation and culture.
- Demonstrated that remunerative cultivation of potato could be undertaken at Goa using the heat tolerant variety Kufri Surya.
- Intercropping of gram, lentil, and vegetable peas with potato increased net returns by Rs.4,392, 5,604 and 11,900/ha, respectively at Jalandhar. Highest system productivity was obtained in case of maize–potato–onion (45.7t/ha), followed by paddy–potato–wheat (43.2t/ha).
- Thematic maps of potato acreage and production statistics at district level was compiled and prepared. An overall increase of 6.6% in potato acreage and 10% increase in potato production over the last year's estimates were forecast.
- It was demonstrated that it is necessary to apply phosphorus fertilizer based on soil test. One-fourth of recommended P_2O_5 is required in soil with > 20 ppm available P. Kufri Pukhraj, Kufri Ashoka, Kufri Sutlej, Kufri Bahar, Kufri Jawahar, Kufri Badshah, Kufri Jyoti, Kufri Sindhuri, Kufri Lalima and Kufri Chandramukhi are the varieties in decreasing order of efficiency in terms of phosphorus uptake.
- Irrigation scheduling based on cumulative pan evaporation (CPE) gave higher yield compared to irrigation at critical stages. Sprinkler irrigation significantly increased processing grade and total tuber yield over that of conventional irrigation.
- A rotary tiller with crumbler roller, a manually operated sieve type or endless screen type of potato grader and wire belt type potato grading system were fabricated. The design of French fry cutting machine and the tractor operated wide row ridger were refined. Pallets of different designs made of wood and metal were fabricated for a 2 t forklift in rough and unlined surfaces.

- Virus-free mericlones of Kufri Pushkar were obtained after repeated attempts. Similarly, mericlones of 133 germplasm accessions were tested with IEM for virus infection and 64 were found to be free from PVX and PVY.

- Forty F1 hybrids positive for PVY° extreme resistance gene (positive for SCAR marker), the variety Kufri Himalini and germplasm accessions CP 1496, CP 4578, CP 2246 and CP 2362 and were found resistant to both PVX and PVY.

- Late blight attack was severe in the state of Karnataka with an average crop loss of 43%. The regression models developed for predicting yield loss in HP hills was validated and gave accuracy to the tune of 87-92 %. Methanol extract of one of the plant species gave late blight control comparable to that provided by mancozeb.

- An integrated tuber treatment comprising *Bacillus subtilis* or *Trichoderma viridae* plus boric acid exhibited a synergistic effect for control of *Rhizoctonia solani*. The dose of boric acid could be reduced to just half if used together with *T. viridae*.

- White grub caused 19-85% tuber damage at Shilaroo, Kharapathar and Kheradhar. Collection of white grub adults with light traps at Fagu during June helped in the reduction of grub population by 50,000.

- Traditional method of potato storage in heaps and pits was improved with single spray application of CIPC. CIPC residues in peels of treated potatoes was only 0.11-3.22 ppm after 100 days of storage.

- Reconditioning of potatoes at 20°C for 15 days after 120 days storage at 4°C improved the chip colour to acceptable level in Kufri Chipsona-1.

- The acrylamide content in chips prepared from Kufri Jyoti tubers was significantly higher than that in Kufri Chipsona-1 and Kufri Chipsona-2 and there was a positive correlation (r=0.80 **) between acrylamide content and chip colour score.

- Approximately 2,515 metric tones (MT) of Breeders' seed was produced from an area of 130.73 ha out of which 2,035 MT was supplied to different stakeholders. At CPRS, Ooty a total of 115 MT quality seed was produced in an area of 8.75 ha and 74 MT was supplied to the farmers.

- It was the third year of targeted achievement of 100% breeder seed production through micro-propagated nucleus material. In this year, 12.3% area for Breeders' seed production was covered with tissue culture raised material and 255 MT seed was produced. This material will cover 71% of the total area next year.

- Internal Rate of Return (IRR) to the research cost for developing the two processing varieties, Kufri Chipsona 1 and Kufri Chipsona 2 was estimated to be as high as 55.28%. Multiyear financial transaction was converted into their present value using Consumer Price Index (CPI). Present Net Worth (NPW) at 0, 5 and 10% rate of interest was Rs 210.92, Rs 96.85 and Rs 46.11 crore respectively. The benefit-cost ratio of K. Chipsona 1 was 1.91 against 1.61 for the average of all potato varieties grown on the farmers' fields in UP.

- An average yield of 230 q/ha was obtained in the demonstration plots at Kharapathar and Koti areas of the Shimla district of Himachal Pradesh compared to 140 q/ha in farmers' plots. The incidence of late blight and white grubs in farmers' plots were 8% and 11% as against 5% and 2%, respectively in demonstration plots.

- The institute held 3 Kisan Melas/Field Days where approx. 2,000 farmers participated. Besides, about 3,000 persons visited the ATICs for collecting information on potato.

सारांश

फसल सुधार

पेरु, कोरिया व संयुक्त राज्य अमेरिका से प्राप्त कल्टीवेटेड व जंगली प्रजतियों को सम्मलित कर जर्मप्लाज्म संग्रहण में वृद्धि की गई। इस प्रकार कुल 3000 से भी अधिक एक्सेशन का संग्रह तैयार किया गया। खेत, कांचघरों, इन विट्रो तथा सत्य आलू बीज के रूप में इस संग्रह का रखरखाव किया गया। विभिन्न बायोटिक व अबायोटिक स्ट्रेसेस, भण्डारण गुणवत्ता, विधायनित गुणों, कम्बाइनिंग एबीलिटी व विभिन्न उष्मा प्रकाशकाल में इसकी उपयुक्तता के लिए काफी बड़ी मात्रा में एक्सेशनों को मूल्यांकन किया गया।

बीज उपज व आम प्रभाव के तौर पर सी.पी 2110 (CFK 69.1) एक विश्वसनीय परीक्षक पाया गया तथा सी. पी 2351 (टॉविक) पिछेता झुलसा प्रतिरोधी रहा। डीटैच-लीफ प्रणाली के साथ-साथ खेतों में 39 सोलेनम प्रजातियों के 586 पुजकों की स्क्रीनिंग में 47 पुंजकों में भारी प्रतिरोधिता देखी गई। आलू जनन द्रव्य (एण्डीजीना संग्रहण सूमह) का विवरण प्रकाशित किया गया।

विगत तीन/चार वर्षों में स्थाई निष्पादन के आधार पर जालन्धर के जे.99-48 व जे. 99-242 नामक दो संकर, मोदीपुरम के एम.एस./2-1741 व एम.एस./2-3964 नामक संकरों व पटना के 2000 पी. 55 नामक संकरों को अखिल भारतीय समन्वित अनुसंधान परियोजना (आलू) में शामिल करने के लिए प्रस्तावित किया गया। मैदानी क्षेत्रों के लिए पिछेता झुलसा के सामान्य प्रतिरोधक अगेती संकर जे. 93-86 को कुफरी ख्याति किस्म के रूप में जारी करने की सिफारिश की गई। उत्तर प्रदेश के लिए एम.एस. /93-1344 नामक संकर को कुफरी सदाबहार किस्म के नाम से जारी किया गया।

फ्रेंच फ्राई उत्पादन के लिए एडवास प्रोसेसिंग संकर एम.पी./98-71 विश्वसनीय व उपयुक्त पाया गया। पहाड़ी इलाकों के लिए विधायनित उत्पादन चिप्स बनाने के लिए उपयुक्त संकर एम.पी/97-644 को कुफरी हिमसोना किस्म के नाम से जारी किया गया।

78 संकरणों से कुल 6.61 कि.ग्रा. सत्य आलू बीज का उत्पादन किया गया। सत्य आलू बीज को 3-4 माह तक 40 डिग्री से. के तापमान पर भण्डारित करने से अंकुरण में सुधार देखा गया। एच.पी.एस.-63/54, एच. पी.एस.-59/13 व एच.पी.एस.-59/54 जैसे तीन समष्टि (पॉपूलेशन) विश्वसनीय पाए गए। कुफरी हार व कुफरी ज्योति की आर.बी. ट्रान्सजेनिक लाइन्स एस.पी. 904/एस. पी. 951 के एफ$_1$सी$_1$ पुंजकों में पिछेता झुलसा रोग की प्रतिरोधिता पाई गई। शीत प्रेरित मीठापन कम करने के लिए आलू की कुफरी ज्योति व कुफरी चिप्सोना-1 किस्मों को जीन के साथ ट्रान्सफार्म किया गया। शीत प्रेरित मीठापन करने के लिए आलू की मेडीकेटेड साइलेन्सिंग वैक्योलन इनवर्टेस जीन के लिए इन्ट्रॉन युक्त इनवर्टेस इनवर्टेड रीपीट जीन कन्सट्रक्ट तैयार की गई। पी.वी.वाई. के सी.पी. जीन का सेन्स, एन्टीसेन्स व नॉन-ट्रान्सलेटेबल दिशा में बाइनरी वेक्टर तैयार किया गया। बाइनरी वेक्टर, जिसमें एन्टीसेन्स, सेन्स व हेयरपिन लूप कन्सट्रक्स थे उससे ट्रान्सफोर्मेशन वेक्टर बनाया गया तथा संभावित कुफरी बादशाह की ट्रान्सजेनिक शाखाओं में एन्टीसेन्स रेप्लीकेस जीन पुनर्जनित किए गए। AFLP के द्वारा सोलेनम

स्पेगेजिन्नी × सोलेनम काकोन्स के 126 पुंजक को जेनोटाइप्ड किया गया।

एन्ड्रोजेनिक डाईहिप्लाइड की फेनोटाइपिक परीक्षण किया गया। प्रोटोप्लास्ट आइसोलेशन व कल्चर के लिए एक सुधरे रीप्रडयूसेबल प्रोटोकाल का निर्धारण किया गया।

फसल उत्पादन

आलू+फ्रेंचबीन की अन्तःफसल में उर्वरकों की आवश्यकता जानने के लिए उदागामण्डलम (तमिलनाडु) व शिमला में अध्ययन किए गए। उदागामण्डलम में आलू+फ्रेंचबीन का अनुपात 75:50 रखा गया और दोनों फसलों के लिए एकल क्षेत्र के आधार पर सिफारिश की गई नाइट्रोजन, फासफोरस व पोटेशियम (NPK) की 75 प्रतिशत मात्रा पर्याप्त रही। शिमला में दोनों फसलों का अनुपात 1:1 था और फ्रेंचबीन फसल के लिए सिफारिश की गई नाइट्रोजन की मात्र 75 प्रतिशत मात्रा की आवश्यकता हुई। ग्वालियर में आलू+मटर की अन्तः फसल का मानकीकरण किया गया। आलू की बीजाई मेड़ों पर और मटर की बीजाई मेड़ों के दोनों तरफ ज़िग-ज़ैग ढंग से करना बेहतर पाया गया। जालन्धर में किए गए अध्ययनों में आलू की फसल के साथ चना, मसूर व मटर की अन्तःफसलें उगाने पर शुद्ध लाभ में प्रति हेक्टेयर क्रमशः 4392/-, 5604/- व 11900/- रूपये की बढ़ोतरी हुई।

दूर संवेदी (रिमोट सेन्सिंग) से वर्ष 2007-2008 में शीतकालीन आलू की फसल के लिए पंजाब, उत्तर प्रदेश, बिहार व पश्चिमी बंगाल राज्यों का अनुमानित क्षेत्र क्रमशः 66.6, 425.0, 169.7 और 335.0 हजार हेक्टेयर रहा तथा INFOCROP-POTAO मॉडल के अनुसार इन राज्यों में क्रमशः 1205.5, 9137.0, 1707.2 व 7504.0 हजार टन अनुमानित उत्पादन हुआ। पिछले वर्ष की भविष्वाणी की तुलना में इस वर्ष आलू उत्पादक क्षेत्र में 6.67 प्रतिशत एवं उत्पादन में 10 प्रतिशत बढ़ोतरी का पूर्वानुमान लगाया गया है।

वर्ष के दौरान जिले स्तर पर आलू के उत्पादक क्षेत्र व उत्पादन संबंधी आंकड़ों का सेंकलन कर थीमेटिक मानचित्र तैयार किया गया। राष्ट्रीय औसत पैदावार को ध्यान में रखते हुए आलू उत्पादक विभिन्न जिलों की सापेक्षिक पैदावार के प्रकरणों (themes) एवं आलू उत्पादक कृषि पारिस्थितिक क्षेत्र तैयार किए गए।

जहां तक विभिन्न किस्मों की फास्फोरस उद्ग्रहण क्षमता का प्रश्न है उस स्थिति में घटते क्रम में कुफरी पुखराज के बाद कुफरी अशोक, कुफरी सतलुज, कुफरी बहार, कुफरी जवाहर, कुफरी बादशाह, कुफरी ज्योति, कुफरी सिन्दूरी, कुफरी लालिमा और कुफरी चन्द्रमुखी का स्थान रहा। नाइट्रोजन उद्ग्रहण क्षमता का संबंध पौधों की जड़ वृद्धि से रहा तथा कुफरी ज्योति की तुलना में नाइट्रोजन उदग्रहण सक्षम कुफरी पुखराज किस्म की जड़ की बढ़वार (जड़ का ताजा भार, जड़ की लम्बाई, जड़ का सतह क्षेत्र और जड़ अंकुर अनुपात) अधिक रहीं।

मोदीपुरम में किए गए परीक्षणों में क्रान्तिक अवस्थाओं में की गई सिंचाई की तुलना में 20 मि.मी. क्यूमूलेटिव पैन इवोपरेशन (सी.पी.ई.) के जल स्तर में आलू की अधिक उपज (35.5 टन/हे.) प्राप्त हुई और उसके बाद 25 मि.मी. सी.पी.ई. का स्थान रहा। मोदीपुरम में परम्परागत ढंग से सिंचाई करने की अपेक्षा छिड़काव (स्प्रिंकलर) विधि से सिंचाई करने से विधायन ग्रेड के कन्दों और कुल कन्द पैदावार में क्रमशः 51.8 प्रतिशत और 40.4 प्रतिशत वृद्धि हुई। शिमला के पहाड़ी इलाकों में, वर्षा आधारित फसल की तुलना में 50 और 75 प्रतिशत उपलब्ध मृदा नमी होने से पैदावार में क्रमशः 15.6 और 4.4 प्रतिशत वृद्धि हुई। पैदावार वृद्धि में बड़े आकार के कन्दों का योगदान था।

मोदीपुरम में दीर्घकालिक उर्वरक/खाद परीक्षण के अध्ययनों से मक्का-आलू-प्याज की फसल प्रणाली में सबसे अधिक पैदावार (45.7 टन/हैकटर) प्राप्त हुई और उसके बाद धान-आलू-गेहूँ की फसल प्रणाली से प्राप्त पैदावार (43.2 टन/हेक्टेयर) का स्थान रहा। जैविक स्रोतों व फसल अवशेषों के प्रयोग द्वारा शतप्रतिशत पोषक तत्वों की प्राप्ति के फलस्वरूप कन्दों में अधिकतम शुष्क पदार्थ प्राप्त हुए। जैविक/कार्बनिक खादों का प्रयोग करने पर मृदा की गुणवत्ता में जैविक कार्बन, सूक्ष्म जीवाणुयुक्त जैवकि कार्बन, डीहाइड्रोजीनेज क्रिया, मृदा की जल धारण क्षमता व मृदा समूहन आदि में सुधार हुआ जबकि आभासी घनत्व (bulk density) में कमी हुई।

यन्त्रों के निर्माण एवं विकास सम्बन्धित कार्यों के मामले में क्रमबलर रोलर सहित रोटेरी, रोलर, हाथ से चलाने वाले छानने आइप या सिरा रहित छानने टाइप का आलू ग्रेडर ओर वायर बेल्ट टाइप की ग्रेडिंग प्रणाली के निर्माण एवं विकास के प्रयास जारी रहे। फ्रेंच फ्राइज

काटने वाली प्रोटोटाइप मशीन के फ्रेम, कन्द उठाने व काटने की यान्त्रिकी तथा ऑपरेटर की सुरक्षा व इसके आपरेशन को सुचारू रूप से चलाने की दृष्टि से सुधार किए गए। दो प्रोटोटाइप मशीनों का निर्माण किया गया।

मेड़ों की ऊंचाई 13-25 सेंटीमीटर तक बढ़ाने के लिए ट्रेक्टर चालित चौड़े पंक्ति रिजन में एडजस्टएबल सक्रेबर को जोड़ कर सुधार किया गया। टाइन लगे ट्रेक्टर चालित दो पंक्तियों वाले इन्टर-कल्टीवेटर में सुधार किया गया। खेत परीक्षणों के आधार पर चार फाली को प्रत्येक पंक्ति की दूरी 170 मिलीमीटर पर टेढ़ा-मेढ़ा जोड़कर रखा गया।

उबड़-खाबड़ और असमतल स्थानों से 2 टन तक फोर्क या पंजेनुमा मशीन से वजन उठाने के लिए लकड़ी व धातु के अलग-अलग डिजाइनों के पैलेटों का निर्माण किया गया। लकड़ी से बने पैलेट की तुलना में धातु से बने पैलेट अधिक कारगर रहे। 8-12 ट्रे के लिए बड़ी ट्रॉली की बड़े पैमाने पर जांच की गई। 300 और 375 मिलीमीटर व्यास के पहियों की तुलना में 500 मिलीमीटर व्यास के पहियों से ट्राली को खींचने के लिए कम बल लगाना पड़ा।

पौध संरक्षण

विषाणुओं व वाइरायड का निदान

इम्यूनो-इलेक्ट्रॉन माइक्रोस्कोपी (आई.ई.एम.) से वायरस संक्रमण आंकने के लिए 80 जनन द्रव्य व 53 Dus रिफरेन्स संग्रहण एक्सेशन के 280 मेरीक्लोन्स का परीक्षण किया गया। वी.पी. एक्स व पी.वी.वाई. की प्रतिरोधिता के लिए पहले वर्ष 60 और दूसरे वर्ष 22 जनन द्रव्य एक्सेशनों की जांच की गई। सी.पी 1496, 4578, 2246 व 2362 पी.वी. एक्स. व पी.वी.वाई. संभावित चालिस संकरों में पी.वी.वाई. की चरम प्रतिरोधिता पाई गई। कुफरी शैलजा व कुफरी चिप्सोना-3 इसकी ग्राही पाई गई जबकि कुफरी हिमालनी में हाइपरसेन्सीटिव प्रतिरोधिता देखी गई। PSTVd संक्रमण के लिए 332 नमूनों की स्क्रीनिंग की गई। कई प्रयासों के बाद कुफरी पुष्कर के वायरस मुक्त मेरीक्लोन्स प्राप्त किए गए। सुषुप्त कन्दों में वायरस की पहचान के एिल आर.टी.-पी.सी.आर. व इम्यूनो इलेक्ट्रॉन माइक्रोस्कोपी से तुलनात्मक अध्ययन किए गए। आर.टी.-पी.सी.आर व इम्यूनो इलेक्ट्रॉन माइक्रोस्कोपी दोनों से केवल पी.वी.एस., पी.वी.एक्स व पी.वी.एम. की पहचान हुई जबकि इम्यूनो इलेक्ट्रॉन माइक्रोस्कोपी से केवल पी.वी.ए. व पी.वी.वाई. की पहचान हो पाई। जीन की प्रतिशता सुनिश्चित करने के लिए पी.सी.आर. से पी.एल.आर.वी. की सी.पी.जीन के साथ कुफरी पुखराज की चौदह लाइन्स का ट्रान्सफार्म करके परीक्षण किया गया।

पिछेता झुलसा प्रबन्धन

इस वर्ष कर्नाटक राजय में पिछेता झुलसा का प्रकोप काफी भयंकर रहा, जिससे फसल को औसतन 43 प्रतिशत नुकसान हुआ। हिमाचल प्रदेश की पहाड़ियों में मेटालेक्सिल की सहनशीलता 400 ppm तक, पंजाब में 300 ppm, उत्तर प्रदेश में 200 ppm व बिहार राज्य में 150 ppm रही। उपोष्ण मैदानों में A_2 मेटिंग टाइप लगातार 0-15 प्रतिशत बने रहे। देश के सभी हिसर्से में कॉम्पलेक्स रेसेस (7-11 जीन फ्रिक्वेन्सी) प्रभावी रही। हिमाचल प्रदेश की पहाड़ियों पर इनका अधिकतम प्रभाव देश गया। दिलचस्प बात यह रही कि कुछ आइसोलेट्स के जूस्पोर्स 34 डिग्री से. के तापमान पर भी सफलतापूर्वक अंकूरित हो सके। हिमाचल प्रदेश की पहाड़ियों के लिए विकसित किए गए रिग्रेशन मॉडल 87-92 प्रतिशत सही पाए गए। जनरेशन आधारित सस्यीय परीक्षण व पिछेता झुलसा प्रतिरोधिता के लिए F_1C_5 से पांच, F_1C_6 से दो व F_1C_7 से एक संकर का चयन किया। छोटे दिनों की परिस्थितियों में SM/92-338 का भी निष्पादन अच्छा रहा। एडवान्स संकर SM/93-237 को कुफरी गिरिराज किस्म के रूप में जारी करने की सिफारिश की गई।

एकीकृत रोग प्रबन्धन

खेतों में रसेट स्कैब की ग्राहिता देखने के लिए आलू की 16 किस्मों की स्क्रीनिंग की गई। रोग की तीव्रता को देखते हुए इन्हें तीन समूहों में विभाजित किया जा सकता है। रसेट स्कैब के नियन्त्रण के लिए वर्ष के दौरान किए गए सात विभिन्न मिट्टी उपचारों में मध्य मई से मध्य जून के दौरान सॉसयल सोलेराइजेशन करना सर्वोत्तम रहा। राइजोक्टोनिया सोलानी के नियंत्रण के एिल बैसीलस सबटिलिस या ट्राइकोडर्मा वीरीडे + बोरिक एसिड का एकीकृत कन्द उपचार ने योगवाही प्रभाव दिखाया। खेतों में किए गए परीक्षणों में पाया गया कि यदि ट्राइकोडर्मा वीरीडे के साथ

बोरिक एसिड का उपचार किया जाए तो इस प्रकार बोरिक एसिड की आधी मात्रा ही पर्याप्त होती है। बैसीलस सबटिलिस (B_s) के मेटॉबोलीटिस के विश्लेषण में इटूरिन, बायोमाइसिन व चालकोन की उपस्थिति प्रदर्शित की।

एकीकृत कीट प्रबन्धन

JEX/A-91 व CP/1851 के जर्मप्लाज्म एक्सेशन, पोटेटो टयूबर मॉथ (पी.टी.एम.) सहनशील पाए गए। शिलांग में देशी भण्डारों में भण्डारित कन्दों में पी.टी.एम. का संक्रमण सी.आई.पी.सी. के उपचार की स्थिति में 0.17 प्रतिशत तथा लेन्टाना पत्तियों के साथ 0.33 प्रतिश रहा। शिलारू, खड़ापत्थर व खेड़ाधार में श्वेत सुण्डियों से कन्दों को 19-85 प्रतिशत नुकसान हुआ। फागू में जून माह के दौरान प्रकाश ट्रैप से वयस्क श्वेत सुण्डियों को पकड़ने पर इनकी संख्या में 50,000 की कमी आई। श्वेत सुण्डी के नियन्त्रण के लिए नीम व जट्रोपा, रीठा की गिरी और क्राइसेन्थियम की पत्तियों के सत का जानवरों के मूत्र में मिलाकर उपचार करना प्रभावशाली रहा। इसके अतिरिक्त कीट रोगजनक नेमोटोड *स्टनेरनिमा कार्पोकैप्सी* व *हैटरोहैबडीटिस इण्डिका* भी श्वेत सुण्डी के नियन्त्रण के लिए प्रभावकारी रहे। मिट्टी से पृथक 22 व रोगी सुण्डी से पृथक 6 जीवाणुओं का अध्ययन किया गया। इनमें से 11 श्वेत सुण्डियों में शत प्रतिशत मृत पाए गए। सुण्डियों के नियन्त्रण के लिए मिट्टी से पृथक 23 फफूंद और रोगी व मृत सुण्डियों के 8 फफूंद का दूसरी इन्स्टार अवस्था में श्वेत प्रयोगशाला में स्क्रीनिंग की गई। इनमें से पृथक किए गए *एस्परगिलस निजर, ए. फ्लेक्स, ए. क्लावेटस* व *आल्टरनेरिया आल्टरनाटा* जैसे चार फफूंद सुण्डियों में शत प्रतिशत मृत पाए गए।

फसल दैहिकी व फसलोत्तर प्रौद्योगिकी

ढेर व गड्ढों में आलू भण्डारण के पारम्परिक तरीके में सी. आई.पी.सी. के फॉग का एकल छिड़काव कर कुछ सुधार लाया गया। 100 दिनों के भण्डारण तक सी.आई.पी.सी. के उपचारित कन्दों में कुल भार हास, शुष्क अव्यव हास, छिलका हास, अवकारक शर्करा, सुक्रोस व कुल फिनोल्स मध्यमान कम रहा। उपचारित कन्दों के छिलके में 50 दिनों के भण्डारण के बाद सी.आसई.पी.सी. के अवशेषों में 0.22-6.68 ppm तथा 100 दिनों के भण्डारण के बाद 11-3.22 ppm कमी हुई। प्री-होल्डिंग अवधि में अवकारक शर्करा के अंशों व चिप्स रंगत में बढ़ोतरी देखी गई तथा इसी प्रकार 4 डिग्री सें. पर 120 दिनों तक भण्डारित करने पर इनमें अधिकतम बढ़ोतरी देखी गई। कुफरी चिप्सोना-1 के कन्दों को 120 दिनों तक भण्डरित करने पर इनमें अध्कितम बढ़ोतरी देखी गई। कुफरी चिप्सोना-1 के कन्दों को 120 दिनों तक भण्डारित करने के उपरान्त 15 व 20 दिनों तक दोबारा 20 डिग्री से. पर भण्डारित करने पर इससे बने चिप्स के रंगों में स्वीकार्य स्तर पर सुधार देखा गया। कुफरी चिप्सोना-1 व कुफरी ज्योति किस्मों की अपेक्षा कुफरी चिप्सोना-2 के कन्दों की श्वसन दर अधिक रही। 4 डिग्री सें. पर बेसल इनवर्टेस व सुक्रोस फॉस्फेट सिन्थेस इन्जाइम की क्रियाशीलता बढ़ने के साथ-साथ क्रमशः अवकारक शर्करा व सुक्रोस के अधिक संचय का सह-सम्बन्ध देखा गया। भण्डारण के दौरान स्कारवेट पर आक्साइड व ग्लूटेथियान रीडक्टेस इन्जाइम की क्रियाशीलता बढ़ी और 22 डिग्री सें. की अपेक्षा 4 डिग्री से. पर भण्डारित करने पर भी इसमें बढ़ोतरी देखी गई। चिप्स व फ्लेक्स बनाने के दौरान आलू में पोषक तत्वों के ह्रास को आंका गया। चिप्स बनाने में अवकारक शर्करा, सुक्रोस, फ्री एमिनो एसिड व कुल फिनोल्स का क्रमशः 83.8, 77.3, 63.2 व 45.3 प्रतिशत औसत ह्रास पाया गया तथा इसी प्रकार फ्लेक्स बनाने में घुलनशील प्रोटीन व एल. एस्कार्बिक एसिड में क्रमशः 29.1 व 68.1 प्रतिशत का औसत ह्रास पाया गया। 75 दिनों पर खोदे गए आलुओं से बने चिप्स की बनावट के मामले में कुफरी सूर्य किस्म के आलुओं से बने चिप्स सबसे ज्यादा कुरकुरे रहे, इसके बाद एम.पी./2 के-625 व कुफरी चिप्सोना-1 का स्थान रहा। गूदे की अपेक्षा छिलके में ग्लाइकोएल्कलायड्स व फिनोल्स के अंश अधिक रहे तथा कुफरी ज्योति व कुफरी चिप्सोना-1 की अपेक्षा कुफरी बहार किस्म में यह अंश अधिक पाए गए।

उष्मा सहनशीलता के लिए कांचघर में 4 संकरणों की स्क्रीनिंग करके 100 सीडलिंग का चयन किया गया। मोदीपुरम में खेत यचन में 13 संकर लगाए गए, इनमें से उष्मा सहनशील 191 व सूखा सहनशील 101 सीडलिंग का चयन किया गया। गोवा में उष्मा सहनशील किस्मों के उपज परीक्षणों में देखा गया कि गोवा में कुफरी सूर्य जैसी उष्मा सहनशील किस्में लगाकर आलू उत्पादन करना संभव है। मोदीपुरम में कुफरी सूर्य की अगेती बीजाई करके फसल के लिए पोषक तत्वों का पता लगाया गया।

बीज प्रौद्योगिकी

मोदीपुरम, जालन्धर, ग्वालियर, पटना, कुफरी व शिमला में 24 किस्मों के 32216 कन्दों को चिन्हित किया गया। विभिन्न चरणों में 130.73 हेक्टेयर क्षेत्रफल में कुल 25,153 क्विंटल बीज आलू का उत्पादन किया गया, जिसमें से 20,352 क्विंटल बीज की आपूर्ति की गई और 4800 क्विंटल बीज अपनी बीजाई में इस्तेमाल किया गया। ऊटी केन्द्र में 8.75 हेकटयेर क्षेत्रफल में ग्रीष्म व पतझड़काल की फसल से 1,149 क्विंटल क्वालिटी बीज पैदा किया गया जिसमें से 741 क्विंटल बीज की आपूर्ति की गई और शेष का इस्तेमाल पतझड़ व ग्रीष्मकाल की बीज फसल के लिए किया गया।

शिमला में 15 किस्मों के कुल 23212 बहुत ही छोटे कन्द (माइक्रोटयूबर्स) और 19 किस्मों के 17375 बहुत ही छोटे पौधे (माइक्रोप्लांटस) पैदा करके संस्थान के विभिन्न केन्द्रों को भेजे गए। इनके अतिरिक्त मोदीपुरम में 7 किस्मों व 3 संकरों के 40,965 माइक्रोप्लांट हिल्स और 4,303 माइक्रोटयूबर्स पैदा किए गए। संस्थान के विभिन्न केन्द्रो के नेट हाऊस, पॉली हाऊस, खेतों में 15 किस्मों के 3 ग्राम से छोटे कुल 75,239 कन्दों को लगाकार 3,42,590 कन्द पैदा किए गए।

कुल मिलांकर 11535 रोग मुक्त बफर स्टॉक कन्दों को पैदा कर उन्हें सुरक्षित रखा गया ताकि उनकी आपूर्ति संस्थान के विभिन्न केन्द्रों में की जा सके। पॉलीहाऊस की कन्ट्रोल (नियन्त्रण) अवस्था में विषाणु मुक्त मातृ कन्द स्टॉक की बुआई की गई। ELISA विधि द्वारा 1560 प्रतिनिधि सैम्पलों (नमूनों) की जांच की गई। कुफरी सिन्दूरी के 4 सैम्पलों को छोड़कर अन्य सभी सैम्पल विषाणु मुक्त पाए गए। जबकि कुफरी सिन्दूरी के नमूनों में पी.वी. एक्स पाया गया। बीज उत्पादक व 17 निजी कम्पनियों/संगठनों को 11 किस्मों के 396 रोग मुक्त माइक्रोप्लांटस (32 परखनलियां) दिए, जिससे 1,48,500/- रूपये प्राप्त हुए। जनरेशन 1 में 3.5 हेक्टेयर एवं 2 में 12.51 हेक्टेयर क्षेत्र में आलू बुआई करके क्रमशः 714.30 क्विंटल एवं 2547.81 क्विंटल उत्पादन हुआ।

संस्थान के विभिन्न केन्द्रों पर बीज अनुसंधान पर किए गए विभिन्न परीक्षणों में पतझड़ की फसल के उपयोग के लिए वसन्तकाल में बीज आलू पैदा करने की संभावना, कवचधारी सूत्रकृमियों के प्रबन्धन में फ्यूराडान का प्रभाव, बीज आलू की फसल में कवचधारी सूत्रकृमियों के प्रबन्धन में फोरेट व कार्बोफ्यूरान का प्रभाव, लघु (मिनी) कन्द उत्पादन में पौधे से पौधे व पंक्ति से पंक्ति की दूरी तथा उर्वरकों का प्रभाव, जैविक व अजैविक खेती का अध्ययन, एकल आंख व साबुत बीज से ली गई फसल की पैदावार, उपज पर सुषुप्तावस्था तोड़ने का उपचार करने के बाद प्राकृतिक रूप से अंकुरित व ताज़े खोदे गए कन्दों का प्रभाव, आलुओं के उपचार से सुषुप्तावस्था तोड़ने के उपरान्त अंकुरित बीज कन्दों का प्रभाव, विभिन्न प्रकार के सड़न रोग पर बोरिक एसिड व ऐमीसान-6 का प्रभाव, विभिन्न पौध सघनताओं व नाइट्रोजन मात्राओं के अन्तर्गत मिनी टयूबर की सुरक्षात्मक संरचना व उत्पादन प्रवृति आदि का पता लगाने के लिए कई बीज अनुसंधान परीक्षण उत्साहवर्धक रहे। कन्दों के सड़ने, कटने-फटने की प्रवृति को कम करने के लिए बोरिक एसिड की तुलना में ऐमीसान-6 दवा अधिक कारगर साबित हुई।

सामाजिक विज्ञान

आलू की किस्में विकसित करने के लिए अनुसंधान निवेश से आर्थिक प्रतिफल या लाभ प्राप्ति की मूल्यांकन प्रणाली का मानकीकरण किया गया। आलू की कुफरी चिप्सोना-1 और कुफरी चिप्सोना-2 किस्मों को विकसित करने के लिए अनुसंधान लागत से प्राप्त प्रतिफल का किस्मों को विकसित करने पर प्रतिफल की आन्तरिक दर अनुसंधान लागत की 55 प्रतिशत थी। शुद्ध वर्तमान मूल्य ब्याज की 0, 5 और 10 प्रतिशत वार्षिक दर के आधार पर क्रमशः 210.92 करोड़, 96.85 करोड़ तथा 46.11 करोड़ रूपये पाई गई। उत्तर प्रदेश में कृषकों के खेतों में आलू की उगाई गई समस्त किस्मों का औसत लागत लाभ अनुपात 1.61 की तुलना में कुफरी चिप्सोना-1 का लागत लाभ अनुपात 1. 91 रहा। कुफरी चिप्सोना-1 किस्म का आर्थिक विश्लेषण करते समय वांछित एवं अत्यन्त छोटे कन्दों से प्राप्त अलग-अलग मूल्यों को ध्यान में रखा गया। उत्पादन लागत के मूल्यांकन में किसानों के खेतों में अपनाई जाने वाली समस्त कृषि क्रियाओं की तुलना में कुफरी चिप्सोना-1 के लिए उच्च दर पर उर्वरकों एवं बीजों का इस्तेमाल, सामान्य से अधिक सिंचाई, उच्च मशीनी लागत एवं पौध संरक्षण पर कम खर्चों को भी ध्यान में रखा गया। शिमला, शिलांग और पटना में आलू उत्पादन की कुछ

चुनिंदा प्रौद्योगिकियों को किसानों द्वारा अपनाने में प्रौद्योगिकी गैप (रिक्ति) का मूल्यांकन किया गया। सर्वेक्षण से पाया गया कि पिछेता झुलसा एवं सफेद सुण्डी के प्रबन्धन तथा स्वस्थ बीज आलू उत्पादन की विकसित तकनीकों को अपनाने में अभी भी 55 प्रतिशत की कमी है। एकीकृत कीट नियन्त्रण के मामले में सबसे अधिक अज्ञानता (70 प्रतिशत) देखी गई। अच्छी गुणवत्ता वाले बीजों का उपलब्ध न होना आलू उत्पादन के लिए सबसे बड़ी समस्या महसूस की गई। शिमला के प्रदर्शनी प्लाटों में पिछेता झुलसा का 5 प्रतिशत एवं सफेद सुण्डी का 2 प्रतिशत प्रभाव देखा गया जबकि किसानों के खेतों में इनका प्रभाव क्रमशः 8 तथा 11 प्रतिशत था। शिलांग में किसानों द्वारा की जाने वाली कृषि क्रियाओं की तुलना में प्रदर्शनी प्लाटों में 359 प्रतिशत अधिक पैदावार प्राप्त हुई। आलू उत्पादन तकनीक के नवीन आयाम पर एक मॉडल प्रशिक्षण कार्यक्रम आयोजित किया गया जिसमें प्रतिभागी कृषि अधिकारियों के औसत ज्ञान में 15 प्रतिशत की वृद्धि हुई।

Executive Summary

Crop Improvement

Germplasm collection was augmented by adding cultivated and wild species from Peru, Korea and USA, thereby raising the total collection to more than 3,000 accessions. The collections were maintained in fields, glass houses, *in vitro* and as TPS. A large number of accessions were evaluated for various biotic and abiotic stresses, keeping quality, processing attributes, combining ability and also adaptability to various thermo-photoperiods. To assess the breeding values of parents based on fewer crosses by top-cross, CP2110 (CFK69.1) was found to be a promising tester for tuber yield and general impression, and CP2351 (Tobique) for late blight resistance. Screening of 586 clones of 39 *Solanum* species by detached leaf method as well as under field condition showed that 47 clones were highly resistant. An Inventory of Potato Germplasm (Group Andigena Collection) was published.

Based on consistent performance over the last three/four years, two hybrids namely, J.99-48 and J.99-242 from Jalandhar; two hybrids namely, MS/2-1741 and MS/2-3964 from Modipuram and one hybrid namely, 2000P55 from Patna are proposed for inclusion in AICRP(P). Early bulking hybrid J.93-86 with moderate resistance to late blight was recommended for release as variety Kufri Khayati for plains. Hybrid MS/93-1344 was released as variety Kufri Sadabahar for UP.

An advance processing hybrid MP/98-71 was found promising and suitable for French fry production. The hybrid MP/97-644 was released as variety K. Himsona for hills for processing into chips.

A total of 6.61 kg TPS of 78 crosses was produced. Storage of TPS at 40°C for 3-4 months improved germination. Three populations, viz. HPS-63/54, HPS-59/13 and HPS-59/54 were found promising.

RB-transgenic lines of Kufri Bahar and Kufri Jyoti were confirmed to have RB gene integration. Late blight resistance was observed in F_1C_1 clones of Kufri Bahar X RB transgenic lines SP904/SP951. Kufri Jyoti and Kufri Chipsona-1 transformed with *Nt-Inhh* gene construct for reduced cold-induced sweetening expressed the transgene. Intron containing invertase inverted repeat gene construct (IR-*iINV*) was developed for RNAi-mediated silencing of potato vacuolar invertase gene for reduction of cold-induced sweetening. Putative transgenic lines of Kufri Chipsona-1 were found positive for *NPTII* gene. Putative bacterial wilt resistant EBD-transgenic lines of Kufri Giriraj gave positive amplification of *npt II* marker gene. Binary vectors carrying the CP gene of PVY in sense, antisense and non-translatable orientations were designed. Transformation vector based on the binary vector pBinAR containing the antisense, sense, and hairpin loop constructs of the replicase gene of ToLCNDV was designed and putative transgenic shoots of Kufri Badshah with antisense replicase gene were regenerated. A mapping population of 126 clones of *Solanum spegazinni* x *Solanum chacoense* was genotyped by AFLP. An efficient *in vitro*

transcription vector/system, pUC-IVT, was constructed.

Phenotypic characterization of androgenic dihaploids was done. Their ploidy was confirmed by the nDNA 2C values and chromosome analysis. An improved reproducible protocol was optimized for protoplast isolation and culture.

Crop Production

Fertilizer requirement of potato+French bean intercropping were studied at Udhagamandalam (Tamil Nadu) and Shimla. At Udhagamandalam, the ratio of potato+French bean was 75:50 and 75% of the recommended dose of NPK to both the crops on sole crop area basis was found to be sufficient. At Shimla, the ratio of both the crops was 1:1 and French bean required only 75% of its recommended N dose. At Gwalior, planting method for potato+peas intercropping system was standardized and potato planting on ridges and peas planted on both sides of the ridge in zig-zag pattern was found best. Studies at Jalandhar revealed that gram, lentil and vegetable peas when intercropped with potato increased net returns by Rs.4392, 5604 and 11900/ha, respectively.

Winter potato acreages for 2007-2008 for Punjab, Uttar Pradesh, Bihar and West Bengal states were estimated to be 66.6, 425.0, 169.7 and 335.0 thousand hectares, respectively through remote sensing and production was estimated to be 1205.5, 9137.0, 1707.2 and 7504.0 thousand tonnes, respectively through INFOCROP-POTATO model. This year, an overall increase of 6.6% in potato acreage and 10% increase in potato production over the last year's estimates were forecast.

During the year, thematic maps of potato acreage and production statistics at district level was compiled and prepared. Themes on relative yield of the different potato growing districts *vis-a-vis* the national average yield and the agro-ecological zone of potato growing districts were also prepared.

Regarding efficiency of varieties to P uptake, their sequence in decreasing order was Kufri Pukhraj, Kufri Ashoka, Kufri Sutlej, Kufri Bahar, Kufri Jawahar, Kufri Badshah, Kufri Jyoti, Kufri Sindhuri, Kufri Lalima and Kufri Chandramukhi. Efficiency of N uptake was related to root growth and N-efficient cv. Kufri Pukhraj had more root growth (root fresh weight, root length, root surface area and root:shoot ratio) than N-inefficient cv. Kufri Jyoti.

Irrigation experiments at Modipuram at 20 mm cumulative pan evaporation (CPE) water level produced significantly higher potato yield (30.5 t/ha) followed by 25 mm CPE as compared to irrigation at critical stages. Sprinkler irrigation significantly increased processing grade and total tuber yield by 51.8% and 40.4%, respectively over conventional irrigation at Modipuram. In the hills at Shimla, irrigation at 50 and 75% available soil moisture (ASM), increased potato yield by 15.6 and 44.4% compared to the control (rainfed). The higher tuber yield was contributed by increase in large sized tubers.

Studies on long term manurial/fertilizer experiment at Modipuram showed that the system productivity was highest in maize–potato–onion (45.7t/ha), followed by paddy–potato–wheat (43.2t/ha). The tuber dry matter content was the highest in treatment receiving 100% nutrients through organic source and incorporation of crop residue. Organic manuring improved the soil properties *viz* organic carbon, microbial biomass carbon, dehydrogenase activity, water holding capacity and soil aggregation, while bulk density decreased.

Regarding design and development of implements, fabrication work on various implements *viz.* rotary tiller with crumbler roller, manually operated sieve type or endless screen type of potato grader and wire belt type potato grading system was continued. The prototype of machine for making French fry cuts was further improved for its frame, tuber receiving and cutting mechanism, improve operator's safety and comfort during operation *etc.* Two prototype machines were fabricated.

Tractor operated wide row ridger was modified by fixing adjustable scrapers to adjust height of ridges from 13-25 cm. The fixed tine tractor operated 2 row inter -cultivator was

modified. Based on field trials, four tines per row spaced at 170 mm fitted in a zigzag fashion were retained.

The pallets of different designs made of wood and metal were fabricated for a 2 t fork lift in rough and unlined surfaces. The metallic pallets worked better than wooden pallets. Bigger trolley for 8-12 trays was also tested on large scale. The trolley required less effort with wheels of 500 mm diameter than the present 300 and 375 mm diameter wheels.

Plant Protection

Diagnostics of viruses and viroid: Two hundred eighty mericlones of 80 germplasm and 53 "DUS" reference collection accessions were tested with IEM for virus infection. Sixty germplasm accessions in the first and 22 in the second year were screened against PVX and PVY; CP 1496, 4578, 2246 and 2362 were found resistant to both PVX and PVY. Forty hybrids possessing PVY° extreme resistance showed resistance against PVY°; Kufri Shailja and Kufri Chipsona-3 were susceptible while Kufri Himalini showed hypersensitive resistance. Screened 332 samples for PSTVd infection; Katahdin carrying RB gene for ToLCNDV and Kufri Jyoti for PLRV infection with RT-PCR. Virus-free mericlones of Kufri Pushkar were obtained after repeated attempts. A comparison of virus detection in dormant tubers with RT-PCR and IEM was made; only PVS, PVX and PVM were detected with both RT-PCR and IEM while PVA and PVY were detected only with IEM. Fourteen lines of Kufri Pukhraj transformed with CP gene of PLRV were examined with PCR to confirm the presence of the gene.

Late blight management: This year late blight attack was severe in the state of Karnataka with an average crop loss of 43%. Metalaxyl tolerance was up to 400 ppm in HP hills, 300 ppm in Punjab, 200 ppm in UP and 150 ppm in Bihar. A_2 mating type continued to maintain low profile (0-15%) in the subtropical plains. Complex races (7-11 gene frequency) dominated in all the parts of the country; highest being in HP hills. It was interesting to note that zoospores of some of the isolates could germinate successfully even at 34° C. The regression models developed for HP hills were found accurate to the tune of 87-92%. Methanol extract of one of the plant species gave disease control comparable to that provided by mancozeb. Thirteen hybrids were selected for further evaluation. Five hybrids were selected from F_1C_5, two from F_1C_6 and one from F_1C_7 generation based on agronomic traits and resistance to late blight. SM/92-338 also performed well under short day conditions. The advance hybrid SM/93-237 has been recommended for release as Kufr Girdhari.

Integrated Disease management: Sixteen potato varieties were screened for their susceptibility to russet scab under field conditions. Based on disease severity, these could be categorized into three groups. Among seven different soil treatments tried during the year, soil solarization from mid-May to mid-June was the best for the control of russet scab. An integrated tuber treatment comprising *Bacillus subtilis* or *Trichoderma viridae* plus boric acid exhibited a synergistic effect for control of *Rhizoctonia solani*. Results of a field trial indicated that dose of boric acid can be reduced to just half if used together with *T. viridae*. Analysis of metabolites of *Bacillus subtilis* (B5) showed presence of iturin, viomycin and chalcone.

Integrated pest management: Germplasm accessions JEX/A-91 and CP/1851 were found tolerant to PTM. PTM infestation in country stored tubers, at Shillong, was 0.17% in CIPC treatment and 0.33% with lantana leaves (0.33%). White grub caused 19-85% tuber damage at Shilaroo, Kharapathar and Kheradhar. Collection of white grub adults with light traps at Fagu during June helped in the reduction of grub population by 50,000. The extract of kernel of neem and Jatropha, soap nut and Chrysanthemum leaves prepared in cattle urine was found effective against white grub. Besides, entomopathogenic nematodes *Steinerneima carpocapsae* and *Heterreorhabditis indica* were also effective against white grub. Twenty two bacterial isolates from soil and six from diseased grubs were studied and 11 of these showed 100% mortality in white grubs. Twenty three fungal isolates from soil and eight from diseased

and dead grubs were screened against 2nd instar white grubs in laboratory and four isolates viz., *Aspergillus niger*, *A. flavus*, *A. clavatus* and *Alternaria alternata* caused 100% mortality in grubs.

Crop Physiology & Post Harvest Technology

Traditional method of potato storage in heaps and pits was improved with single spray application of CIPC. CIPC treated tubers showed lower mean total weight loss, dry matter loss, peeling loss, reducing sugars, sucrose and total phenols up to 100 days of storage (DOS). CIPC residues in peels of treated potatoes ranging between 0.22-6.58 ppm after 50 days, decreased to 0.11-3.22 ppm after 100 days of storage. Reducing sugar contents and chip colour increased during the pre-holding period and storage up to 120 days with maximum increase recorded at 4°C. Reconditioning of potatoes at 20°C for 15 and 21 days after 120 DOS improved the chip colour to acceptable level in Kufri Chipsona-1. Rate of tuber respiration was significantly higher in Kufri Chipsona-2 as compared to Kufri Chipsona-1 and Kufri Jyoti. Increased activity of basal invertase and sucrose phosphate synthase enzymes at 4°C correlated with higher accumulation of reducing sugars and sucrose, respectively. The activities of ascorbate peroxidase and glutathione reductase enzymes increased during storage and were also higher at 4°C as compared to 12°C. Nutritional losses during the preparation of chips and flakes were quantified. The average losses in reducing sugars, sucrose, free amino acids and total phenols during preparation of chips were 83.8, 77.3, 65.2 and 45.3% respectively and the average losses in soluble protein and L-ascorbic acid during preparation of flakes were 29.1 and 68.1% respectively. Texture of chips made from 75 day harvested crop showed that most crispy chips were made from Kufri Surya followed by MP/2K-625 and Kufri Chipsona-1. The acrylamide content in chips prepared from Kufri Jyoti tubers was significantly higher than that in Kufri Chipsona-1 and Kufri Chipsona-2 and there was a highly positive correlation (r=0.80 **) between acrylamide content and chip colour score. Higher content of glycoalkaloids and phenols was observed in peels than in flesh and their content was higher in Kufri Bahar compared to Kufri Jyoti and Kufri Chipsona-1.

Out of 4 crosses screened for heat tolerance in the glass house, 110 F_1 hybrid were selected. In the field selection at Modipuram for 13 crosses, 191 seedlings were selected for heat tolerance and 101 for drought tolerance. Yield trial at Goa with heat tolerant varieties showed that it is possible to grow potatoes in Goa using heat tolerant varieties like Kufri Surya. Nutrient requirement of Kufri Surya during early planting at Modipuram has been worked out.

Seed Technology

Indexing of 23,272 tubers of 23 varieties was done at Modipuram, Jalandhar, Gwalior, Patna, Kufri and Shimla. A total production of 25,153 q was achieved in an area of 130.73 ha in different stages and 20,352 q was supplied and 4,800 q was used for own planting. At CPRS, Ooty a total of 1,149 q quality seed was produced in an area of 8.75 ha during summer and autumn out of which 741 q was supplied and the remaining quantity was used subsequently for raising the autumn and summer seed crop.

A total of 23,212 microtubers of 15 cultivars and 17,375 microplants of 19 potato cultivars produced at Shimla were supplied to CPRI stations. In addition, total of 40,968 microplant hills and 4303 microtubers of 10 varieties were produced at Modipuram. A total of 75,239 <3g tubers of 15 varieties were planted in net/polyhouse/field at different stations and 3,42,590 tubers were produced.

A total of 11,535 disease free buffer stock tubers were produced and stored for supply to the stations. Disease free buffer stock tubers of 22 varieties were planted for maintenance of virus free mother stocks under controlled conditions in the polyhouse. 1,560 representative samples were tested with ELISA. All were found free from all the viruses except 4 samples of variety Kufri Sindhuri which were positive for PVX. 396 disease-free microplants (132 test tubes) of eleven varieties were supplied to 17 private seed producing organizations and a revenue of Rs.1,48,500/- was generated. In

Generation 1 & 2 an area of 3.5ha and 12.51ha was planted and a total production of 714.30q and 2547.81q was achieved.

Social Sciences

Methodology for assessing economic returns to the research investment made for developing potato varieties was standardized. Economic Surplus (partial equilibrium) method was employed to assess the returns on research cost for developing Kufri Chipsona 1 and Kufri Chipsona 2 varieties of potato. Internal Rate of Returns to the research cost for developing Kufri Chipsona 1 and K. Chipsona 2 varieties was 55%. Net Present Worth at 0, 5 and 10% rate of interest was worked out to Rs 210.92 crore, Rs 96.85 crore and Rs 46.11 crore, respectively. The benefit-cost ratio of K. Chipsona 1 was 1.91 against 1.61 for the average of all potato varieties grown on the farmers' fields in UP. Differential price received for desirable and under sized tubers was taken into consideration while performing economic analysis of K. Chipsona 1. Further, higher seed and fertilizers rates, additional irrigation, higher machine cost and less plant protection expenditure for Kufri Chipsona 1 as compared to the average of other potato varieties on farmers' field were also taken into consideration while calculating the cost of cultivation. Technological gap for selected potato technologies was assessed at Shimla, Shillong and Patna. The survey indicated that there was 55 per cent gap in adoption of potato technologies with respect to late blight management, white grub management and healthy seed potato production. Maximum knowledge gap (70%) was found in case of integrated pest management. Unavailability of good quality seed was perceived as the biggest constraint for potato production. The incidence of late blight and white grubs was recorded 8% and 11% on farmers' fields against 5% and 2% on demonstration plots in Shimla. In Shillong 359% yield increase was achieved in demonstration plots against farmers' practice. Overall knowledge of the participants of the model training course on 'Recent Advances in Potato Production Technologies' improved by15%.

Research Achievements 2007-08

Most of the Institutes research programmes are of multidisciplinary nature and have been identified as per mandate set by the Council and priorities identified in the Research Advisory Committee (RAC) and Institute Research Council (IRC) meetings held every year. At present, potato research is being carried out under the following 21 programmes. For convenience - research achievements under these programmes during 2007-08 are presented under different disciplines.

Research Programmes 2007-08

Research Programmes & Institute Code No.	Programme Leader and Associates
Potato genetic resources P1-2004/1-IPR-F30/0210	Dr. Jai Gopal **Associates:** Drs. PH Singh, VK Chandla, AK Somani, Ashiv Mehta, DB Singh, RS Marwaha, TA Joseph, D Sarkar, Yash Gupta, Shambhu Kumar, SK Luthra, Raj Kumar, Vinod Kumar, SJ Gawande, KM Nagraj, Kamlesh Malik, Vinay Bhardwaj, and N Somasekhar.
Development of varieties and technology for potato processing P1-2004/3-IPR-F30/0210	Dr. SV Singh **Associates:** Drs. SK Pandey, RS Marwah, Dinesh Kumar, Parveen Kumar and Vinay Bhardwaj.
Breeding potato cultivars for Indo Gangetic plains P1-2004/5-IPR-F30/0210	Dr. GS Kang **Associates:** Drs. BP Singh, PC Pande, Raj Kumar, SK Luthra and Shambhu Kumar.
Biotechnology in potato improvement P1-2004/6-IPR-F30/0210	Dr. SK Chakrabarti **Associates:** Drs. PS Naik, SK Kaushik and D Pattanayak.
TPS technology for potato production P1-2004/11-IPR-F30/0210	Dr. PC Pande **Associates:** Drs. KC Thakur, SV Singh, Shambhu Kumar, RR Burman, KM Nagraj and Devender Kumar.
Cell biology and somatic cell genetics for potato improvement P1-2004/22-IPR-F-30/0210	Dr. D Sarkar **Associate**: Dr. SK Pandey.
Develop sustainable potato based cropping systems P1-2004/7-IPR-F27/0210	Dr. SS Lal **Associates:** Drs. JP Singh, PM Govindakrishnan, VS Kushwah, RK Arora, SK Singh, VK Dua, SP Singh, CK Sharma, Sanjay Rawal, Parveen Kumar, Manoj Kumar, K Manorama, Shashi Rawat and Islam Ahmed.
Low cost input technology in potato production P1-2004/8-IPR-F27/0210	Dr. VS Kushwah **Associates:** Drs. SP Singh, S Gulati, Sanjay Rawal, Parveen Kumar and SK Singh.

Research Programmes & Institute Code No.	Programme Leader and Associates
Integrated nutrient and water management in potato P1-2004/9-IPR-F25/0210	Dr. SP Trehan **Associates:** Drs. NC Upadhyay, MC Sood, KC Sud, Name Singh, Manoj Kumar, Parveen Kumar, K Manorama, MA Khan and MK Jatav.
Studies on long term manurial/fertilizer application and organic farming in potato production P1-2004/20-IPR-F25/0210	Dr. NC Upadhayay **Associates:** Drs. BP Singh, DB Singh, OP Singh, PM Govindakrishnan, V Sunaina, MC Sood, MA Khan, Kamlesh Malik, Sanjay Rawal and KP Chandran.
Mechanization of potato cultivation P1-2004/10-IPR-N20/0210	Er. Manjeet Singh **Associates:** Drs. Sunil Gulati and Sukhwinder Singh.
Management of late blight in potato P1-2004/2-IPR-H20/0210	Dr. BP Singh **Associates:** Drs. PH Singh, RK Arora, SK Chakrabarti, M Narayan Bhat, SK Kaushik, Yash Gupta, Vinay Bhardwaj, KM Nagrajan and Shashi Rawat.
Diagnostics and detection of pathogens in potato P1-2004/12-IPR-H20/0210	Dr. ID Garg **Associate:** Dr. SJ Gawande.
Integrated disease management in potato P1-2004/13-IPR-H20/0210	Dr. RK Arora **Associates:** Drs. AK Somani, V Sunaina and Narayan M Bhatt.
Integrated pest management in potato P1-2004/14-IPR-H10/0210	Dr. VK Chandla **Associates:** Drs. DB Singh, Ram Kishore, Gulab Ram, Anuj Bhatnagar and K Malik.
Management of potato cyst nematodes P1-2004/15-IPR-H10/0210	Dr. TA Joseph **Associates:** Drs. N Somasekhar and K Manorama.
Physiological response of potato plants to heat stress P1-2004/4-IPR-F60/0210	Dr. JS Minhas **Associates:** Drs. Devendra Kumar, D. Pattanayak, Brajesh Singh, Kamlesh Malik and Vinay Bhardwaj.
Storage behaviour and processing quality of potatoes P1-2004/16-IPR-F60/0210	Dr. Ashiv Mehta **Associates:** Drs. R Ezekiel, RS Marwaha, SV Singh, RK Arora, Brajesh Singh and Dinesh Kumar.
Diversified utilization of potatoes P1-2004/17-IPR-Q10/0210	Dr. R Ezekiel **Associates:** Drs. RS Marwaha, Dinesh Kumar and Brajesh Singh.
Development and production of nucleus and breeder seed of potato P1-2004/18-IPR-F00/0210	Dr. Sarjeet Singh **Associates:** Drs. BP Singh, VS Kushwah, GS Kang, KR Dhiman, RP Rai, Ram Kishore, AK Somani, DB Singh, Gulab Ram, Rajpal Singh, Vinay Singh, Manoj Kumar, Ashwani Sharma, SP Singh, Vinod Kumar, R Muthu Raj, SK Singh, Dhruv Kumar, Anuj Bhatnagar, G Ravichandran, EP Venkatasalam, RK Verma, AMR Sanwale, Kapil Kumar, SK Awasthy, P Jassal and Brij Mohan.
Impact of potato technologies developed by the Institute P1-2004/19-IPR-COO/0210	Dr. NK Pandey **Associates:** Drs. Rambir, RK Rana, Anil Kumar, Barsati Lal, Arun Pandit, RR Burman and KP Chandran.

DIVISION OF

CROP IMPROVEMENT

- Germplasm collection was augmented by adding cultivated and wild species from Peru, Korea and USA, thereby raising the total collection to more than 3,000 accessions.
- Released the early-bulking variety Kufri Khayati (J 93-86) for Indian plains, medium maturing late blight resistant variety Kufri Girdhari (SM/93-237) for Indian hills, Kufri Sadabahar (MS/93-1344) for Uttar Pradesh, and the processing variety Kufri Himsona (MP/97-644) for hills.
- Identified the advanced hybrid MP/96-71 suitable for making French Fries. The hybrid may become the first ever variety from India suitable for making French Fry.
- Promising hybrids of Kufri Bahar/Kufri Jyoti x RB-transgenic Katahdin identified. RB-transgenic lines of Kufri Bahar and Kufri Jyoti were confirmed to have RB gene integration.
- Putative transgenic lines of Kufri Jyoti and Kufri Chipsona-1 with reduced cold induced sweetening developed. Binary vectors carrying the *CP* gene of PVY in sense, antisense and non-translatable orientations as well as *replicase* gene of ToLCNDV in antisense, sense, and hairpin-loop orientations designed.
- Phenotypic characterization of androgenic dihaploids was done. Their ploidy was confirmed by the nDNA 2C values and chromosome analysis. An improved reproducible protocol was optimized for protoplast isolation and culture.
- Demonstrated that remunerative cultivation of potato could be undertaken at Goa using the heat tolerant variety Kufri Surya.

Potato Genetic Resources

This programme is the backbone of all potato improvement activities at the CPRI. The use of genetic resources available at this institute has resulted in the development and release of 45 potato cultivars and one TPS population for cultivation under different agro-climatic zones of the country. In order to further improve the utilization of genetic resources, the efforts were continued not only to augment the collection, but also to evaluate it and pre-breed wild species for important characters.

Collection

During the year under report, 40 accessions received from CIP, Lima, Peru, 14 varieties from Korea and 31 hybrids/varieties developed by CPRI, and True Seeds of 199 accessions of 33 wild species from Inter Regional Potato Introduction Station, NRSP-6, Sturgeon Bay, USA were added to the collection. The present germplasm collection at the CPRI consists of more than 3,000 accessions of cultivated and wild species from 30 countries.

Conservation

One thousand one hundred twenty five Tuberosum accessions, 772 Andigena accessions and 69 indigenous samples were maintained in fields at Jalandhar. Nearly 1,150 Tuberosum accessions and 90 indigenous samples and 15 VDS lines were maintained in fields at Kufri. Seven hundred eighty five Andigena accessions were maintained in fields at Patna. Four hundred and forty one clones of 99 accessions of 46 species were maintained in tuber form in glasshouses/polyhouse at Shimla and 132 clones in fields at Modipuram. Ten dihaploids of Indian commercial varieties were maintained in glasshouses at Shimla. True seeds of 45 accessions were used to produce tubers, and 350 clones of 18 accessions were obtained. True seeds of 60 clones of 25 accessions pertaining to 14 wild species were produced through inter-specific crosses/selfings/sib-mating at Shimla.

Nearly 1,450 Tuberosum accessions were maintained in *in vitro* form. Minitubers of 172 accessions from *in vitro* repository were produced and added to the germplasm collection maintained under field conditions. Forty *in vitro* accessions were made free of all viruses through meristem tip culture.

Evaluation

A large number of accessions were evaluated for various biotic and abiotic stresses and also for adaptability and physcio-biochemical qualities. Promising accessions identified in these evaluations are listed in Table 1.

Combining ability for late blight resistance

Combining ability study based on 75 progenies from 25 x 3 (L x T) matings, evaluated in first clonal generation at Kufri and Patna showed that female parents namely CP 1160, CP 2390, CP 3187 and CP 3203 were good general combiners for tuber yield at Kufri, whereas CP 1160, CP 3187, CP 3201 and CP 3379 were good

Table 1. Evaluation of potato germplasm

Character	Location	No. of accessions evaluated	Promising accessions
Adaptability	**Kufri**		
	Replicated Trial	50	None
	Row Trial	195	CP nos. 1187, 1308, 1366, 1384, 1516, 1890, 1961, 2001, 2030, 2180, 2399 and 3090
	Jalandhar		
	Spring	93	CP nos. 2379, 2391 and 2392
	Modipuram		
	Autumn (Early)	133	CP 2284, CP 2287, CP 2302, CP 2306, CP 2351, CP 2364, CP 2365, CP 2368, CP 2369, CP 2378, CP 2384, and CP 2421
	Autumn (Main)	105	CP 2337, CP 2340, CP 2994, CP 2287, CP 2292, CP 2297, CP 2298, CP 2306 and CP 2369
Late blight Foliage	Kufri (field)	245	3-HR (CP 1012, CP 1187 & CP 1412); 11-R; 24-MR
	Ootty (field)	11	2-R (CP 1673 & CP 2068); 3-MR
	Shillong (field)	63	10-MR
	Shimla(Lab)	70	1-HR(CP 3493); 13-R, 29-MR
Tuber	Shimla(Lab)	46	2-HR (CP nos. 1648 & 3102), 6-R, 21-MR
Bacterial wilt	Bhowali	45	All susceptible
	Shillong	162	Results inconclusive
	Hassan	30	CP 3781 and CP 3786
Stem necrosis	Gwalior	106	11-HR; 2-R; 12-MR (confirmed for 4 years)
Viruses PVX and	Shimla	60 (1st time)	22 accessions were resistant to both PVX and PVY
PVY	Shimla	21 (2nd time)	5 accessions namely CP 1496, CP 1578, CP 1990, CP 2246 and CP 2362 were resistant to both PVX and PVY
PALCV	Modipuram	50	6 accessions were infected with PALCV
Leaf hopper and Mites	Modipuram	232	165 accessions showed no mite damage; 6 accessions viz., CP 1592, CP 1689, CP 1697, CP 1747 and CP 2322 were resistant to hopper burn
PTM	Shimla (Lab)	86	JEX/A-91 and CP 1851
Cyst nematodes	Ooty	119	CP No. 1555, 2044, 2066, 2163 & 3448 were resistant to both species of cyst nematodes; CP No. 2246, 2315, 2318, 3479 and 3764 were resistant only to *G. rostochiensis*.
Keeping quality	Jalandhar	88	10- best keepers; 38-good keepers and 26-average keepers
Chipping	Jalandhar	75	Only one accession CP 1940 was found suitable for processing and 5 andigena accessions viz., JEX/A nos. 663, 695, 712, 785 and 798 were promising for cold chipping.

HR- highly resistant, R- resistant, MR- moderately resistant

combiners at CPRS Patna. CP 1160 and CP 3187 were good combiners for tuber yield at both the locations. For late blight, CP 3072, CP 3203, CP 3316 and CP 3332 were found to be good combines at Kufri. CP 3203 was good general combiner for both late blight and tuber yield.

Documentation

Computer databases of cultivated as well as wild species were updated by incorporating the evaluation data for various accessions. An Inventory of Potato Germplasm (Group Andigena) Collection has been published (Fig. 1). Databases of availability of various accessions at different conservation sites were also updated.

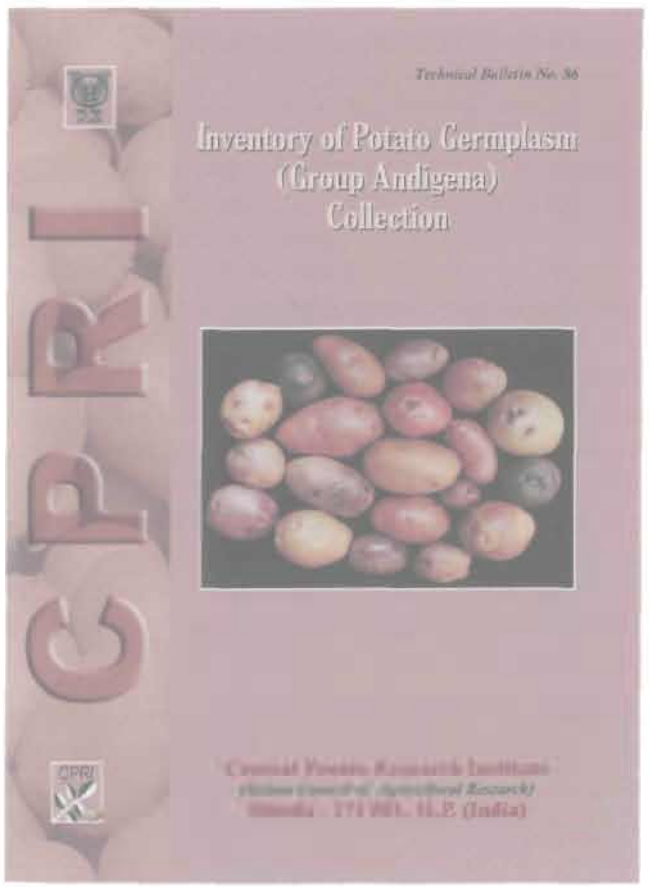


Fig. 1. Inventory of potato germplasm (group Andigena)

Germplasm registration

Parental line JX-123 developed at the CPRI has been registered as elite germplasm by ICAR/ NBPGR germplasm registration committee for earliness and resistance to late blight. This clone is a selection from the progeny of the cross "JE 812 x CP 2144".

Development of improved parental lines

Improvement of Andigena

I[st] cycle of recurrent selection: Ten advanced Andigena hybrids were evaluated in a replicated trial for yield at 90 days under spring planting conditions. Hybrids A.98-98 (259.4 q/ha) and A. 98-178 (253.5 q/ha) gave significantly higher total as well as marketable tuber yield than control Kufri Jyoti (192.7 q/ha). Total yield of A.97-14 and marketable yield of A.98-47 were also significantly better than that of Kufri Jyoti. Among these, hybrids A.98-98, A.98-178 and A.98-47 were promising during previous crop season also.

In second and third clonal generations, clones from andigena x andigena crosses and backcrosses of andigena hybrids, were evaluated. In second clonal generation, 58 clones were planted in observational rows and at the time of harvest 38 clones were selected. The yield range of the selected clones was 430 to 480 g/plant as compared to 400 g/plant of Kufri Pukhraj. In third clonal generation, 71 clones were planted in observational rows and 30 clones were selected. The yield range of the selected clones was 400 to 467 g/plant as compared to 381 g/plant of Kufri Pukhraj. Data were recorded in improved andigena hybrids and their parents for number of stolons and stolon length (Fig. 2). Average stolon length in early variety Kufri Ashoka was 5.29 cms, which was higher than in most of the andigena clones. The shortest stolons (1.54 cms) among 47 andigena clones were in JEX/A 1102, and among the 9 released varieties it was in Kufri Pukhraj (1.58 cms). Thus, andigena clones in general have stolons comparable to tuberosum.

2[nd] cycle of recurrent selection: Backcrosses of improved Andigena hybrids, and crosses among Andigena hybrids were attempted for further improvement of Andigena. In total, 13,990 seeds of 14 crosses were sown in nursery beds and a total of 4,325 seedlings were transplanted in field and 817 selections were made on the basis of tuber characters such as colour, shape and eye depth.

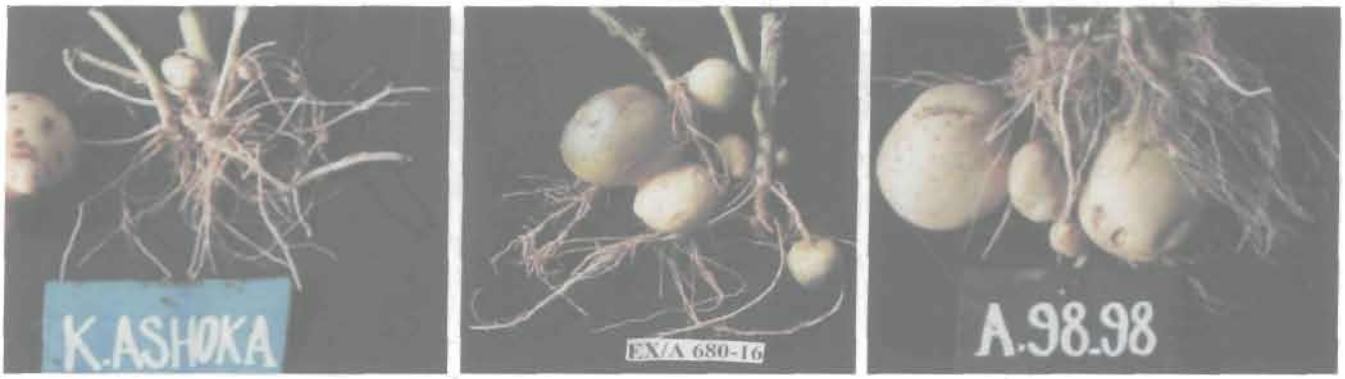


Fig. 2. Stolons in Kufri Ashoka, and andigena clones JEX/A 680-16 and A.98.98

Pre-breeding of wild species

Screening for late blight resistance: In order to diversify the sources of resistance to late blight in potato breeding programmes, 586 clones of 39 *Solanum* species were screened by detached leaf method for two years in the laboratory and results were confirmed by screening them for at least one year in the field under natural epiphytotic conditions. In all, 47 clones were found to be highly resistant, 196 were resistant, 214 were moderately resistant and remaining was susceptible. Among species, the highest proportion of highly resistant clones was obtained in *S. demissum* (22%) followed by *S. spegazzinii* (14.5%) and *S. microdontum* (10.5%). The species *S. arnezii* (68.2%) followed by *S. microdontum* (63.2%) had the maximum number of resistant clones. All the clones in two species viz., *S. cardiophyllum* and *S. vernei* were either resistant or moderately resistant. The highly resistant clones were SS 1735-2, 1736, 1835, 1837-2, 1844-1, 1844-2, 1846, 1846-2, 1847-9, 1848-8, 1850, 1850-1 and 1850-4 of *S. demissum*, SS 1725-52, 1725-54, 1725-61, 1725-72, 1725-73, 1725-84, 1725-93, 2021-9, 2021-10 of *S. spegazzinii*, SS 1672-6, 1926, 1926-9, 1926-13 of *S. microdontum*, SS 1425-5, 1664-2, 1724-25 and 1724-26 of *S. sparsipillum*, SS 1763-9, 1763-18 and 1763-25 of *S. albicans*, SS 1764-19 and 1765-8 of *S. alandiae*, SS 1784-3 and 2086-4 of *S. berthaultii*, SS 551-2 and 680-6 of *S. chacoense*, SS 1794-7 of *S. brevicaule*, SS 508-2 of *S. aeroscopium*, SS 1768-1 of *S. amabile*, SS 1878-3 of *S. guerreroense*, SS 1719 of *S. hondelmannii*, SS 1652-9 of *S. jamessi*, and SS 1301-1 of *S. sleumeri*.

Screening for bacterial wilt: One hundred fifty six clones of wild species were evaluated for bacterial wilt at Bhowali. However, none of the accessions was resistant.

Glucose estimation: The glucose estimation was done in 95 clones of wild species by analyzing the potato tuber juice through Biochemistry analyser before cold storage and after cold storage. In total, 28 clones were found to have lower glucose content compared to the best control Kufri Chipsona-1 both before and after cold storage. Among theses, the five best accessions which accumulated the lowest glucose content (< 10mg/100g fresh wt.) during 6 months cold storage were SS 1767-10, SS 1833-1, SS 1732, SS 1301-9 and SS 2040-3 in the given order, as compared to 240mg/100g f.wt. in the best control Kufri Chipsona-1. These results, however, need to be confirmed.

Production of dihaploids: Twenty-seven pistilate parents were pollinated with two inducer parents (CP 3810 & CP 3811) and 95 berries from 10 female lines were obtained producing 1,106 seeds. Out of 28 putative dihaploids planted in the field, 10 produced tubers and their ploidy level was again tested with chloroplast count. In addition, 13 dihaploids were identified from the seedling generation.

Breeding Potato Cultivars for Indo-Gangetic Plains

Hybridization and seedling evaluation

For development of improved varieties suitable for cultivation in Indo-Gangetic plains, 315 crosses were made and 5,28,352 botanical seeds were obtained. By sowing more than 3 lakhs seeds, nearly 1.35 lakhs seedlings were evaluated in field. At harvest, 7,147 single plant selections were retained based on tuber characters such as shape, skin colour and eye depth etc.

Early clonal generations

In F_1C_1-F_1C_3, 9,649 cultures were evaluated at 75/90 days harvest and 1,865 cultures were selected.

Replicated yield trials

Jalandhar

Early (September) planting conditions: Six hybrids were evaluated with three controls i.e. Kufri Pukhraj, Kufri Surya and Kufri Ashoka. Hybrid J.99-234 produced significantly higher yield (335q/ha) compared to the best control Kufri Pukhraj (292 q/ha) at 75 days harvest. This hybrid yielded significantly better (201 q/ha) than the best control Kufri Surya (173 q/ha) at 60 days harvest also.

Normal (October) planting conditions: Thirty one hybrids were evaluated in five trials of 60 and 75 days duration keeping Kufri Ashoka as control. A total of thirteen hybrids were selected based on their yield performance and tuber traits. Among these, hybrids J.2-14, J.2-26 and J.2-54 significantly outyielded the control Kufri Ashoka both at 60 and 75 days harvest while hybrids J.2-80, J.2-13, J.2-75, J.2-89, J.2-33 and J.2-27 performed significantly better than control Kufri Ashoka at 75 days harvest.

Confirmatory trials: Twenty one hybrids were evaluated in 3 trials using Kufri Ashoka as control at 60 and 75 days crop durations. Eleven hybrids were selected based on tuber traits and yield performance. Among these, hybrids J.99-242, J.1-169, J.1-179 and J.1-390 significantly outyielded the control both at 60 and 75 days harvest, whereas hybrids J.99-48, J.1-119, J.1-155 and J.1-171 produced significantly higher yield than control at 75 days harvest only.

Modipuram

Preliminary trials: Thirteen hybrids were evaluated with two controls i.e. Kufri Pukhraj and Kufri Bahar at 75 and 90 days crop durations. Kufri Pukhraj was the best control in both the crop durations. Five hybrids were selected based on yield performance and tuber traits. Among these, hybrid MS/4-1246 outyielded controls both at 75 and 90 days harvests, whereas at 90 days harvest, hybrids MS/4-974, MS/4-292, MS/4-954 and MS/4-2261 yielded significantly higher than both the controls.

Confirmatory trials: Ten hybrids were evaluated in 2 trials using Kufri Pukhraj and Kufri Bahar as controls at 75 and 90 days crop durations. Six hybrids were selected based on yield performance and tuber traits. Among these, hybrids MS/3-190 and MS/3-1763 at 75 days

crop duration and hybrids MS/3-190, MS/3-2086, MS/2-1741 and MS/2-3964 at 90 days crop duration significantly outyielded the best control. Hybrid MS/3-1716 having red tubers was also selected.

Patna

Preliminary trials: Twenty six hybrids were evaluated with three controls i.e. Kufri Pukhraj, Kufri Arun and Kufri Ashoka at 75 days crop duration in 4 trials. Kufri Pukhraj was the best control in most of the trials. Eight hybrids namely, 2003P21, 2003P24, 2003P102, 2003P101, 2003P2, 2003P33, 2003P4 and 2003P16 were selected based on yield performance and tuber traits.

Confirmatory trials: Fifteen hybrids were evaluated in 3 trials using Kufri Pukhraj, Kufri Arun, Kufri Ashoka and Kufri Khayati as controls at 60 and 75 days crop durations. Ten hybrids were selected based on yield performance and tuber traits. Among these, hybrids 2002P26 and 2001P26 outyielded controls both at 60 and 75 days harvests. Hybrids 2002P13, 2002P14, 2002P38 gave significantly higher yield only at 60 days harvest than the controls except Kufri Khayati.

Introduction of hybrids into AICRP (Potato)

Jalandhar

Based on consistently good performance over the years (Table 2), two hybrids namely, J.99-48 and J.99-242 are proposed for inclusion in AICRP (P). Hybrid J.99-48 has creamy, long oval tubers, shallow eyes and creamy flesh, whereas hybrid J.99-242 has white, long oval tubers, shallow eyes and white flesh.

Modipuram

Based on consistently good performance over the years (Table 3), two hybrids namely, MS/2-1741 and MS/2-3964 are proposed for inclusion in AICRP (P). Hybrid MS/2-1741 has white, round oval tubers, shallow eyes, light yellow flesh, 17.7% dry matter and field resistance to

Table 2. Cultures proposed to be initiated in AICRP (P) from Jalandhar.

Hybrid/ control	Yield (q/ha)									
	2004-05		2005-06		2006-07		2007-08		Average	
	60 days	75 days	60 days	75 days	60 days	75 days	60 days	75 days	60 days	75 days
J.99-48	249	367	209	417	260	417	262	432	245	408
K Ashoka	253	348	188	322	230	333	244	361	229	341
CD (0.05)	26.5	42.4	27.2	39.1	25.2	45.2	20.3	23.4		
J.99-242	244	369	268	385	230	347	311	431	263	383
K Ashoka	242	309	255	354	198	314	244	361	235	335
CD (P≤ 0.05)	25.5	32.3	32.3	28.4	20.6	45.7	20.3	23.4		

Table 3. Cultures proposed to be initiated in AICRP (P) from Modipuram.

Hybrid/ control	Yield (q/ha)							
	2005-06		2006-07		2007-08		Average	
	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days
MS/2-1741	261	386	264	303	229	373	251	354
MS/2-3964	287	454	254	341	250	392	264	396
Kufri Pukhraj	234	335	210	242	270	352	238	310
Kufri Bahar	204	354	174	180	216	305	198	280
CD (P≤ 0.05)	33.4	37.2	14.4	13.9	11.0	11.1		

late blight at Modipuram, whereas hybrid MS/2-3964 has white, oval tubers, shallow eyes, light yellow flesh, 16.7% dry matter and field resistance to late blight at Modipuram.

Patna

Based on consistently good performance over the years (Table 4), one hybrid namely, 2000P55 is proposed for inclusion in AICRP (P). Hybrid 2000P55 has dark red, flattened round tubers, medium deep eyes, creamy flesh and is moderately resistant to late blight. Its dry matter is comparable to Kufri Arun and higher than that of Kufri Ashoka and Kufri Pukhraj.

Hybrids recommended for release as new cultivars

Early bulking hybrid J.93-86 with moderate resistance to late blight was recommended for release as variety Kufri Khayati by the 26th Group Meeting of Potato workers held on 7th to 9th September, 2007 at RAU, Pusa, Bihar (Figure 3).

Hybrid MS/93-1344 was released as variety Kufri Sadabahar during 2007 by UP Horticulture Department for cultivation in Meerut, Agra, Kanpur and Bareilly mandals of UP (Fig. 4).

Fig. 3. Kufri Khayati

Fig. 4. Kufri Sadabahar

Table 4. Cultures proposed to be initiated in AICRP (P) from Patna.

Hybrid/ control	Yield (q/ha)									
	2004-05		2005-06		2006-07		2007-08		Average	
	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days
2000P55 *	286	374	313	475	319	359	268	-	297	403
K Arun	253	343	-	412	301	353	228	-	261	369
K Ashoka	250	-	245	-	291	-	-	-	262	-
K Pukhraj	243	396	274	428	346	364	303	-	292	396
CD (P≤ 0.05)	15	23	NS	NS	17	24	29.5	-		

Development of Varieties and Technology for Processing

Potato processing is increasing at a fast pace in India after liberalization of the economy and availability of specialized varieties for processing. India currently processes approximately 2% of its production, which is more than double as compared to that of late nineties. The potato processing industry is expected to grow by 7% by the year 2010. To make this sector grow at this rate, quality raw material needs to be available in the country. This programme aims at development of early maturing varieties and technology suitable for French fry and chip making.

Variety development

Hybridization and seedling evaluation

A total of 1,05,475 hybrid seeds from 64 crosses were produced at Kufri and seedlings were raised at Modipuram, out of which 1,022 seedlings were selected on the basis of tuber characters.

Early clonal generations

A total of 868 clones of F_1C_1 to F_1C_2 generations were evaluated and 28 clones were retained based on tuber characters and chip colour. In F_1C_3, a total of 11 genotypes were evaluated and on the basis of tuber yield and chip colour, 5 hybrids were selected. In F_1C_4, three cultures namely MP/02-32, MP/02-34, MP/03-626 were selected out of 5 tested.

Advance clonal generations

Seven chipping hybrids along with three control varieties were tested, and based on total and processing grade yield, chip colour and percent dry matter, five hybrids namely, MP/2K-516, MP/01-916, MP/01-1006, MP/01-1142 and MP/02-105 were selected. Seven French fry hybrids and three control varieties were tested and on the basis of total and French fry grade yield, French fry colour and percent dry matter only two hybrids namely MP/98-71 and MP/02-204 (Fig. 5) were selected.

Fig. 5. French fry hybrids

Performance of advanced hybrids at different locations

An advance hybrid MP/98-71 suitable for French fries being evaluated at AICRP (P) locations was also tested at six locations in UP and one each at MP and West Bengal along with the control cultivars. The crop duration was 110 days at all the locations. On the basis of total and French fry grade yield, French fry colour and percent dry matter, hybrid MP/98-71 was found promising at all the eight locations (Tables 5 & 6).

Table 5. French fry grade and total tuber yield of advance hybrid MP/98-71 and control varieties at different locations

Hybrid/Variety	Modipuram		Meerut		Ghaziabad		Farrukhabad		Badaun		Agra		Indore		Burdwan	
	FFGY[b]	TTY[c]	FFGY	TTY	FFGY	TTY	FFGY	TTY	FFGY	TTY	FFGY	TTY	FFGY	TTY	FFGY	TTY
MP/98-71	13.53	32.56	15.23	31.96	10.63	36.29	14.06	50.94	27.13	49.88	19.75	40.64	21.5	38.9	13.71	44.90
K.Chipsona-1	11.53	28.84	14.99	28.73	5.02	31.54	8.35	44.19	11.98	41.31	10.03	28.81	9.8	23.2	13.05	41.33
K. Surya	12.11	35.76	16.79	28.88	5.75	19.52	10.33	43.29	10.65	33.13	11.78	27.47	7.4	35.5	12.69	39.71
KCM[a]	-	-	13.57	26.11	3.71	21.44	7.79	40.23	9.50	32.63	8.36	24.19	-	-	-	-
K.Chipsona-3	3.97	32.68	12.07	30.32	3.69	30.38	8.38	44.25	9.75	48.08	7.89	32.39	4.3	40.5	5.12	46.76
K.Himsona	0.00	37.59	0.00	29.05	2.13	31.85	4.46	55.92	9.00	43.98	5.33	21.11	0.0	37.3	4.21	49.43
LSD (P< 0.05)	0.591	2.308	1.647	2.008	1.956	5.947	1.998	5.094	1.889	5.099	2.275	4.729	2.837	3.308	2.065	7.471

[a]Kufri Chandramukhi; [b]FFGY= French fry grade tuber yield (t/ha); [c]TTY = total tuber yield (t/ha)

Table 6. Processing quality of advance hybrid MP/98-71 and control varieties at different locations

Hybrid/Variety	Modipuram		Meerut		Ghaziabad		Farrukhabad		Badaun		Agra		Indore		Burdwan	
	Fry Colour	Dry matter	Fry Colour	Dry matter	Fry Colour	Dry matter	Fry Colour	Dry matter	Fry Colour	Dry matter	Fry Colour	Dry matter	Fry Colour	Dry matter	Fry Colour	Dry matter
MP/98-71	1.5	23.0	1.9	21.0	3.2	21.0	1.1	18.1	1.0	24.8	1.7	26.0	1.0	25.3	1.3	21.3
K.Chipsona-1	3.0	21.9	4.8	19.5	2.2	21.2	2.9	25.1	1.0	20.4	2.0	25.1	1.0	22.9	1.1	19.7
K. Surya	1.8	21.2	2.2	18.2	4.0	18.7	1.0	20.5	1.0	20.7	1.8	22.6	1.2	21.6	1.0	19.5
KCM[a]	-	-	3.0	16.8	4.2	21.1	3.7	19.7	3.5	22.2	2.0	19.8	-	-	-	-
K.Chipsona-3	2.2	23.9	5.3	20.2	2.0	24.6	2.0	26.0	1.8	22.6	1.2	24.8	1.1	23.6	2.9	24.2
K.Himsona	2.3	25.5	3.6	20.8	1.5	22.9			1.2	21.3	1.3	25.2	1.0	22.6	2.2	22.3

[a]Kufri Chandramukhi

Three trials were conducted with seven processing varieties at Janjheli, Pandhar and Multan in Mandi district of Himachal Pradesh. The highest processing grade and total tuber yield was recorded in K. Himsona (12.5 and 24.6 t/ha, respectively) and quality was suitable for chipping. Its superior quality was also confirmed by on-line chipping at Frito Lay India factory at Channo (Punjab). The variety, K. Himsona, has superior late blight resistance, higher yield and quality as compared to the popular variety K. Jyoti.

Eight potato cultivars, including 4 processing varieties and one hybrid along with three table varieties were evaluated during spring season for yield and processing quality after 100 days of harvest at Jalandhar and Hoshiarpur. There was no significant difference in the mean total yield of 8 cultivars averaged over two locations, and the total and processing grade tuber yield was maximum in K. Anand (385.1 q/ha and 149.5 q/ha, respectively). K. Chipsona-2 showed maximum proportion of processing grade tubers (43.2%) followed by K. Jyoti (39.4%) and K. Anand (39.2%). MP/98-172 showed maximum mean tuber dry matter content (24.5%) followed by K. Chipsona-3 (24.0%). K. Chipsona-3 and MP/98-172 showed lightest colour of chips (chip colour score 3.0) followed by K. Chipsona-1 (Chip colour score 3.5), while the chips made from other cultivars were unacceptable. Chip yield was the highest in K. Chipsona-1 (29.3%), which was at par with MP/98-172 (29.1%). K. Chipsona-2 contained maximum content of true protein (1.674% on fresh wt basis), while MP/98-172 had maximum L-ascorbic acid (32.3 mg/100 g fresh wt). Based on processing grade tuber yield, chip colour, dry matter and chip yield, it is concluded that K. Chipsona-2 grown at Hoshiarpur in spring season would provide suitable raw material for the processing industries. K. Anand, producing the highest total and marketable yield, and having high levels of true protein, free amino acids, total phenols and L-ascorbic acid would be most suitable for table consumption.

Performance of advanced hybrids in different seasons

Early season crop: Four processing hybrids and seven control varieties were planted in a replicated trial. At 75 days, none of the hybrid yielded higher than control varieties K. Surya, K. Chandramukhi and K. Lauvkar, which were at par with each other. At 90 days, K. Chipsona-3 gave the highest yield of 25.1 t/ha. Based upon two years results K. Surya was the most suitable variety for chipping from early season.

Main crop season: Seven potato varieties and one advance stage processing hybrid, MP/98-71 were evaluated for yield and processing quality after 100 days of harvest at Jalandhar. K. Chipsona-3 gave the highest tuber yield (492.4 q/ha), which was at par with K. Himsona (475.0 q/ha) and MP/98-71 (450.8 q/ha). The yield of processing grade tubers was also maximum in K. Chipsona-3 (415.5 q/ha) which was at par with K. Surya. (389.5 q/ha). Fry grade tuber yield (>75 mm long) was maximum in K. Surya (342.2 q/ha) followed by MP/98-71 (316.8 q/ha). The yield recovery of fries was maximum in K. Chipsona-1 (40.5%) followed by K. Surya (39.7%). Fry colour was acceptable in all the 4 varieties/hybrid. The textural analysis by the Texture Analyzer (Micro Stable Systems, UK) showed maximum firmness of fries in K. Chipsona-3 (1603 g Force) followed by K. Chipsona-1 (1501 g Force). Fries made from MP/98-71 also showed good texture (1393 g Force).

Processing qualities of varieties/hybrids grown at Hassan and Chickmaglore in Karnataka during 2007

Four Indian potato varieties namely K. Jyoti, K. Surya, K. Chipsona-2 and K. Chipsona-3, two advanced hybrids, viz. MP/2K-625 and MP/2K-916 and two American cultivars i.e. Atlantic and FL 1533 harvested after 75 days at Hassan and Chickmaglore were evaluated for processing traits at Jalandhar. Based on total and processing grade tuber yield, tuber sp. gravity and dry matter, chip colour, reducing sugars and amounts of free amino acids and phenols, MP/2K-916 was rated as the most suitable processing hybrid.

Evaluation of Indian potato varieties for processing quality

Forty three Indian potato varieties including table and processing ones being tested under DUS programme were tested for chipping quality for the second year. The highest dry matter content was in K. Kuber (24.6%) and lowest in

K. Khayati (12.2%). Best chip colour was shown by K. Chipsona-1 and K. Surya. The lowest glucose content was obtained in tubers of Kufri Himsona (45.0 mg/100 g f.wt.), while the highest was in tubers of K. Jeevan (368 mg/100 g f.wt.). Based upon two years study, it can be concluded that the processing quality potential of K. Kuber could be exploited.

Processing quality of Indian and exotic cultivars at different dates of harvest

At 70 days stage, none of the variety yielded acceptable coloured chips (<3.0), though lowest values were obtained for K. Chipsona-1, K. Surya and Lady Rosetta. The dry matter content of >20% was achieved in K. Himsona, Lady Rosetta, K. Lauvkar and Atlantic. The lowest glucose content was obtained in Lady Rosetta (4.0 mg/100 g f.wt.) and the highest in K. Chipsona-3 (100.5 mg/100 g f.wt.). At 78 days harvest, Lady Rosetta and Atlantic were found to have acceptable chip colour. The dry matter content of >20% was obtained in K. Chipsona-1, K. Himsona, Lady Rosetta, K. Lauvkar and Atlantic. Chip colour improved with maturity, while dry matter content remained unchanged. Glucose content decreased from 70 to 78 days.

At 100 days after planting, acceptable chip colour was obtained in K. Chipsona-1 and Lady Rosetta. The dry matter content was >20% in all the six varieties tested except K. Surya. Lowest glucose content was in K. Surya and Lady Rosetta. At 105 days acceptable chips could be made from K. Chipsona-1 and K. Himsona. At 110 days (after soil curing of one week), nearly acceptable chip colour was obtained in all varieties and was best in K. Chipsona-3 and K. Himsona. Mean chip colour was best in K. Chipsona-1, K. Himsona and Lady Rosetta.

Agronomical Studies with processing varieties

To get higher proportion of processing grade (chipping & French fry grade) tubers following experiments were conducted.

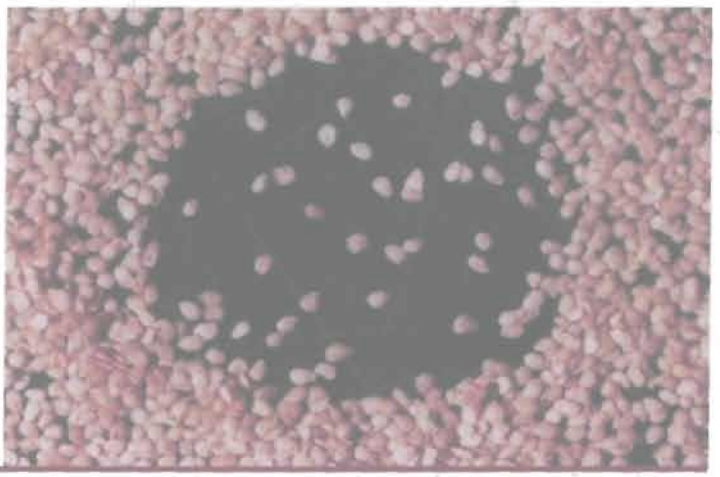
Advance stage French fry hybrid MP/98-71 and control cultivars K. Chipsona-1 and K. Surya were evaluated at four fertility levels ($N:P_2O_5:K_2O$ kg/ha) 270:80:150 (F_1); 252:80:150 & 2% spray of urea at 60 & 80 DAP (F_2); 338:80:188 (F_3) and 320:80:188 & 2% spray of urea at 60 & 80 DAP (F_4) at Modipuram and Patna. At Modipuram, French fry grade and total tuber yield was not influenced by fertility levels but French fry grade yield decreased significantly in F_4 treatment compared to F_3 treatment in K. Surya. Specific gravity, tuber dry matter content and French fry colour were not affected by fertilizer levels. Total and French fry grade tuber yield was the highest in MP/98-71 (Mean yield over treatments 378.2 and 143.2 q/ha, respectively). Tuber specific gravity and tuber dry matter content of French fry grade tubers was the highest in MP/98-71 (1.091 and 23.8%) and the lowest in K. Surya (1.074 and 18.5%). However, glucose concentration of MP/98-71 was at par with control cultivars.

At Patna, the variety K. Surya and K. Chipsona-1 attained senescence in about 100 days, whereas MP/98-71 remained green even after 110 days. MP/98-71 yielded higher than both the controls. Yield of French fry grade tuber was also the highest in MP/98-71, which ranged between 54 to 58%, whereas it was the lowest in K. Chipsona-1. The chip-grade tuber production was the highest in K. Chipsona-1.

A large scale (1 acre) trial was conducted to define crop geometry and plant density for French fry grade tuber production in K. Chipsona-1. French fry grade tuber yield was the highest at plant density of 49,400 plants/ha. Growing 55,500 plants/ha at 67.5 x 26.5 cm was comparable to 90 x 20 cm geometry. This row to row spacing fits well in the existing machinery and tractors.

To find correlation between leaves glucose concentrations and frost tolerance, leaves samples of 90 days old crop of processing varieties were analysed for glucose estimation. The results indicated that the highest glucose content was in leaves of K. Himsona (897 mg/100 g f.wt.) followed by MP/98-71 (313 mg/100 g f.wt.). These concentrations were much higher than the K. Surya (163 mg/100 g f.wt.) and K. Chipsona-1 (104 mg/100 g f.wt.). Higher glucose concentration in leaves is desirable for inducing frost tolerance as higher solutes in cell sap brings down the freezing point of cells and probably improves survival of plants.

TPS Technology for Potato Production



TPS inherits some basic constraints like late maturity of the crop and proneness of TPS seedlings to transplanting shock. The objectives of the project thus include development of early bulking parents/populations with wider adaptability, and resistance to abiotic and biotic stresses. The work done on different aspects is summarized below.

Development of early bulking and hardy TPS populations

During the year, a total of 6.61 kg TPS of 78 crosses including three recommended populations viz. HPS-I/13, TPS-C-3 and 92-PT-27 was produced at Shimla, Modipuram and Patna.

Seedlings of 8 bi-parental crosses at Shimla and 7 at Modipuram were evaluated and 40 clones with desirable tuber attributes were selected.

Fourteen white/red tuber populations (10 at Patna and 4 at Shillong) were evaluated with control 92-PT-27 as transplanted crop. At Patna, one population viz. PT/07-124 gave significantly higher yield than the control 92-PT-27 both at 75 & 90 DAT. At Shillong, none of the populations gave significantly higher yield than the control.

Twelve white tuber populations with controls 92-PT-27 and Kufri Bahar at Modipuram at 75 and 90 DAP and 10 populations with controls 92-PT-27 at Patna at 90 DAP were evaluated for early bulking and tuber characters. None of the populations yielded significantly higher than the controls 92-PT-27 at 75 days harvest at Modipuram, whereas one population viz. HPS-60/54 gave significantly higher yield than Kufri Bahar (Table 7). At 90 days harvest, three populations viz. HPS-47/54, HPS-7/54 and HPS-26/54 yielded significantly higher than both the controls. At Patna three populations, viz. HPS-63/54, HPS-59/13 and HPS-59/54 yielded significantly higher than the control 92-PT-27. Based on tuber uniformity and yield at both the locations, seven populations i.e. HPS-7/54, HPS-26/54, HPS-47/54, HPS-60/54 HPS-63/54, HPS- 59/13 and HPS- 59/54 were selected.

Seedling tubers of eight red tuber populations were evaluated with controls Kufri Arun and Kufri Kanchan. At 90 Days harvest, none of the populations yielded significantly higher than the controls.

Bulked seedling tubers of 15 selected crosses from F_1C_1 generation were evaluated at Modipuram. In total, 30 early bulking clones were selected. At Modipuram, F_1C_2 tubers of seven bi-parental crosses were evaluated and 18 early bulking clones were selected.

Crop raised from seedling tubers of 29 crosses was evaluated for flowering under natural day length conditions at Patna. On the basis of plant type, flowering, pollen fertility, tuber skin color and resistance to late blight, 57 clones were selected.

Table 7. Yield performance of seedling tuber populations

Modipuram			Patna		
Populations	Yield (q/ha)		Populations	Yield (q/ha)	
	75 DAP	90 DAP		Mkt. yield	Total yield
HPS-7/54	247.40	343.68	HPS-63/54	256.71	300.37
HPS-8.8/13	214.40	305.53	HPS-59/13	222.96	253.01
HPS-26/54	219.47	335.93	HPS-59/54	219.44	246.30
HPS-32/D-150	235.14	307.89	HPS-64/D-150	206.85	234.07
HPS-47/54	221.61	349.38	HPS-60/54	198.98	231.94
HPS-51/54	194.81	316.90	HPS-61/54	196.76	218.94
HPS-60/54	284.71	291.25	HPS-63/D-150	193.43	215.60
HPS-63/54	241.18	322.96	HPS-67/54	182.08	211.25
HPS-64/D-150	229.79	292.38	HPS-68/MST-1	166.48	197.69
HPS-65/D-150	233.92	312.82	D-150	142.64	168.94
HPS-71/54	215.76	271.13	92-PT-27	190.00	217.22
HPS-71/D-150	253.50	300.07	CD (P≤ 0.05)	22.5	23.1
92-PT-27	249.00	281.41			
K Bahar	221.97	288.06			
CD (P≤ 0.05)	41.5	45.7			

Development of techniques for seedling establishment and vigour

High temperature priming to enhance seed germination and seedling vigour in TPS: Seeds of two TPS population HPS I/13 and TPS- C-3 were kept for 4 months in BOD with five treatments viz. T1- Storage at room temperature, T2- Storage at room temperature and treated with GA_3 1500 ppm, T3- 20°C, T4- 30°C and T5- 40°C. Samples were drawn at monthly intervals and evaluated for germination at 20°C. Storage at 40°C for 3-4 months improved germination and it was at par with those kept at room temperature (~30°C) and treated with 1500 ppm GA (Fig. 6). TPS-C-3 responded better than HPS I/13.

Effect of plant growth regulators (PGRs) on transplant survival, seedling vigour and productivity: One month old seedlings of HPS I/13, TPS-C-3 and 92-PT-27 raised in nursery bed with following treatments at 3-4 leaf stage were transplanted in field.

T1 (control)- No treatment and transplanted immediately after uprooting.

T2- Seedling sprayed with paclobutrazole (25

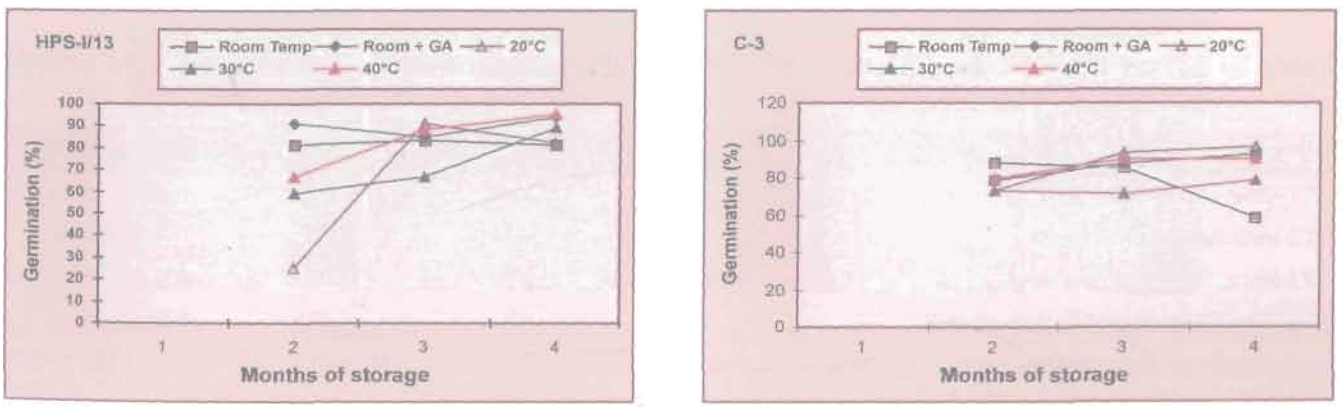


Fig. 6. Effect of temperature priming on germination & germination index in TPS

ppm) and transplanted immediately after uprooting.

T3- Seedling sprayed with botanical (*Badchi-3.5%*) and transplanted immediately after uprooting.

T4- Seedling dipped in bio-agent B_5 before transplanting.

T5- No treatment, uprooted and kept in wet hessian cloth for 24 hrs before transplanting.

The transplant survival was >90% in all the treatments. Application of paclobutrazole significantly reduced the shoot height and root length. The reduction in shoot height was also noticed in seedlings treated with botanical *(Badchi-3.5%)* but resulted in higher root length. The spray of paclobutrazole and botanical reduced the shoot/root ratio and turned seedlings more compact.

Phenotypic effect of PGRs on seedlings compactness noticed at the time of transplanting slowly vanished and at 55 DAT, most of the morphological parameters except shoot height, were at par in all treatments. Seedlings sprayed in nursery bed with paclobutrazole (T2) and botanical (T3) had higher shoot weight and total plant fresh weight at 75 DAT. Tuber number was significantly higher in T2 and T5, whereas tuber yield was slightly higher in seedlings transplanted after 24 h of uprooting (T5) but only upto 75 DAT.

Proline content in the root and leaf tissues in uprooted seedlings was the highest in control (T1) and in those treated with B_5 (T4) followed by botanical (T3). It was lowest in paclobutrzole treatment (T2). Comparison of proline content in the uprooted seedlings (at the time of transplanting) and subsequently at 55 DAP in the transplanted crop indicated that proline had the least fluctuation in the plants raised from seedlings treated with paclobutrazole (Fig. 7).

Number of tubers and total tuber yield were also significantly higher in this treatment (14,55,000/ha and 181 q/ha, respectively) as compared to control (8,73,000/ha and 167 q/ha, respectively) (Table 8).

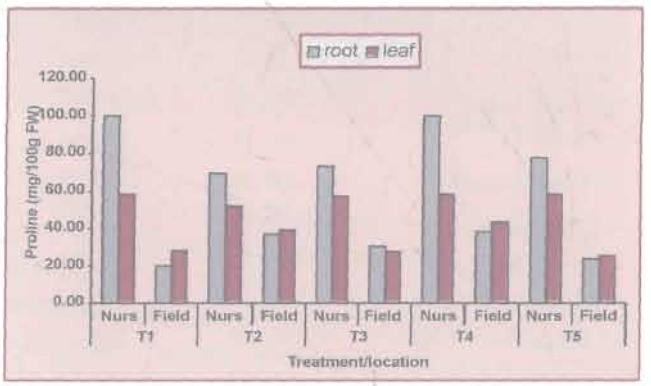


Fig. 7. Proline content in root and leaf tissues in freshly uprooted seedlings (Nurs) and at 55 days after transplanting in the field (Mean of 3 TPS families)

Effect of water-stress in nursery bed of TPS seedlings on tuber yield: Watering was stopped in nursery beds 4 days prior to uprooting the seedlings for transplanting. Compared to control (no water stress), no effect of this treatment was observed on tuber yield, tuber number and proportion of marketable tubers at 90 day.

Selection of populations for baby potatoes

Fifty TPS populations grown as transplanted as well as seedling tubers crop were evaluated for selection of baby potatoes. Four populations having >20 tubers/plant were selected for further evaluation.

Table 8. Effect of PGR formulations and transplanting treatments on productivity of potato crop raised through TPS seedlings

Treatment	No. of Tubers ('000'/ha)	Tuber yield (q/ha)
T1-Control	873	167
T2-Paclobutrazole-25ppm	1455	181
T3-Botanical (3.5% *Badchi*)	978	169
T4- Seedlings dipped in bioagent B_5	939	170
T5- Seedlings uprooted 24 hrs before transplanting	719	108
LSD ($P \leq 0.05$)	65	14

Biotechnology in Potato Improvement

Potato is highly amenable to genetic manipulations through biotechnological means. This programme was initiated to best utilize the potentials of modern biotechnological tools for potato improvement.

Development of potato transgenics

Late blight resistance

The *RB* gene from the wild potato species *Solanum bulbocastanum* is being used at CPRI for conferring late blight resistance. The F_1C_1 clones obtained from the cross Kufri Bahar X RB transgenic lines SP904/SP951 were screened under controlled environment chamber. One hundred twenty hybrids showing different levels of resistance were selected for further screening. At least 10 different types of resistance reactions were recorded from HR to yellowing and abscission of infected leaves (Fig. 8). Twenty seven F_1C_2 clones out of these were selected based on tuber characteristics and yield at Modipuram.

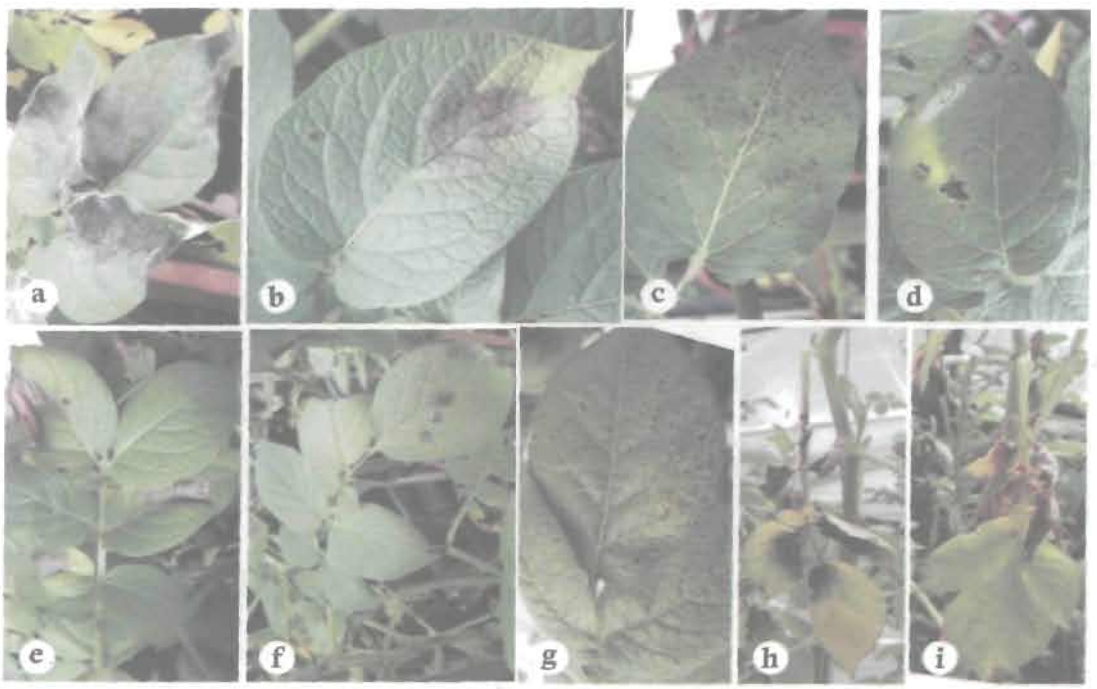


Fig. 8. Different types of resistant reaction observed in the hybrids of Kufri Bahar x SP904/SP951: (a) susceptible parent Kufri Bahar, (b) resistant transgenic parent SP 951, (c) hybrid with HR like resistance, (d) hybrid with small necrosis with yellowing, (e) hybrid with large necrotic area, (f) hybrid with reaction like SP951, (g) hybrid with pin head like shot holes, (h) hybrid with yellowing and leaf abscission, (i) hybrid with yellowing and epinasty.

Two hundred and fourteen hybrids from the cross Kufri Jyoti x SP951 were tested and 106 clones were positive for the RB gene.

119 putative RB-transgenic lines of Kufri Bahar and Kufri Jyoti were checked for RB gene integration. Most of the lines were negative for the full length RB gene. Positive PCR amplification using the internal MAMA primers was observed in case of 19 putative transgenic lines of Kufri Bahar and 6 of Kufri Jyoti. The selected 25 lines were screened against *P. infestans* under controlled environment chamber. Six lines of Kufri Bahar (KBRB-129, KBRB-145, KBRB-163, KBRB-169, KBRB-172, KBRB-180) and 2 lines of Kufri Jyoti (KJRB-2, and KJ-RB-34) were found promising.

Reduction of cold-induced sweetening

A total of eighty putative transgenic lines of two Indian potato cultivars, Kufri Jyoti and Kufri Chipsona-1 transformed with *Nt-Inhh* gene construct were screened by RT-PCR with gene-specific primers for *Nt-Inhh* expression. Seven transgenic lines, four for Kufri Chipsona-1 and three for Kufri Jyoti, were found positive (Fig. 9).

Intron containing invertase inverted repeat gene construct (IR-*iINV*) was developed (Fig. 10) for RNAi-mediated silencing of potato vacuolar invertase gene for reduction of cold-induced sweetening. Out of 100 putative transgenic lines of Kufri Chipsona-1, 41 were found positive for *NPTII* gene expression.

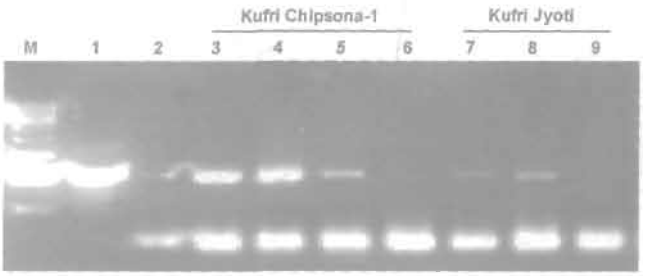


Fig. 9. *Nt-Inhh* expression in the selected seven transgenic lines as evidenced by RT-PCR analysis. Lanes: M, molecular marker; 1, positive control; 2, non-transformed control; 3-6, Kufri Chipsona-1 transgenic lines; 7-9, Kufri Jyoti transgenic lines.

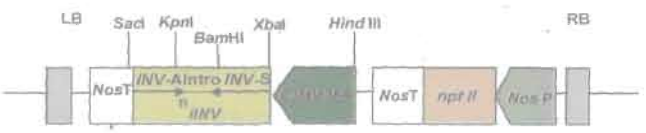


Fig. 10. Map of T-DNA region of pBI121::CaMV 35S::*iINV*-PTGS vector cassette

Bacterial wilt resistance

The late blight resistant cultivar, Kufri Giriraj was transformed with the EBD gene for conferring tolerance to bacterial wilt. Out of 53 putative EBD-transgenic lines regenerated, 21 gave positive amplification of *npt II* marker gene. Twelve putative EBD-transgenic lines of Kufri Jyoti were also regenerated.

Virus resistance

The CP gene cloned from the Indian PVY^{O} strain and the replicase gene from the ToLCNDV are being used for conferring resistance to the respective viruses. Binary vectors carrying the CP gene of PVY in sense, antisense and non-translatable orientations were designed. Cloning of the CP gene in desired frame was checked by sequencing using a CaMV 35S promoter based primer. DNA sequences at the cloning site of the binary vector pBinAR showed perfect orientation of the cloned genes. The binary vector carrying the CP gene in sense, antisense and non-translatable forms were named as pBinRJ-1, pBinRJ-2, and pBinRJ-3, respectively. The vectors were mobilized into the *Agrobacterium tumefaciens* strain EHA105 and pure cultures of *Agrobacterium* carrying the appropriate gene constructs were established by single colony isolation. In all, 40, 23, and 6 shoots were regenerated for sense, non-translatable, and antisense constructs respectively of the CP gene.

Similarly, transformation vector based on the binary vector pBinAR containing the antisense, sense, and hairpin loop constructs of the replicase gene of ToLCNDV was designed and 25 putative transgenic shoots of Kufri Badshah with antisense replicase gene were regenerated.

QTL mapping of late blight horizontal resistance

A mapping population consisting of 126 clones from the cross *Solanum spegazzini* x *Solanum chacoense* was genotyped by the AFLP-Plant-Kit module of M/S Applied Biosystem. Selective amplification was done with four primer pairs. The amplified products were analysed by genetic analyzer ABI Prism 310. A total of 200 peaks were detected from the two parents out of which 158 were polymorphic (Table 9).

Purification and characterization of potato ribonuclease P

An efficient *in vitro* transcription vector/ system, pUC-IVT (Fig. 11), was constructed to remove the caveat of incorporation of undesirable sequences in the transcript. Efficacy of pUC-IVT was assessed by ligating different DNA fragments encoding precursor tRNAs into pUC-IVT, and generating precursor tRNA transcripts by *in vitro* run-off transcription.

Table 9. Data on parental polymorphism of AFLP bands generated by four selective primer pairs.

Primer combination	Total number of bands	Size range (bp)	Number of polymorphic bands
MseI-CGG/*EcoRI*-AAC	60	71-407	49
MseI-CTT/*EcoRI*-ACC	40	80-422	36
MseI-CAG/*EcoRI*-AGC	26	51-317	24
MseI-CTT/*EcoRI*-AAC	74	51-423	49
Total	200	51-423	158

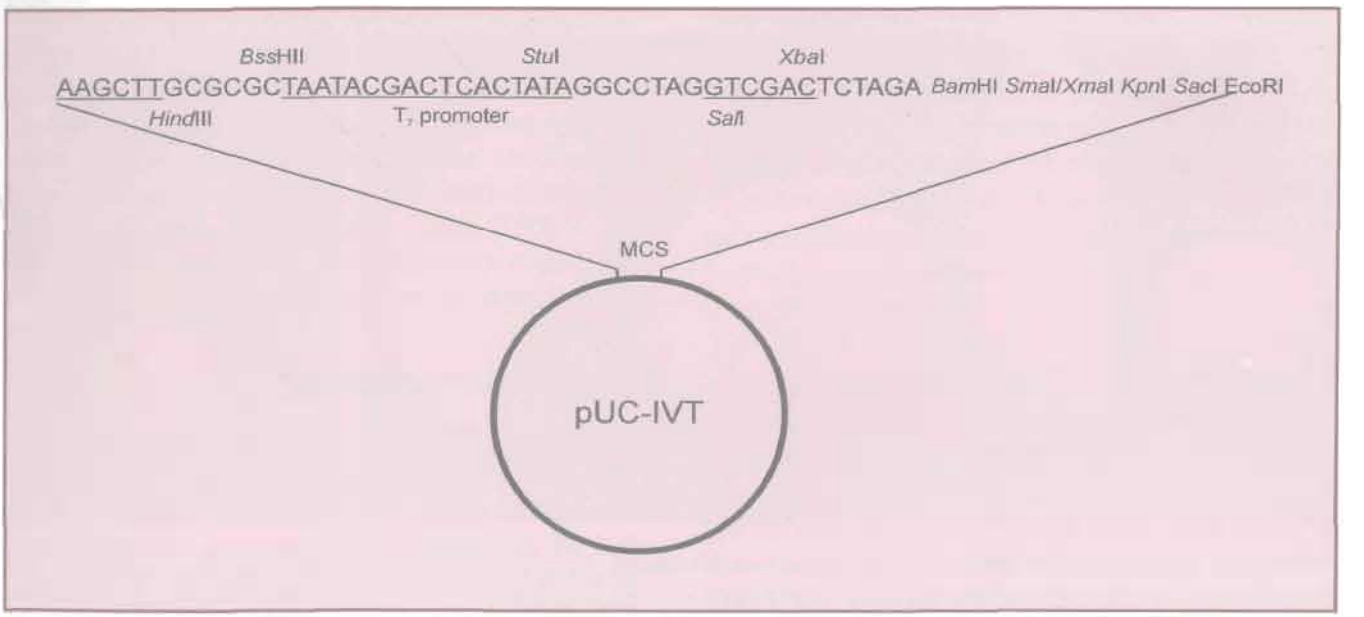
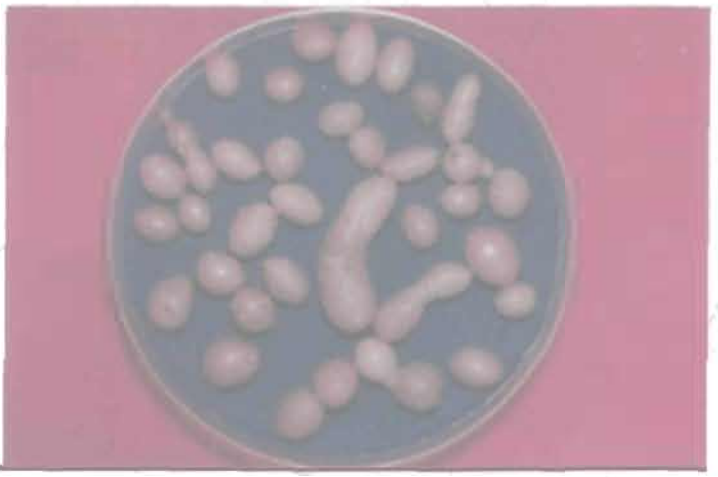


Fig. 11: Simplified map of *in vitro* transcription vector pUC-IVT. Nucleotide sequence of modified MCS to generate pUC-IVT is mentioned.

Cell Biology and Somatic Cell Genetics for Potato Improvement



Characterization of putative dihaploids

Phenotypic characterization of androgenic dihaploids was done. In contrast to its tetraploid anther donor Kufri Chipsona-2, dihaploid C-13 was a dwarf, with a semi-compact bushy appearance, short internodes and small lighter green leaves. Another dihaploid D4 had an open canopy structure, with short internodes and small dark green leaves, compared to compact canopy structure of its tetraploid parent JTH/C-107. A complete reversal of corolla colour from intense purple to white occurred in D4. The male fertility of C-13 was comparable to K. Chipsona-2 based on pollen stainability and FCR assays. However, the FCR test showed that the per cent pollen quality was significantly higher in D4 (23.3%) than in JTH/C-107 (8.5%). Dihaploid C-13 was found to be highly resistant to late blight and it appeared almost immune. The nDNA 2C values of C-13 and D4 were 1.72 and 1.76 pg, respectively, in comparison to 3.62 and 3.59 pg of their corresponding tetraploid anther donors. There were significant differences in the 2C values among the JTH/C-107 androgenic clones. Except for D2-2 and D2-3, significantly higher 2C values (3.69-3.86 pg) were observed in the other JTH/C-107 androgenic clones (D1-1 to D1-3, D2-1, D2-4, D2-5 and D2-7) than the tetraploid anther donor. Chromosome analysis showed that both androgenic dihaploids were with 24 chromosomes in their L_2-cell layers, and no meiotic abnormalities were observed. Nuclear microsatellite analysis produced 35 alleles, with their sizes ranging from 88 to 462 bp and with an average number of 3.5 alleles per locus. Maximum number of alleles was detected for microsatellite loci *POTM1-2* followed by *STM0015*, *STM0019a* and *STWAX-2*. These four loci together accounted for 19 alleles, with an average polymorphism information content (PIC) of 0.633. Of the four nSSR genotypes produced at *POTM1-2*, *STM0015* and *STM0019b*, two androgenic dihaploids and their corresponding tetraploid anther donors had unique genetic profiles, while nine androgenic tetraploids had a common allelic profile true-to-type to their tetraploid anther donor. Based on RAPD assays using 84 decamers, the androgenic dihaploids, tetraploids, tetraploid anther donors could be grouped into distinct clusters.

Somatic hybridization

An improved reproducible protocol was optimized for protoplast isolation and culture. Protoplast digestion solution (PDS) containing 0.4 M mannitol, 0.1 M glucose, modified MS macroelements (0.95 gL^{-1} KNO_3, 0.085 gL^{-1} KH_2PO_4, 0.185 gL^{-1} $MgSO_4 \times 7H_2O$ and 0.66 gL^{-1} $CaCl_2 \times 2H_2O$), ½ MS micro elements, full-strength MS vitamins, 0.5% (w/v) polyvinylpyrrolidone (PVP), 5.0 mM MES NaOH pH 5.7, 1-2% Cellulase Onozuka-RS and 0.5% Macerozyme R-10 was found to be optimum for the isolation of good quality viable protoplasts. The protoplasts were electrofused with the following optimized parameters: 10-20 V alignment amplitude (50-100 V cm^{-1}) for 20-30 s; 260 V electrofusion

amplitude (1-1.3 kV cm^{-1}) for 40-60 μs; number of DC pulses, 1; post-fusion incubation, 15-30 min. Out of various fusion combinations involving androgenic dihaploids and diploid *Solanum* wild species, successful electrofusion leading to the development, separation and culturing of fusion products (calli) was obtained in C-13/ *S. bulbocastanum* (accession no.: CGN 23074) and C-13 / *S. commersonii* (accession no.: CGN 17988).

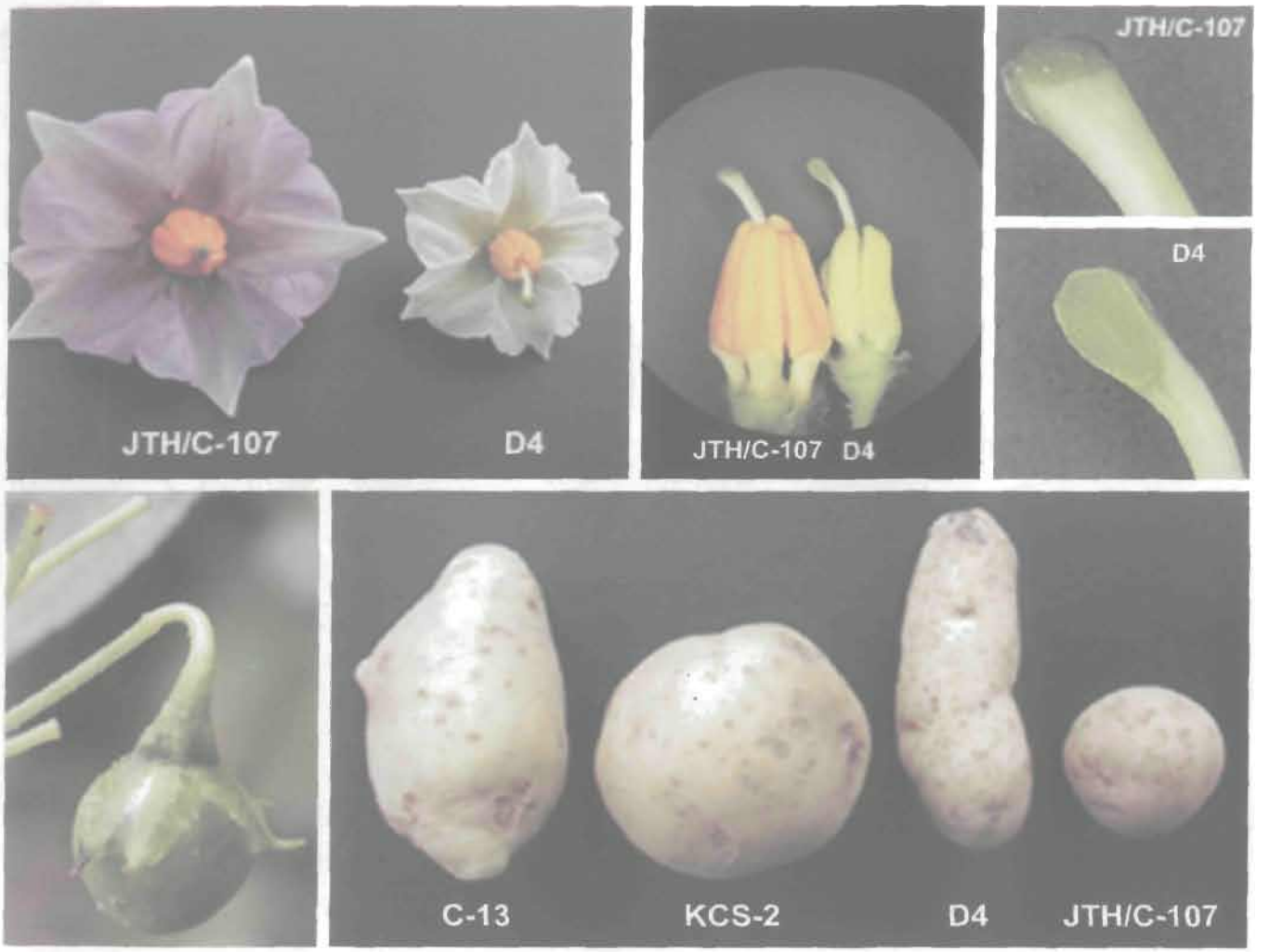


Fig. 12. Floral and tuber characteristics of androgenic dihaploid (2n=2*x*=24) D-4 in relation to its tetraploid (2n=4*x*=48) anther donor TPS parental JTH/C-107. Clockwise from top-left: a complete flower colour reversion in D-4; variation in anther and stigma; variation in tuber characteristics (tubers of androgenic dihaploid C-13 are also shown in comparison to its tetraploid anther donor Kufri Chipsona-2); a selfed berry in D-4.

DIVISION OF

CROP PRODUCTION

- Intercropping of gram, lentil, and vegetable peas with potato increased net returns by Rs.4,392, 5,604 and 11,900/ha, respectively at Jalandhar. Highest system productivity was obtained in case of maize–potato–onion (45.7t/ha), followed by paddy–potato–wheat (43.2t/ha).
- Thematic maps of potato acreage and production statistics at district level was compiled and prepared. An overall increase of 6.6% in potato acreage and 10% increase in potato production over the last year's estimates were forecast.
- It was demonstrated that it is necessary to apply phosphorus fertilizer based on soil test. One-fourth of recommended P_2O_5 is required in soil with > 20 ppm available P. Kufri Pukhraj, Kufri Ashoka, Kufri Sutlej, Kufri Bahar, Kufri Jawahar, Kufri Badshah, Kufri Jyoti, Kufri Sindhuri, Kufri Lalima and Kufri Chandramukhi are the varieties in decreasing order of efficiency in terms of phosphorus uptake.
- Irrigation scheduling based on cumulative pan evaporation (CPE) gave higher yield compared to irrigation at critical stages. Sprinkler irrigation significantly increased processing grade and total tuber yield over that of conventional irrigation.
- A rotary tiller with crumbler roller, a manually operated sieve type or endless screen type of potato grader and wire belt type potato grading system were fabricated. The design of French fry cutting machine and the tractor operated wide row ridger were refined. Pallets of different designs made of wood and metal were fabricated for a 2 t forklift in rough and unlined surfaces.

Develop Sustainable Potato Based Cropping Systems

Potato being a high input crop sets the course, content and extent of other crops in potato based cropping systems under diverse agro-climatic conditions of India. Efficient use of inputs in potato and other rotational crops in the system influences the productivity and sustainability of the cropping system for which scientific resource management is of utmost importance. Work has been taken up on identification of remunerative cropping systems and their input management for different agro-climatic zones in the country. Besides, the work on crop modeling and use of GIS and remote sensing tools in potato production were carried out during the year.

Resource management in potato based cropping systems

North western plains: Three year (2004-2007) data at Modipuram showed that in the potato-maize + black gram (1:1)-groundnut system, when 100% NPK applied to the potato crop + residue incorporation, the succeeding crop of maize required only 50-100% N. Leguminous crops of black gram and groundnut did not require macro-nutrients application but groundnut needed gypsum to meet its calcium and sulphur requirements. The mean yield levels of potato, maize cobs and fodder, black gram and groundnut were 31.2-34.9, 5.6-7.4, 10.6-14.6, 0.46-0.62 and 2.0-2.4 t/ha, respectively.

North central plains : In an experiment conducted at Gwalior to assess the effect of manurial scheduling and date of harvesting of potato in potato–onion crop sequence on production

Fig. 13. Intercropping of maize in potato in mid hills of Shimla

potential, tuber yield increased significantly from 9.0 to 14.3 t/ha with delaying harvesting from 60 to 74 days after planting, respectively. Application of 25% recommended dose of fertilizer through FYM and 75% through NPK to potato, and raising onion crop on residual soil fertility produced highest potato equivalent yield of 29.4 t/ha with production efficiency of Rs. 400/ha/day.

At Modipuram, in potato based sequence, 6 crops *viz.* Tuberose 'Single', African marigold, Zinnia 'Double', okra 'Selection-12', cluster bean 'Pusa Nav Bahar' and cowpea 'Pusa Komal' were evaluated. Although all the crops barring zinnia enhanced gross total income, growing floral crops of Tuberose (flowers and bulbs) and marigold when no other flowers are available during summers and nitrogen fixing high yielding crop of cowpea proved promising.

North eastern plains : Results from long term studies at Patna on optimizing fertilizer schedule

for 3 potato based sequences *viz.* potato - green gram – rice (C1), potato-maize- rice (C2), and potato – onion - rice (C3) and four manuring schedules i.e. 100% of recommended doses of fertilizers (RDF) to all the crops in sequence (F1), 100% RDF + residue incorporation @ 5 t/ha of previous crop to all the crops (F2), 100% RDF to all the crops + *in situ* green manuring of *sesbania* to rice only (F3) and 100% RDF to all the crops + FYM @ 10 t/ha to potato only (F4) showed no significant effect of cropping systems on tuber yield (Table 10). However, integrated use of FYM @ 10 t/ha with 100% RD of NPK (F4) maximized tuber yield due to improved soil physical conditions and higher availability of macro and micro nutrients with the addition of FYM. The crop residue incorporation (F2) also brought about significant increase in potato yield compared to 100% RD of NPK application (F1).

Maximum yield of onion bulbs (23.0 t/ha) and green gram grain (1.9 t/ha) were obtained with F3 while grain yield of maize (5.9 t/ha) was highest in F4. The residual effect of FYM gave 7.14% higher yield of maize grain whereas, green manuring increased the yield of onion and green gram by 3.82 and 36.36 %, respectively. *In situ* residue incorporation and application of 100% RDF resulted in higher yields of onion, maize, and green gram over application of only 100% RDF.

Grain yield of rice was significantly higher in potato-green gram–rice sequence followed by potato-onion–rice sequence probably due to beneficial effect of legume crop in the sequence. Likewise, green manuring with *Sesbania* resulted in the highest rice grain yield due to improved soil physical and chemical properties. The *in situ* residue incorporation also increased the grain yield of rice.

System productivity in terms of rice equivalent yield (REY) was highest in potato-onion-rice (28.3 t/ha) followed by potato-green gram–rice (27.2 t/ha) and lowest in potato-maize-rice system (22.2 t/ha). The higher REY in potato-onion-rice cropping system was because of high yield of onion coupled with better price of the produce. Among the manuring treatments, maximum REY (27.0 t/ha) was obtained with F3 followed by F4 (26.4 t/ha).

The cost of cultivation of potato-onion–rice sequence was Rs. 87,715/ha/year due to higher cost of cultivation of onion on account of fertilization, labour and more irrigation to the system. On the other hand, potato-green gram–rice system proved to be the most remunerative as evident by net profit of Rs. 1,08,140/ha/year because of higher yield and value of the produce. This cropping system also had the highest benefit: cost ratio (1.51) and lower cost of cultivation (Rs. 71,411/ha/year). Potato-onion-rice showed the highest land use efficiency

Table 10. Effect of cropping systems and fertilization on economics, land use efficiency and production efficiency at Patna

Treatments	Potato yield (t/ha)	Rice yield (t/ha)	REY (t/ha)	Net income (Rs/ha)	Benefit cost ratio	Land use efficiency (%)	Production efficiency (kg/ha/day)
Cropping systems							
C_1	26.6	4.9	27.2	1,08,140	1.51	74.53	94.8
C_2	25.4	4.5	22.2	74,126	1.02	60.95	76.6
C_3	26.0	5.0	28.3	87,909	1.00	77.52	99.3
CD (0.05)	NS	0.3	1.8	-	-	-	-
Fertilizer schedules							
F_1	24.6	4.3	24.4	82,055	1.10	66.83	87.6
F_2	25.3	4.8	26.0	90,038	1.18	70.98	93.1
F_3	26.5	5.2	27.0	95,578	1.23	73.87	85.5
F_4	27.5	4.5	26.4	92,562	1.20	72.32	94.8
CD (0.05)	1.3	0.3	1.1	-	-	-	-

REY% Rice equivalent yield.

(77.5%) compared to 74.5 % by potato-green gram-rice. Production efficiency was highest in the treatment 100% RDF to all the crops + FYM @ 10 t /ha to potato only.

Effect of rotational crops on nematode population: The results from effect of rotational crops (wheat, cabbage, *Solanum nigrum* and winter potato) on potato cyst nematodes (PCN) population following summer potato at Ooty indicated that *Solanum nigrum* performed better in terms of potato yield and reducing PCN populations by 50% compared to potato-potato sequence. The other sequences with cabbage and wheat were also effective in reducing PCN population. Growing cabbage or radish after potato also effectively reduced PCN population.

Feasibility of intercropping in potato

Intercropping aimed at providing insurance against possible crop losses due to late blight and frost. Innovations were also made in seed, fertilizer placement and earthing of potato. Legumes are susceptible to high N and water, while potato essentially requires them for high productivity.

North western hills: In mid hills of Shimla, higher yield of component crops were obtained in potato+ maize (1:1) intercropping, when both the crops were fertilized with 100% N (Fig 13). The value of relative crowding coefficient of potato (1.13) and maize (1.44) further showed that both the crops are complementary to each other. The partial land equivalent ratio (LER) was 1.06 and 1.18 for potato and maize, respectively. Likewise, in potato + French bean (1:1) intercropping, French bean needed only 75% of recommended N with LER of 1.26 thereby saving of 26% of land area over sole cropping of component crops grown with recommended N. The competition functions further revealed that the French bean was more 'aggressive' (Aggressivity value 1.14) and 'dominant' (competition ratio of French bean 1.16) than potato in potato + French bean intercropping.

In another study, potato tuber yield was significantly higher under hand weeding either at 45 (15%) or 60 days (21%) over the control (weedy check). However, it was significantly lower than that under weed free plots. The weed biomass production at 90 days after planting was about 40 and 58% lower, respectively, under these treatments, over the control.

Southern hills: At Udhagamandalam, the highest potato equivalent yield (PEY) of 15.3 t/ha was obtained when 75% of recommended doses of NPK was applied to both the crops in proportions to their population in potato + French beans intercropping (75:50) during this year while PEY was higher with 100% recommended doses of NPK applied to both the crops in previous year showing thereby that the incorporation of legume crop (French beans) residues improved the soil organic carbon content of the system. However, cyst count was lowest at 125% of recommended dose of NPK.

Northern plains: Studies at Jalandhar on innovative potato + legume intercropping system revealed that legumes are incompatible with potato owing to widely varying requirement of potato and legumes for nutrients and water.

Therefore, legumes were sown between paired rows of potato in FIRB (Furrow irrigation in raised bed) method (Fig. 14). Productivity and profitability of potato + vegetable peas, potato + lentil and potato + gram intercropping systems were evaluated with potato sole crop under normal and FIRB method of cultivation. Intercropping gram, lentil and vegetable peas increased the net returns by Rs. 4,392, 5,604 and 11,900/ha, respectively (Table 11).

Fig. 14. Potato + lentil intercropping

Indo-Gangetic plains: The feasibility of including short duration crops between rows of potato, bed planting method *vis*-a-*vis* ridge furrow method for providing seed bed to intercrops was

Table 11. Productivity and profitability of potato + legumes intercropping systems at Jalandhar

Treatments	Planting method	Sole Crop density (%)	Potato yield (q/ha)	Inter-crop yield (q/ha)	PEY (q/ha)	Net returns (Rs/ha)	B:C ratio
Potato (control)	FR	100	202	-	202	36800	1.83
Potato	FIRB	100	200	-	200	36000	1.81
Potato + Vegetable peas	FIRB	100:25	191	19.0	236	48700	2.06
Potato + Gram	FIRB	100:25	200	4.7	217	41192	1.90
Potato + Lentil	FIRB	100:38	200	4.2	220	42404	1.93
CD (0.05)			NS		13.1		

PEY: Potato equivalent yield
FR: Furrow and ridge method.
FIRB: Furrow irrigation in raised bed.

explored at Modipuram. The improvement in design of bed is required in traditional irrigation system for improved water supply. Tuber yield reduced up to 14.6% in bed planting system over conventional (ridge-furrow method) in traditional system of irrigation attributed to constraint of moisture in bed planting method. Maximum yield reduction was in Kufri Chipsona-1 (19.5%) while it was minimum in Kufri Pukhraj (11.6%) in bed planting method.

In an another study at Modipuram on exploring the scope of including short duration intercrop with minimum yield loss with 4 potato cultivars (Kufri Sutlej, Kufri Anand, Kufri Pukhraj and Kufri Chipsona-1) at reduced planting densities, the number and yield of tubers remained unaffected statistically at 100% and 75% planting densities of potato. However, reduction was significant at 50% planting density in tuber number (26.3%) and total tuber yield (13.2%) as compared to 100% planting density. Kufri Pukhraj recorded equal total tuber number at 100 and 75% density, with improved yield of 14.8% at 75% planting density. Intercropping of floral crops *viz.* annual chrysanthemum (single and double), marigold (French and African) and Dianthus were found profitable at Modipuram.

Central Plains: At Gwalior, in potato + pea intercropping, potato tuber yield (29.0 t/ha) and green pod yield of pea (2.3 t/ha) were highest when potato was planted on ridge and pea was sown on both sides of the ridge in zig-zag planting pattern.

Eastern Indo- Gangetic plains: At Patna, results from intercropping of vegetable pea, gram and lentil in potato showed 14% decrease in potato productivity when planting method was changed from furrow-ridge to furrow-raised bed, which decreased further when it was intercropped with legumes. However, the decrease was less when potato was intercropped with gram.

Remote sensing and GIS

Winter potato acreage and production estimation: For winter potato acreage estimation during 2007-08, advanced wide field sensor (AWiFS) data from Indian remote sensing satellite IRS-P6 acquired at 17th November, 2007; 31st December, 2007; 1st January, 2008 and 6th February, 2008 were used for potato acreage estimation of Punjab, Uttar Pradesh, Bihar and West Bengal states, respectively. A two step approach of unsupervised and supervised classification *i.e.* (i) a mask of non-agricultural area was made to exclude settlements, water, forest and fallow area using unsupervised classification and rest of the area was treated as potential potato area and (ii) potato crop was classified using maximum likelihood classification with null classes based on the ground truth data, was used (Fig 15).

The remote sensing estimates for 2007-2008 winter potato acreage for Punjab, Uttar Pradesh, Bihar and West Bengal states were 66.6, 425.0, 169.7 and 335.0 thousand hectares, respectively. The respective total production in these states was estimated to be 1205.5, 9137.0, 1707.2 and 7504.0 thousand tonnes through INFOCROP-POTATO simulation model using weather data up to January 31, 2008. This year, an overall mean increase of 6.6% in potato acreage and

10% increase in potato production were observed in these states over the last year's estimate. The work was conducted in collaboration with Space Applications Centre (ISRO), Ahmedabad.

Characterizing potato growing regions: Study on use of crop model and GIS tools for characterizing potato growing regions, estimating yield gap *etc.* were initiated and various spatial and attribute databases were created. During the year, database of potato acreage and production statistics at district level were prepared and thematic maps developed (Fig. 16). The relative yield of the different potato growing districts *vis-a-vis* the national average yield was also

Fig. 15. AWiFS image of November, 2007 from IRS-P6 satellite showing potato crop distribution in Punjab

calculated and thematically presented (Fig. 17). Further the agro-ecological zones of potato growing districts was prepared by digitizing the NBSSLUP-AEZ map and over laying the potato growing districts vector boundaries on it.

The SRTM DEM data were also collected and vector boundaries of potato growing districts was over laid on it. In addition, daily weather database of more than 1,500 stations were generated using MARKSIM weather generator. This generated weather database was also converted into INFOCROP-POTATO format as well as in the format required by the summary model.

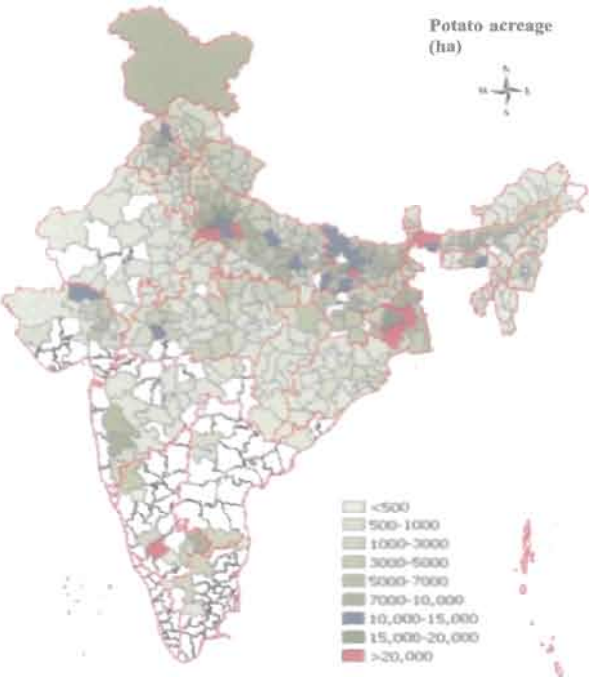


Fig. 16. District-wise potato area in India

A spread sheet tool with the summary model of Versteeg and van Keulen was programmed and embedded into the database. The outputs from the summary model were imported into the ArcGIS environment for developing thematic maps of various attributes *viz.* mean temperature of the growing season, length of thermally suitable growing period, potential yield (production situation 1), harvest index *etc.*

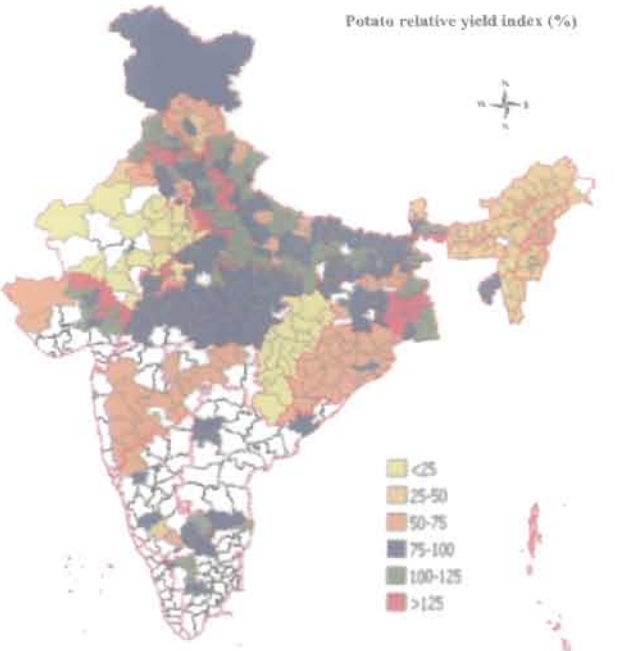
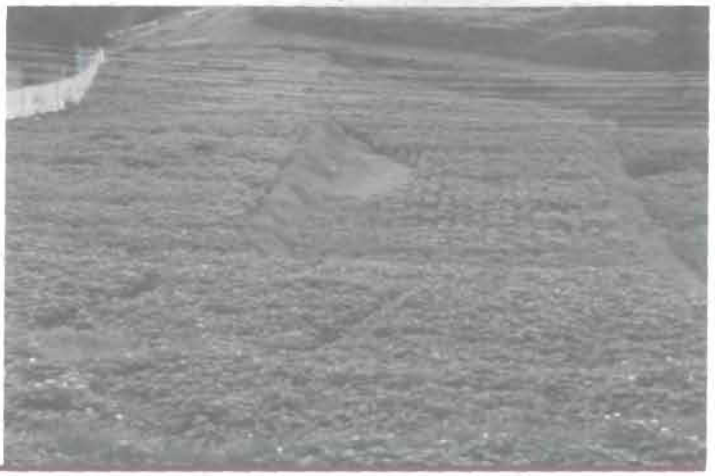


Fig. 17. Relative yield of the different potato growing districts to the national average

Low Cost Input Technology for Potato Production



Potato is a highly input intensive crop. The cost of cultivating potato is much higher than many cereal crops on account of cost of seed and labour. This is a major constraint for small and marginal farmers to adopt potato cultivation. To popularize potato cultivation among these farmers, reduction in cost of cultivation becomes imperative. The programme is, therefore, aimed at reducing the cultivation cost without much reduction in tuber yield and returns.

Study conducted at Gwalior with cv. Kufri Ashoka with 5 variable seed sizes gave highest total number of tubers (12.7 lacs/ha) and also number of tubers weighing 10-20 g (5.8 lacs/ha) with 55 g seed tubers planted at 40 x10 cm (Table 12). It was significantly higher than 15 and 25 g seed tubers. There was however, no significant difference in total yield. Data presented in table 13 revealed that among economic parameters, highest net return of Rs 51,473/ha and benefit: cost ratio of 1.79 were obtained with 15 g planted tubers showing that 15 g tubers planted at 40 cm inter-row and 10 cm intra-row spacing was most economical for producing 10-20 g size tubers.

Table 12. Number of tubers in produce as affected by the size of seed tubers

Seed size (g)	Number of tubers (lacs/ha)			Total
	<10 g	10-20 g	>20 g	
15	3.67	3.62	3.44	10.72
25	2.85	3.55	3.65	10.06
35	3.35	4.72	3.98	11.70
45	3.73	4.69	3.66	12.08
55	4.05	5.77	2.87	12.69
CD (0.05)	1.37	1.24	6.00	2.17

Table 13. Economic parameters as influenced by the size of seed

Seed size (g)	Total yield (t/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
15	23.3	65,027	1,16,500	51,473	1.79
25	22.9	85,027	1,14,500	29,473	1.34
35	26.7	1,05,027	1,33,500	38,473	1.40
45	25.8	1,25,027	1,29,000	2,973	1.03
55	27.4	1,45,027	1,37,000	(-)8,027	0.94

Integrated Nutrient and Water Management in Potato

To sustain productivity of potato and different potato based cropping systems, efficient nutrient management is vital. There is a need to develop more efficient, effective, economic and integrated system of nutrient management for realizing high productivity without affecting soil fertility. Integrated management of the nutrients that incorporates both organic and inorganic plant nutrients for proper plant growth, together with effective crop and water management, is critical for sustaining productivity of potato based cropping systems. The current project is aimed at attaining these objectives.

Integrated Nutrient Management

Potato response of N: At Modipuram, Kufri Surya, Kufri Arun, Kufri Pukhraj, Kufri Chipsona-3, Kufri Bahar, Kufri Anand and Kufri Pushkar responded to N application up to 200 kg/ha with response varying with cultivars. The highest tuber yield was recorded in Kufri Pukhraj (29.6 t/ha) and the lowest in Kufri Surya (20.7 t/ha).

Screening of potato cultivars for N efficiency

Root and shoot parameters: In a solution culture study at Jalandhar, cv. Kufri Pukhraj was more N efficient than Kufri Jyoti as it produced higher dry matter at lower dose of N. During first 10 days, nitrate level although did not affect shoot growth but significantly increased root growth in both the cultivars with the magnitude of increase in root growth being of higher order in Kufri Pukhraj than in Kufri Jyoti (Fig. 18). At 10 days, shoot growth (top dry weight) was same in both the cultivars but root growth differed significantly between cultivars and among nitrate levels.

Between 10 to 26 days after planting, root growth did not increase much whereas, top dry weight increased significantly with Kufri Pukhraj achieving maximum top dry weight at lower nitrate level of 0.25 mM while Kufri Jyoti achieved this at higher nitrate level of 0.5 mM. Thus, N-efficient cv. Kufri Pukhraj had more root growth (root fresh weight, root length, root surface area and root:shoot ratio) than Kufri Jyoti.

Screening of potato cultivars for P efficiency

Evaluation of potato cultivars for P efficiency :At Jalandhar, potato cvs., Kufri Badshah, Kufri Ashoka, Kufri Jawahar and Kufri Bahar responded significantly up to 100 kg P_2O_5 /ha whereas, in Kufri Pukhraj, Kufri Sutlej, Kufri Sindhuri, Kufri Jyoti and Kufri Lalima the significant response was up to 50 kg P_2O_5/ha in the absence of green manuring. In the presence of green manure, only Kufri Chandramukhi, Kufri Bahar, Kufri Lalima and Kufri Pukhraj responded to P application. Kufri Pukhraj was the most P efficient potato cultivar both in the absence and presence of green manuring with *dhaincha* as it produced highest yield without P and needed least P dose to

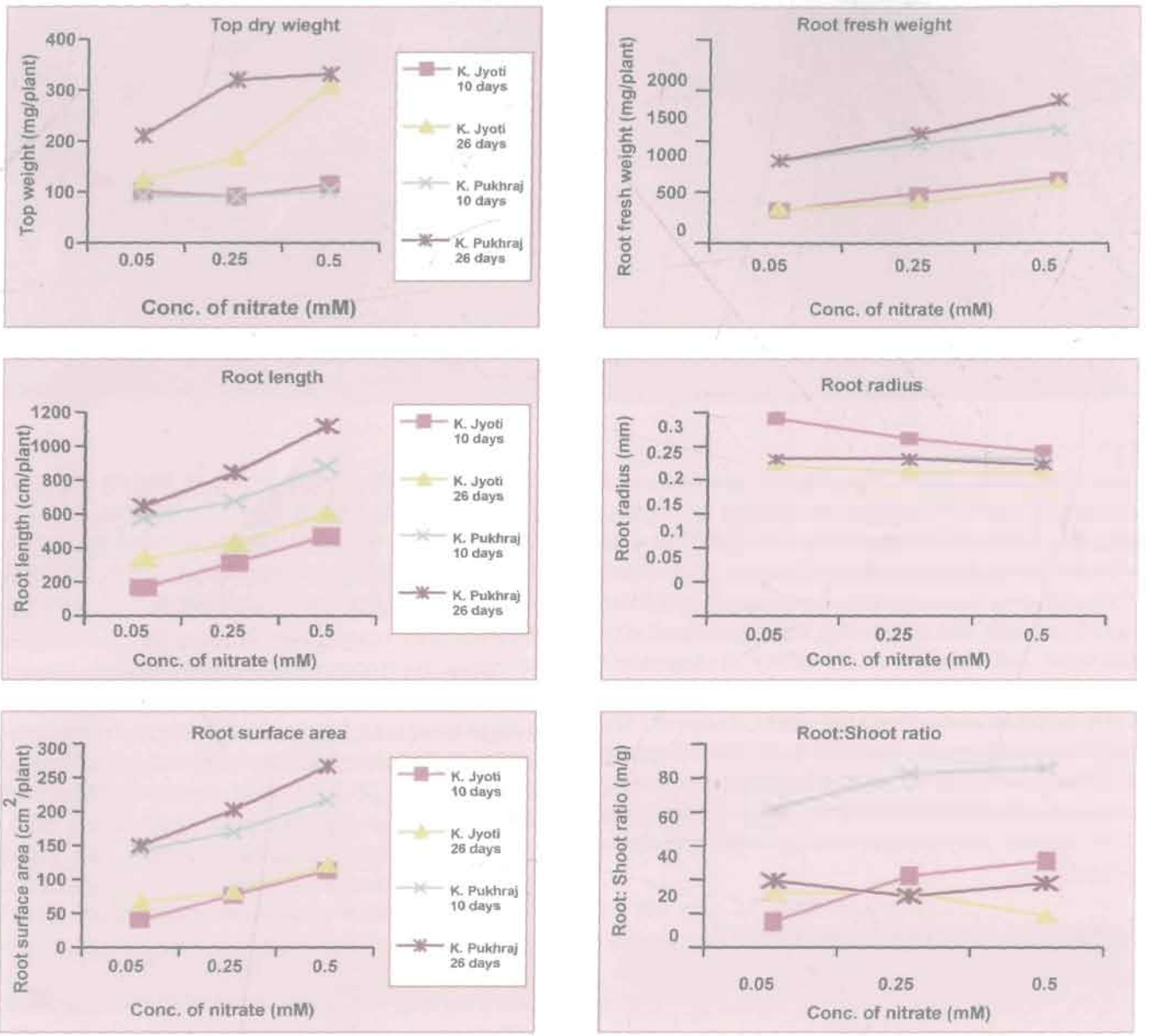


Fig. 18. Root and shoot parameters of N-efficient (Kufri Pukhraj) and N-inefficient (Kufri Jyoti) potato cultivars

produce same fixed yield (Table 14). In the absence of P fertilizer, cv. Kufri Badshah and Kufri Ashoka gave highest while Kufri Sindhuri and Kufri Pukhraj gave lowest response to green manuring.

Tracer study: Fourteen potato cultivars/hybrids from Jalandhar were evaluated for P use efficiency using tracer techniques at Shimla. Eye plugs from mother seed tuber were grown in acid washed sands in absence of P. Plants were removed at 45 days and roots were dipped in 22 ppm labeled KH_2PO_4 having sp. activity of 200 μ Ci /mg P (Fig. 19). At intervals *viz.*, 24, 72, 120, 168, 216 and 264 hours, ^{32}P activity was measured in TRICAB Liquid Scintillation counter. The amount of ^{32}P absorbed by the plant root was taken as difference between initial and activity at each time interval.

Radiotracer data on P absorption kinetics showed higher adsorption of P by the potato roots from phosphate carrier in Kufri Jawahar, Kufri Lalima, Kufri Bahar, Kufri Badshah and Phulwa hence most P efficient. Kufri Chandramukhi, Kufri Chipsona 1, Kufri Pukhraj and Kufri Sutlej were intermediate whereas, Kufri Ashoka, Kufri Chipsona 2, JX-576, Kufri

Table 14. Effect of green manuring (with *dhaincha*) on P requirement of different genotypes

Genotype	P_2O_5 (kg/ha) for fixed yields								
	20 t/ha		23 t/ha		27 t/ha		30 t/ha		34 t/ha
	Without GM	With GM	Without GM	With GM	Without GM	With GM	Without GM	With GM	With GM
Kufri Pukhraj	-ve	-ve	-ve	-ve	-ve	-ve	2	-ve	17
Kufri Ashoka	-ve	-ve	-ve	-ve	29	-ve	86	-ve	47
Kufri Sutlej	-ve	-ve	6	-ve	61	-ve	np	16	np
Kufri Bahar	-ve	-ve	7	-ve	61	29	np	75	np
Kufri Jawahar	-ve	-ve	16	-ve	94	99	np	np	np
Kufri Badshah	5	-ve	31	-ve	100	-ve	np	30	np
Kufri Jyoti	-ve	-ve	34	-ve	np	8	np	np	np
Kufri Sindhuri	-ve	-ve	53	7	np	np	np	np	np
Kufri Lalima	np	6	np	np	np	np	np	np	np
Kufri Chandramukhi	np	6	np	47	np	np	np	np	np

-ve = means higher than fixed yield was achieved in the absence of Pnp = not possible because maximum achievable yield under the given conditions was less than fixed yield.

Fig. 19. Plants dipped in tagged P carriers for absorption study

Sindhuri and Kufri Jyoti were least efficient in absorbing P from applied P (Fig. 20).

Root length had a positive correlation with initial P content of the seed tuber (0.572*). Similarly, number of leaves/plant were positively correlated with plant height (0.374) and number of shoots (0.750**). Initial P content in the seed tubers was however, negatively correlated with the P absorption by the plant roots indicating the importance of P composition of mother seed tuber on the plant growth during early stages of crop. Plant height was again found to exert a great influence on the P absorption by roots from the tagged P carrier with highest value of correlation obtained at 24 hours (0.423*).

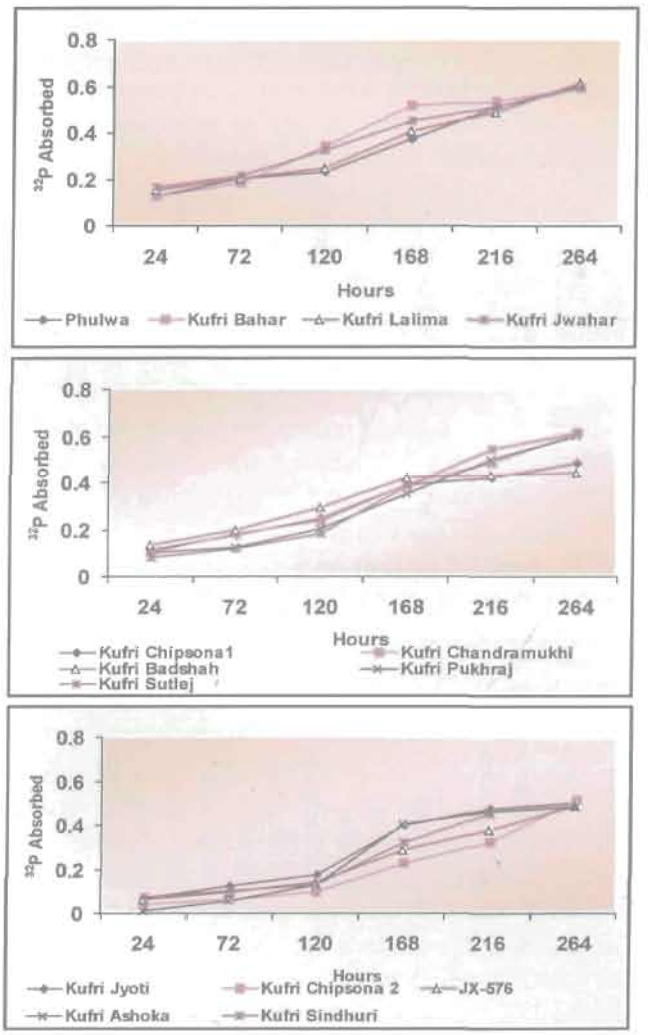


Fig. 20. Phosphorus absorption curve for potato cultivars

Green house studies: 14 potato cultivars were tested for P use efficiency on slightly acidic sandy loam soil medium in Bray P (40 ppm P) at three levels of P (0, 22 and 44 ppm P from KH_2PO_4 tagged with carrier free ^{32}P at sp. activity 300μ Ci /mg P)

Variety played a vital role in influencing plant dry matter yield both in absence and presence of applied P. Radio assay data on leaf P accumulation showed that in absence of applied P, Phulwa, Kufri Chipsona-1 and 2, Kufri-Sutlej and Kufri Jawahar were most effective in utilizing native soil P during initial growth stage when plant needs for P is high whereas, at later stages Kufri Bahar, Kufri Pukhraj, Kufri Lalima and Kufri Ashoka and Kufri Jyoti were at par in P utilization (Fig. 21). Phulwa, Kufri Sindhuri, Kufri Lalima, Kufri Ashoka and processing varieties *i.e.* Kufri Chipsona-1 and 2 were most efficient in utilizing P from applied carrier through out their growing phase (Fig.22).

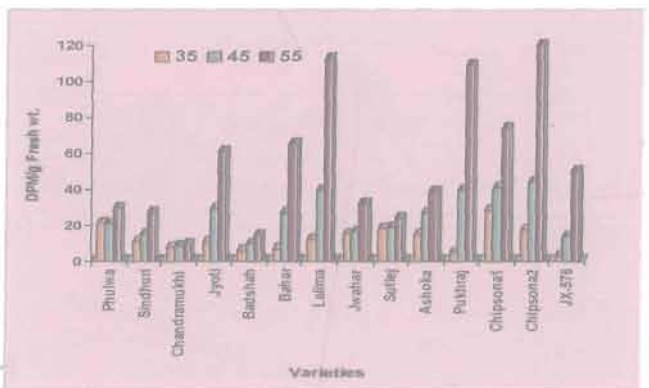


Fig. 21. Leaf ^{32}P activity in potato cultivars/hybrid at different stages of crop growth in absence of P

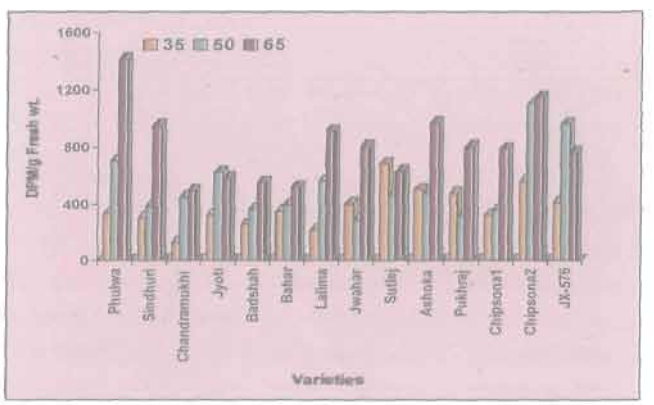


Fig. 22. Leaf ^{32}P activity in potato cultivars/hybrid at different stages of crop growth in presence of applied P

Soil test based fertilizer recommendations: At Jalandhar, potato cv. Kufri Badshah responded significantly up to 75 to 100 kg P_2O_5/ha in soils containing < 10 ppm available P (Olsen P) whereas, the response was up to 25 to 50 kg P_2O_5/ha in soils having 10 to 20 ppm P but no response was obtained in soils having > 20 ppm P. In acidic soils of Shimla, response to P decreased with increase in available P content of the soil and P fertilizer can be saved if application is made based on soil test value taking 36 ppm (Bray P) as critical limit.

Available P status of soils from potato growing areas of Punjab: The analysis of surface (0-15 cm) soil samples from different potato growing soils of Punjab (Jalandhar, Nakodar, Kartarpur, Kapurthala, Hoshiarpur, Dhogri, Phagwara and Amritsar) representing 80% of potato growing areas of Punjab showed that 11, 50, 25, 75, 10 and 25% soil samples from Jalandhar, Nakodar, Kartarpur, Kapurthala, Hoshiarpur (including Dhogri and Phagwara) and Amritsar contained more than 40 ppm available P ($NaHCO_3$ extractable P), respectively which was more than critical limit of 10 ppm established for potato in alluvial soils of Punjab.

The overall mean indicated that 25, 34, 19 and 22% of soil samples collected from different potato growing soils of Punjab were in the range of >10-20, >20-30, >30-40 and >40 ppm available P, respectively. The 75% of total samples contained more than 20 ppm available P. Results suggested that farmers should apply fertilizer P to potato only after getting their soil tested for available P.

Phosphorus forms in soils of potato growing areas of Shimla: The soils of potato growing areas of Shimla had pH varying from 5.15 to 7.32. The organic C content of the soils ranged from 0.63 to 3.34% with a mean value of 1.75%, indicating that these soils were acidic to neutral in reaction and medium to high in organic C.

Bray P varied from 13.5 to 124.0 kg P/ ha with a mean value 37.1 kg P/ ha. Taking the critical limit of 78 kg P/ ha fixed for potato, more than 50% of soils were deficient in available P. The amount of P ranged from 0.99 to 4.17 for saloid -P, 45.7 to 102.6 for Al-P, 33.5

to 90.6 for Fe-P and 49.5 to 116.4 mg/ kg soil for Ca-P. Only 1.25% of the total P was in form of sal.- P while Al-P and Fe-P constituted 29.2% and 26.8% of total P, respectively and rest was Ca- P (Fig. 23).

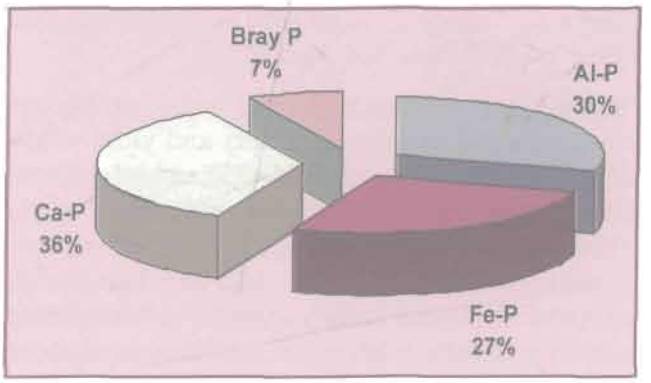


Fig. 23. Distribution of P among various inorganic fractions in Shimla soils

Organic carbon had a positive correlation with all forms of P. Available P showed close association with Fe-P, Al-P and Ca-P which were also positively related to each other. Micronutrients also modify the P availability in these soils. Because of antagonistic relationship between P and micronutrients, the presence of large quantities of Al, Fe ions or Mn also reduces the P availability to the plant. Soils low in P, need regular application of P from fertilizers and organic manures on the basis of soil P tests and crop removal of P so as to maintain soil productivity and fertility in the region.

Site specific nutrient management (SSNM): At Modipuram, the highest reduction (16.1 and 19.1 t/ha) in tuber yield was in Kufri Anand and Kufri Bahar in N omission plot whereas, the lowest reduction was registered in Mg omission plot. In Kufri Anand, after N omission plot, the highest effect was obtained in K omission plot (7.3 t/ha) followed by Zn (6.55 t/ha), P (4.3 t/ha), B (3.15 t/ha), S (1.48 t/ha) and Mg (0.95 t/ha) whereas, in Kufri Bahar, the order of reduction was K (11.45 t/ ha), Zn (10.81 t/ha), B (9.88 t/ha), S (9.3 t/ ha), Mg (9.07 t/ha) and P(8.77 t/ha). As compared to best SSNM option, the tuber yield with recommended dose of fertilizer was lower by 10.96 and 10.63% in Kufri Anand and Kufri Bahar, respectively.

Efficiency of organic sources

Contributions of organic sources on N efficiency: At Patna, response of N was recorded up to 240 kg/ha in the plots where no organic sources or paddy straw was used, however, in the plots where FYM and green manure was used a saving of 40 kg N/ha was achieved. The green manuring with *dhaincha* was best in Kufri Jyoti and Kufri Pukhraj followed by 20 t FYM, 10 t FYM and paddy straw. Kufri Pukhraj was better than Kufri Jyoti in terms of tuber yield. Paddy straw on the other hand did not decompose fully during crop growth, hence could not supply nutrients to potato during short spell of 90 days.

Effect of composts on tuber yield: At Shimla, poultry manure applied alone and in - combination with FYM and vermicompost significantly increased potato yield of cv. Kufri Giriraj over vermicompost, FYM and control. The increase in yield was in order of 17, 30 and 45%, respectively over control and increase was due to increase in the proportion of large and medium sized tuber yield. Recommended doses of NPK were however, superior over organic sources.

In potato + maize intercropping at Patna, when 100% recommended NPK was applied to potato and 100% NPK or only N supplied to maize, maize yields were at par or superior to that where organic source of nutrients was used either in potato or in maize by potato residue incorporation. Intercropping raised potato equivalent yield by improving its economic superiority where potato was applied with 100% recommended NPK inorganically and maize with either 100% NPK or N alone inorganically.

Effect of organic and inorganic P on soil fertility in potato-radish crop: Soil analysis data on forms of inorganic phosphorus after 3 cycles of potato-radish cropping sequence showed wide variation in amount of P recovered in various fractions depending upon the source from which PK was applied to the potato crop. The sal.- P ranged from 4.14 to 10.18, Al-P from 75.2 to 105.3, Fe-P 58.2 to 87.4 and Ca-P from 100 to 141 ppm. The relative distribution of sal.-P and Ca-P forms were higher with the use of FYM while Fe-P and Al-P were more where inorganic

fertilizer was applied. Averaged across treatments, water soluble and saloid P constituted only 4% of the inorganic P whereas, Al-P, Fe-P and Ca-P constitute 25%, 20% and 35% of inorganic P (Fig. 24).

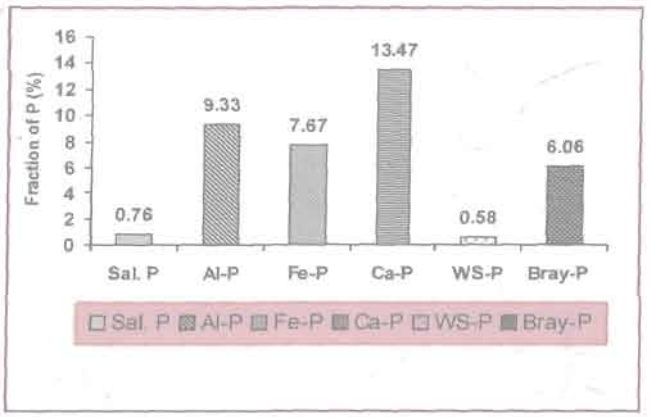


Fig. 24. Inorganic P fraction as % of total P after three cycles of potato-radish sequence.

The Bray P and total P increased both in presence of inorganic and organic manure, whereas, water soluble P increased with increasing doses of FYM. The increase in Bray P was highest with 100% recommended dose of N along with 50% PK from inorganic fertilizers and rest 50% PK from FYM.

Biofertilizers role in fertilizer economy in potato

Role of PSB on phosphorus use efficiency: Studies conducted in mid-hills (Shimla) and high hills (Kufri) on the role of phosphate solubilizing bacteria (PSB) on P use efficiency showed significant increase in the plant height, number of shoots and number of leaves plant by 13.7, 12.9 and 22.1% , respectively at 100 kg P_2O_5/ ha over control (no P). Application of P alone or with PSB enhanced P concentration in potato leaves during early stages of crop growth but effect of PSB was not significant.

Seed inoculation with PSB had a significant effect on total number of tubers and yield when compared with control (Table 15) and its positive effect was more at lower levels of P application. There was significant increase in tuber dry matter content with PSB (18.51%). The beneficial effect of PSB was further evident in enhancing nutrient uptake with highest nutrients uptake recorded with seed inoculation with PSB and 50% recommended dose of P_2O_5. The P recoveries with the application of 50, 75 and 100% P_2O_5 were 15.64, 12.09 and 14.91%, respectively which increased to 18.95, 19.84 and 17.72% in presence of PSB indicating that PSB was able to enhance P use efficiency in this soil. The results showed that the seed inoculation with PSB can save up to 50 % fertilizer P in acidic soils of Shimla.

Azotobacter on N economy in potato: Seed tuber inoculation with *Azotobacter* had a significant effect on N use efficiency at lower doses of N at Shimla, whereas, at higher levels of N the yields were at par with 100% recommended dose of N (Fig. 25). In another study, maximum uptake of N, P and K by tubers was

Table 15. Effect of phosphorus and phosphorus solubilizing bacteria (PSB) on potato nutrition

P Levels (P_2O_5)	Yield (q/ha)	Dry matter (%)	Tuber nos. (Lakhs/ha)	Nutrients uptake (kg/ha)		
				N	P	K
			Without PSB			
0	127	15.59	3.61	31.41	5.34	27.21
50%	172	17.90	3.32	48.15	8.78	42.86
75%	190	17.07	3.87	57.11	9.33	46.30
100%	221	16.60	4.24	56.87	11.90	54.39
			With PSB			
0	157	18.51	2.16	45.15	8.12	45.32
50%	192	17.08	4.71	50.08	9.51	50.55
75%	219	17.41	3.82	63..92	11.89	41.34
100%	227	17.23	3.42	68.67	13.14	28.33
CD (0.05)	51.0	1.38	-	20.70	4.49	17.22

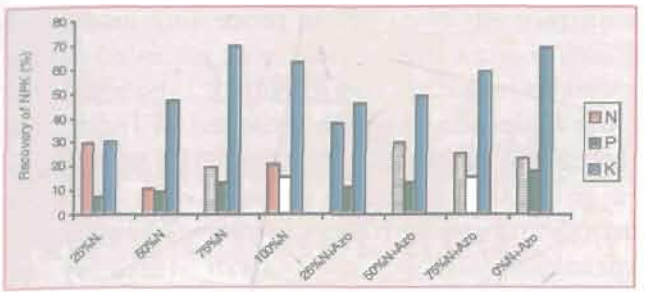


Fig. 25. Effect of N and *Azotobacter* on recovery of NPK

obtained with 50% recommended dose of NPK along with tuber inoculation with bio-fertilizer and was statistically at par with 100% recommended dose of NPK. Application of NPK (50%) + FYM @ 5t/ha + seed inoculation with bio-fertilizer (phosphate solubilizing bacteria + *Azotobacter)* was sufficient for increasing potato productivity in Shimla hills.

Water Management in Potato

Water requirement of potato varies from 400-600 mm depending upon soil type/texture, atmospheric conditions, duration of variety, length of growing period, cropping pattern and management practices. In the present day context, due to continuous cropping and need for high water requiring crops, the over draft of ground water at rates higher than recharge has led to decline in the water table in many areas of north-western and central plains of India. Therefore, concerted efforts are absolutely necessary to conserve and utilize each drop of water efficiently by using drip and sprinkler methods of irrigation/fertigation in order to avert the possibilities of an impending water famine in the country.

Water management in North-western plains

Computing phasic water need of potato under modern methods of irrigation: At Modipuram, irrigations at 150% cumulative pan evaporation (CPE) water level gave significantly higher yield of potatoes under drip and sprinkler methods of irrigation and was at par with the yield obtained with irrigations applied at 125% CPE under drip irrigation methods. However, the yields and number of tubers decreased with decrease in irrigation levels from 150 to 100% CPE both under drip and sprinkler irrigations. In case of furrow irrigation method, the yield of potatoes was significantly higher with irrigations given at 20 mm CPE. Similar trend was also observed in case of large and medium grade tuber yields. The potato cv. Kufri Anand produced significantly higher total yields and tuber numbers followed by Kufri Pukhraj in comparison to other varieties tried under all irrigation methods.

Bed planting patterns on potato production under drip fertigation: At Modipuram, single drip layout fertigation system for raised bed/triple row potato planting with 1,25,000 plants/ha of potato cv. Kufri Bahar gave 26% higher yield of potatoes along with 50% water saving as compared to furrow irrigation method (Table 16). The yield of large size tubers was significantly higher under single row drip potato planting at 60 cm spacing. However, the raised bed/triple row potato planting along with single drip lateral placed at 120 cm spacing with 1,25,000 plants/ha produced significantly higher

Table 16. Effect of drip fertigation and planting patterns on potato production

Treatments	Graded tuber yields (t/ha)			Total yield (t/ha)	Total tubers ('000/ha)
	Large (>75g)	Medium (25-75g)	Small (<25g)		
Furrow irrigation	10.5	15.0	3.9	29.4	617
DRP at 120 cm under drip	11.6	17.3	3.3	32.2	537
SRP under drip	15.3	16.5	3.4	35.2	653
DRP at 90 cm under drip	11.1	21.4	4.0	36.5	683
RB/ TRP at 120 cm under drip	9.7	23.6	4.0	37.3	699
CD (0.05)	2.1	2.6	NS	3.0	63

SRP: Single row planting; DRP: Double row planting; RB/TRP: Raised bed triple row planting

number of seed sized tuber which may be used as seed material for planting of additional area under potato without sacrifice in yield.

Optimizing irrigation requirement of potato: At Modipuram, the effect of irrigation treatments was significant on total yield as well as tuber numbers in potato cv. Kufri Bahar. Irrigations at 20 mm CPE water level produced significantly higher potato yield followed by 25 mm CPE as compared to irrigations at critical stages. Two split application of N produced higher yield of potatoes in comparison to three and four split of N with all the levels of N. Similar trend was also observed in case of total tuber numbers produced.

Maximization of seed size tuber yield under sprinkler irrigation system: At Modipuram, seed size tuber yields were maximum and significantly higher (19.2%) in bed planting system having 3 rows as compared to ridge furrow system (Table 17). This was 19.2% greater than conventional system. Similarly total tuber yield was significantly higher in bed planting having 3 rows over ridge furrow system. The proportion of seed size tuber yield remained unaffected due to change in planting system. An increase in planting density improved seed size tuber yields, maximum of it was recorded with 150% (25.1 t/ha).

Influence of irrigation methods on potato productivity and quality: A significant improvement of 51.8% in processing grade and 40.4% in total tuber yield was recorded under sprinkler irrigated crop of Kufri Chipsona-1 and Kufri Chipsona- 3 which recorded 54 and 57.8% increase in processing grade and 41.7 and 33.1% in total tuber yield, respectively. Percent processing grade tubers improved slightly in sprinkler irrigation system (80.6%) in comparison to conventional system (74.6%). Method of irrigation had no effect on chip colour but a slight decrease in specific gravity (0.73%) was observed in sprinkler crop.

Water management in the north-western hills

Soil moisture and N levels: At Shimla, plant emergence was unaffected by soil moisture regimes or N levels as the soil moisture was adequate during seedling emergence. Plant height increased markedly with N dose up to 100 kg N/ha and effect was more in early growth period. Irrigation at 75% and 50% available soil moisture (ASM) increased potato yield over control by 4.4% and 15.6%, respectively mainly due to increase in large and medium sized tubers. However, N had little effect on small sized tuber yield. Soil moisture regimes and N level although had no affect on the percentage dry matter in the tubers, the total content of N, P and K in tuber increased significantly with increased available soil moisture and N levels.

Table 17. Effect of sprinkler fertigation and planting patterns on potato production

Treatments	Graded tuber yields (t/ha)			Total yield (t/ha)	Total tubers ('000/ha)
	Large (>75g)	Medium (25-75g)	Small (<25g)		
SRP furrow irrigation	10.3	16.2	4.3	30.8	624
DRP furrow irrigation	7.8	18.1	4.6	30.5	694
Raised bed /TRP furrow irrigation.	6.8	18.7	5.1	30.6	695
SRP sprinkler irrigation	12.7	20.4	3.7	36.8	689
DRP sprinkler irrigation	11.8	24.2	3.8	39.8	756
Raised bed /TRP sprinkler irrigation	11.1	26.8	4.0	41.9	753
CD (0.05)	2.8	3.0	NS	1.6	84

SRP: Single row planting; DRP: Double row planting; RB/TRP: Raised bed triple row planting

Long Term Manurial/Fertilizer Application and Organic Farming in Potato Production

Long term manurial/fertilizer experiments on potato based cropping systems

Long term manuring and fertilization influence soil organic matter content and other physico-chemical properties. Changes in soil organic matter can be studied only through long term Experiment due to low rate of change in organic matter in response to management practices. Long term fertilizer and manurial trials were initiated at Modipuram with the objective of assessing long term impact of implication of manure and fertilizer application on productivity of potato based cropping systems and on soil properties.

Cropping systems productivity: Manuring and fertilizer treatments were imposed on cropping systems potato – wheat – paddy (C_1), potato – onion – maize (C_2) and potato–black gram–sesamum (C_3) at Modipuram. Results showed that irrespective of sources of nutrients, tuber numbers increased ranging from 0.7- 2.36, 1.07-2.74 and 0.99- 2.82 lakh/ha in C_1, C_2 and C_3 cropping systems, respectively. The maximum increase (2.36-2.82 lakh/ha) was obtained, when 100% NPK was applied through inorganic fertilizers. The organic source of nutrients reduced the tuber number, indicating insufficiency of nutrients to meet crop requirement. The incorporation of crop residue combined with organic or inorganic sources of nutrients did not improve the tuber number.

Application of 100% NPK + secondary nutrients maximized large sized tuber yield constituting 36.4, 35.5 and 36.5% of total tuber yield in C_1, C_2 and C_3 cropping systems, respectively. Restricted crop growth period of 70, 75 and 80 days gave variable mean tuber yield in different cropping systems. Recommended NPK (100%) with or without secondary nutrients from inorganic fertilizers maximized the yield of all component crops. The yields of rice and black gram in organics were at par with inorganic. The system productivity in organic (100%) treatment was 31 to 47% less than inorganic. Mean systems productivity was highest in maize-potato-onion followed by rice-potato-wheat. The tuber dry matter content was highest in organic manures (100%) through vermicompost, and was at par with organic (50%) + inorganic (50%) and 100% NPK + Secondary nutrients.

Incorporation of crop residues and organic manures, with or without fertilizers improved organic carbon in soil after potato harvesting (Fig. 26). Mineral N content in soil was although at par in three cropping systems, but the differences were significant between organic and inorganic. Incorporation of crop residues tended to increase the mineral nitrogen content of the soil.

The N uptake by paddy, maize and sesamum grain was higher with NPK (100%) applied from inorganic fertilizers than organic (100%). In wheat, Zn uptake ranged from 119 – 270 g/ha in different treatments. The highest Zn uptake (270 g/ha) was recorded in treatment NPK (100%) through fertilizer along with crop

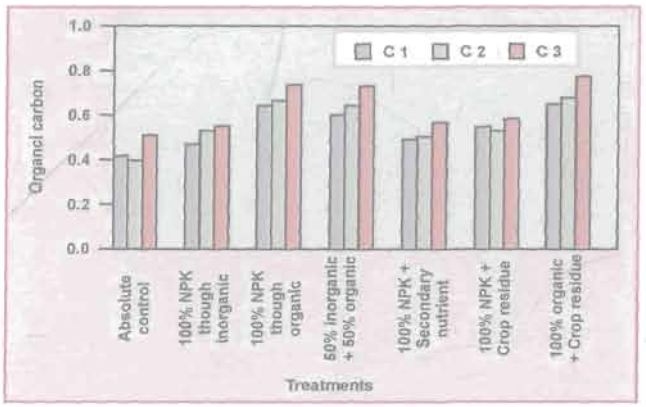


Fig. 26. Long-term effect of organic manure and inorganic fertilizer combinations on organic carbon content after potato harvest (2007-08) under various cropping systems. (C1=Rice-Potato-Wheat, C2=Maize-Potato-Onion and C3=Sesamum-Potato-Urd/Moong bean cropping systems.)

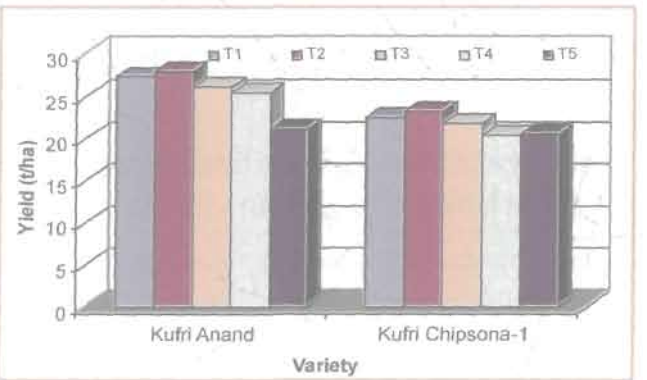
residue incorporation of preceding potato crop. The Cu uptake ranged from 5-11 g/ha.

The Zn and Cu uptake by rice ranged from 274-450 and 20-28 g/ha, respectively. Potato tuber uptake of Zn and Cu ranged from 1-58 and 3-13 g/ha, respectively while in maize it was 136-197 and 7-12 g/ha, respectively. The uptake of Zn and Cu was least in control (without manure/fertilizer). In sesamum (oil seed), highest Zn uptake (141 g/ha) was recorded with NPK (100%) through fertilizers along with crop residue incorporation of preceding black gram crop. Least Cu uptake of 1 g/ha was recorded in organic manure (100%).

Organic farming in potato production

Organic farming improves soil structure, water holding capacity and other soil physico-chemical properties, checks soil erosion and nitrogen leaching of nitrate-N through conservation and sustainable usage of valuable soil and water resources and is eco-friendly. Profitability of organic farming is accomplished by premium on organically produced food products, thereby some yield loss is an acknowledged fact. Therefore, studies were conducted to develop organic farming practices for potato crop and potato based cropping systems. Impact of organic manures, vermicompost, biofertilizers, bioagents and biodynamic approach on tuber yield and potato cultivar responses were assessed.

Evaluation of vermicompost: Studies on the effect of variable ratios of fertilizers and vermi-compost to supply nutrient equivalent of 180-80-100 kg/ha of N, P_2O_5 and K_2O (approximately) on two potato cultivars Kufri Anand and Kufri Chipsona-1 showed that Vermicompost (100%) gave similar tuber yield in both the cultivars (Fig. 27). Tuber yield was maximized in both the cultivars with application of vermicompost (25%) + NPK fertilizers (75%). Kufri Anand performed better than Kufri Chipsona-1.



T1: 100 % fertilizer , T2: 25 % vermicompost+75 % fertilizer , T3 :50%vermicompost+50 % fertilizer , T4:75 % vermicompost+25 % fertilizer , T5:100 % vermicompost.

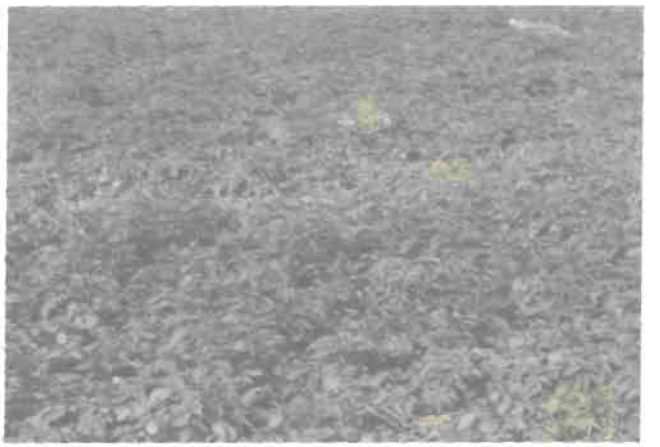
Fig. 27. Effect of fertilizer and vermi compost on tuber yield

Comparison of vermicompost with farmyard manure: Integrated nutrient supply through NPK fertilizers in combination with farmyard manure (FYM) or vermicompost at fixed site for several years with 5 potato cultivars showed that vermicompost was superior to FYM. Tuber yield though improved over the years due to cumulative effect in organically manured plots, yet it could not match that of inorganically fertilized/plot.

Effect of organic manure on tuber quality: Organic treatments invariably enhanced the tuber quality parameters of dry matter content, specific gravity and chip colour score in all potato cultivars including those exclusively for processing purposes compared to inorganic fertilizer treatments. Leaf chlorophyll reading recorded at 60 days after planting showed linear relationship with tuber yield.

Effect of organic manures on soil properties: Organic manuring significantly increased the

Inorganically raised potato crop



Organically raised potato crop

organic carbon (OC%), microbial biomass carbon (MBC), dehydrogenase activity, water holding capacity (WHC) and degree of aggregation in soil (Table 18). Organic manuring also resulted in desirable reduction of soil bulk density (BD). It also improved soil tilth and reduced leaching of nitrates. Lower layers of the soil profile had more or less similar NO_3-N content in both organic and inorganic treatments, however, upper layers of the profile contained significantly less NO_3-N in organic treatment/organically bound N indicating microbial activities to prevent leaching of NO_3-N in soil.

Table 18. Effect of organic manuring on water holding capacity and soil properties

	Initial	100% NPK	100 % organic
		Water content (% by wt)	
Saturation	28.4	30.8 ± 1.2	40.8 ± 1.6
-0.2 bars matric potential	25.6	27.0 ± 1.4	34.4 ±1.5
-1.5 bars matric potential	23.5	24.5 ± 0.9	29.3 ±1.2
-15 bars matric potential	16.6	17.3 ±1.3	20.4 ±1.4
		Soil properties	
BD (CC)	1.58	1.52±0.08	1.32±0.11
MBC (µg/kg)	119.3	130.2±0.10	161.9±0.14
Dehydrogenase activity (µg TPF/g/24h)	74.8	82.9± 2.5	113.2± 3.1

Mechanization of Potato Cultivation

Mechanization of potato production for small and marginal farmers

Investment on human labour accounts for 15-20% of total cost of potato cultivation since it requires over 1,800 man hours/ha for various operations, from planting to harvesting and post-harvest handling. Mechanization of operations reduces cost of cultivation and helps in timely operations, which is crucial for high productivity in potato. Special purpose machines for various operations from primary tillage to grading and seed treatment were designed, developed and improved during the year. A machine for making French fry cuts for small scale potato processing was also developed.

Development of rotary tiller with crumbler roller for seed bed preparation

Fabrication work of rotary tiller with crumbler roller was carried out during the period under report. The prototype has a horizontal shaft (made of 62.5 mm diameter 'C' class pipe) which runs the full width of the machine. This shaft rotates in the same direction as the tractor wheels and is driven through a gearbox from the PTO of the tractor. Main frame (size 875 mm x 1540 mm) of the prototype consists of C class pipe. There are six cutting blades assemblies in all and each has six numbers of L-shaped cutting blades. The cutting blades of the prototype rotate in a plane coinciding with the direction of motion. Power to the cutting mechanism is given through a heavy-duty reduction gearbox which has been fitted with the help of bearings and brackets in such a way that it could be moved forward or backward, upon requirement.

Design and development of implements

Work on the fabrication of a manually operated sieve type or endless screen type of potato grader was continued during the period under report. The major systems of the grader are main frame, grading mechanism and power transmission system. The sizing unit comprised of two endless wire belts having square openings of 30 and 50 mm size, one moving over the other at right angles to each other with gentle shaking. The shaking helps in changing the orientation of the produce and thus increases the grading efficiency. The graded potatoes roll down to the bag holding attachment fitted at the outlet of each chute.

Provision has been made to hold two gunny bags simultaneously for two chutes whereas the small chute (for undersize grade) has been provided with the provision of holding one bag at a time. Proper inclination to these chutes has been given so that the potatoes roll down smoothly to the gunny bags. Rubber sheets have been fixed on these chutes with the help of an adhesive, to prevent any bruising to the tubers. With this grader (sizer), the potato tubers could be graded into three different size grades *viz* first grade with tuber diameter exceeding 5 cm, second grade with tuber diameter between 3 and 5 cm, and a third grade with tuber diameter below 3 cm. Provision has also been made in

the system to operate it with an engine, if need be. Fabrication work of the grader is completed and the preliminary testing and improvements are being carried out at present.

Development of equipments and machines for small scale potato processing

Development of machine for making French fry cuts: The prototype developed was tested and evaluated for its performance in preparing French fry cuts and the problems encountered were studied. The possible design improvements were identified and improvement of different systems of the prototype machine was carried out. During operation the push plate moves back and forth, thus pressing and pushing the tuber placed into the cutter blade holder. The tuber is cut into fingers and is thrown at the other side of the cutter blade. Based on the design of improved prototype, two more machines were fabricated for trials and used at different centers of the institute. Some important specifications and the performance indices of the machine are given in table 19.

Development of farm machines and equipment for potato cultivation

Develop equipment for stage I and II of seed production: Breeder seed programme of CPRI is hub of potato production in India. In this programme, seed is produced through four stages, starting from growing indexed tubers in stage I, followed by stage II, III and IV. In stage I and II unique crop geometery is followed, in which row to row spacing is kept 100 cm. For this special seed arrangement, traditional potato machinery can not be used. Hence a new set of machines was designed, developed and tested at Modipuram.

For potato planting, a tractor operated wide row ridger was finally tested on large area for planting stage I and II as per specifications given in table 20.

This ridger, after removing ridge scrapers, was also tested for earthing up operation after inter row cultivation and a total soil cover of 12-15 cm over the seed pieces could be achieved with this tool. Final ridges were found fairly firm

Table 19. Specifications and performance of improved French fry cutting machine

Items	Specifications and performance
Overall dimensions	
Length (cm)	740
Width (cm)	300
Height (cm)	230
Weight (kg)	23 kg
Main Frame	74x30x23 made from 25 mm square M S tube section
Reduction gears	Reduction ratio 40:1, with
Cam system	Circular plate dia. 170 mm and thickness, 6 mm
Cutting mechanism	Trough type, rectangular 70mm wide, stainless steel 320 x 130 mm with provision to fit/remove the blade unit, frame of PVC and steel blades
Power transmission	Through direct coupling
Power source	Single phase electric motor 370 watt (0.5HP), 4.2 ampere, 1425 RPM rating class-B
Output of reduction gears (RPM)	35.5
	Stroke frequency (no.) 40
Amplitude (mm)	135
Capacity	40 tubers/min

Table 20. Performance of different equipments for stage I and II of breeder seed production

Performance/ functional parameters	Wide row ridger	Cultivator	Wide row digger
Operation	Wide (100 cm) ridge making and earthing operation	Weeding and inter row cultivation in Stage I and II	Potato digging from 100 cm row spacing
Tractor suitability	25-35 hp	25-35 hp	25-35 hp
Width of operation	200 cm	200 cm	100 cm
Effective field capacity (ha/hr)	0.5-0.6	0.5-0.6	0.10-0.12
Operational parameters	Uniformity of shape and fairly compressed ridges which do not fall with flow of irrigation water	Complete weeding of furrow without any damage to plants	Exposure of tubers 90-95% damage <2%

with no side fall of soil. The cultivator was extensively tested in area of 5 ha. In final design of this inter-row cultivator frame consisted of square section of 50x50x6 mm with standard three point hitch system. Tines were made of MS flat and were fitted with reversible shovel of size 200x50 mm (Fig. 28).

Improvement of on-farm potato handling implements: Heaping, treating and loading-unloading usually results in deterioration of quality of potato in terms of external and internal damages. Further, manual handling with aids like bags, *tokras etc.* is bone breaking and time consuming, which results into delayed treatments, marketing, storage and sowing of subsequent crop. To reduce energy and time required, work on potato handling was started. Fork lift assisted and manual trolley assisted movements of potato was further tested and improved.

Fig. 28. Inter row cultivator for weeding of stage I and II.

A. Pallets for fork lift

For fork lift, pallets of different designs were fabricated and tested for performance and suitability of operation (Table 21). In total more

Table 21. Specifications and performance of different designs of pallets for fork lift assisted handling of potato

Parameter	Wooden pallet	Mettalic pallet I	Mettalic pallet II
Material used	Wood (Eucalyptus)	Mild steel	Mild steel
LxBxH (mm)	1320x1055x180	1830x1200x800	1830x1830x800
Side wall	Open from all sides	Side wall of 660 mm on three sides	Side wall of 660 mm on three sides
Extension of fork	Not required	Not required	Required extension of 1830 mm
Capacity (trays of 20 kg)	18-30	30-40	40-60
Centre of load from back rest of fork	660 mm	660 mm	900 mm
Suitability	Requires smooth surface of operation	Can be used on all kinds of surfaces	Can be used on all kinds of surfaces

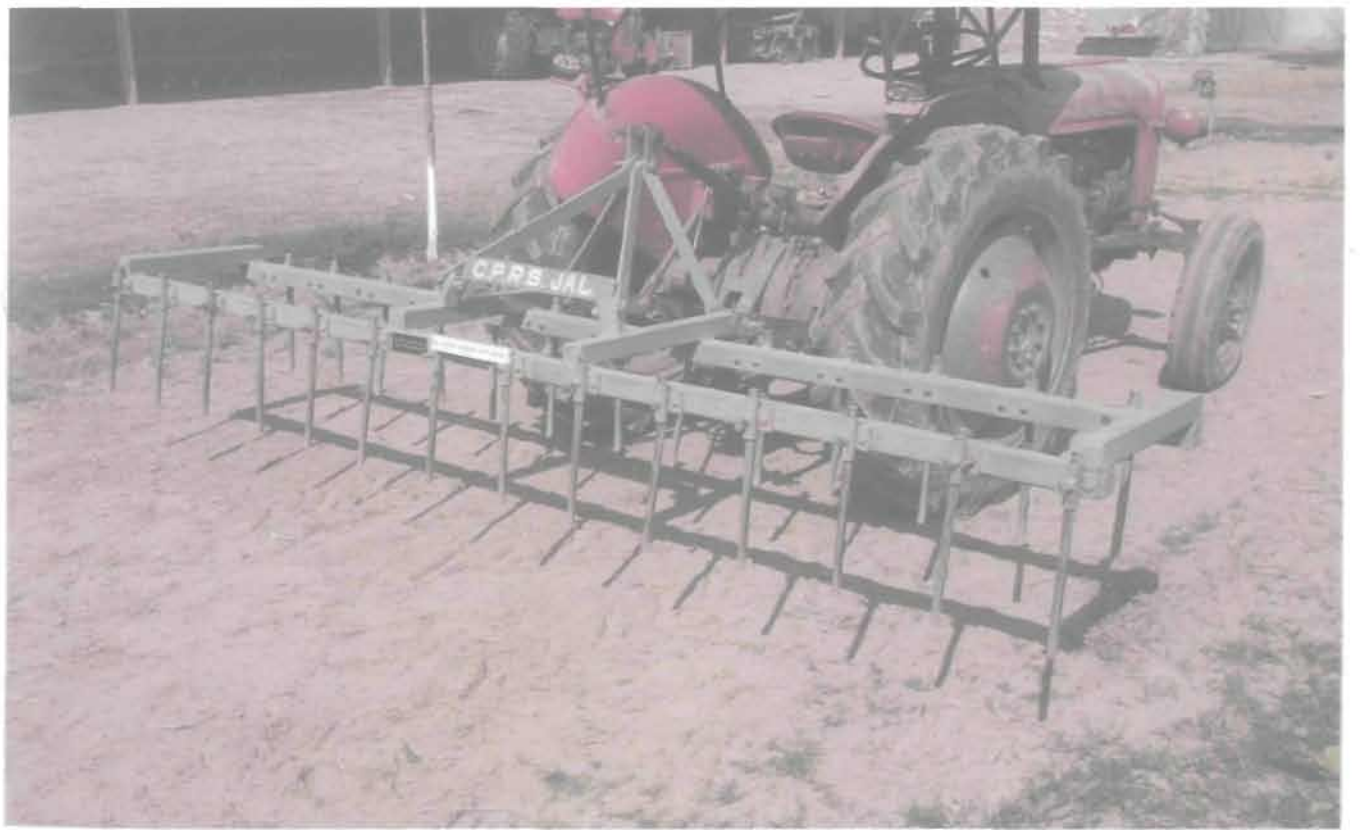
than 200 t of potato was handled. A two ton fork lift was operated with wooden and metallic pallets of different sizes in two surface conditions of smooth (concrete floor) and firm soil surface.

Wooden pallets were not provided with any kind of retaining wall while metallic pallets were provided with three side walls for preventing loads from falling to sides. Potato was filled in plastic trays to make pallet loads and observations were recorded for speed of operation, stability of load and time required for shifting of material.

On smooth, concrete surface all pallets worked well at forward speed of 10-14 km/h and there was no side tipping of load. In rough and unlined surface conditions, metallic pallets worked better than wooden pallets. Side and front tipping of trays was observed in wooden pallets as there was no retaining wall to hold the load. Further wooden pallets could only be used on rough surface when fork lift was operated at speed of 4-5km/h.

B. Trolleys

Small trolleys and large trolleys were tested and feed back was collected from users to further improve the designs. On the basis of that, handle of small trolley, which is meant for carrying 2-3 trays or one 80 kg bag, was increased in length by 110 mm. Bigger trolley, meant for carrying 8-12 trays, was also tested on large scale. Load and force analysis was done and it was observed that present size of wheels (300 mm and 375 mm diameter) requires more effort for pulling than a wheel of diameter 500 mm.

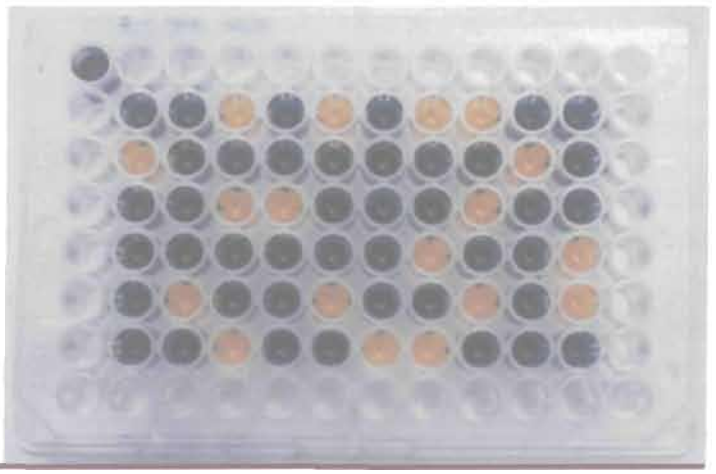


DIVISION OF

PLANT PROTECTION

- Virus-free mericlones of Kufri Pushkar were obtained after repeated attempts. Similarly, mericlones of 133 germplasm accessions were tested with IEM for virus infection and 64 were found to be free from PVX and PVY.
- Forty F1 hybrids positive for PVY° extreme resistance gene (positive for SCAR marker), the variety Kufri Himalini and germplasm accessions CP 1496, CP 4578, CP 2246 and CP 2362 and were found resistant to both PVX and PVY.
- Late blight attack was severe in the state of Karnataka with an average crop loss of 43%. The regression models developed for predicting yield loss in HP hills was validated and gave accuracy to the tune of 87-92 %. Methanol extract of one of the plant species gave late blight control comparable to that provided by mancozeb.
- An integrated tuber treatment comprising *Bacillus subtilis* or *Trichoderma viridae* plus boric acid exhibited a synergistic effect for control of *Rhizoctonia solani*. The dose of boric acid could be reduced to just half if used together with *T. viridae*.
- White grub caused 19-85% tuber damage at Shilaroo, Kharapathar and Kheradhar. Collection of white grub adults with light traps at Fagu during June helped in the reduction of grub population by 50,000.

Diagnostics and Detection of Potato Viruses and Viroid



The mandated activities of this programme include development and use of diagnostics for the reliable detection of potato viruses in the pre-basic seed stocks, mericlones of important potato varieties and germplasm accessions for virus freedom, post entry quarantine testing of imported germplasm, screening of germplasm accessions and advance potato hybrids for virus resistance, screening of samples received from different sources for virus status including contract service to private parties. Activities undertaken and corresponding progress made are reported below.

Testing of mericlones of germplasm accessions for potato viruses with IEM

A total of 161 mericlones of 57 germplasm accessions were checked by ISEM and 38 were found free from PVX and PVS. The germplasm accessions freed from PVX and PVS were KLK -13, KDW-5, CP-1143, CP-1159, CP-1162, CP-1177 & CP-1197, CP-1232, CP-2334, CP-3417, CP-3419, CP-3544, CP-3554. Similarly, 22 mericlones of 11 accessions were checked for PVX and six accessions (CP-1366, CP 1412, CP-1433, CP-2345, CP-2613 and CP-3872) were free from PVX. Twenty four mericlones of 12 accessions and 8 mericlones of advance hybrids MP-97-64 and J-93-86 (Kufri Khayati) were checked by ISEM and all were found infected with either PVX or PVS or both. Similarly, all the 53 DUS reference collection acce3ssions except CP-2194 were infected with PVX and PVS.

Screening of germplasm accessions

Sixty accessions were inoculated individually with PVX and PVY, and also with combined PVX and PVY for the first season screening for resistance against these viruses. They were then tested for these viruses with ELISA after 4 weeks of inoculation. Following 26 accessions tested negative to PVX, 41 to PVY and 22 to both PVX and PVY.

Negative to PVX: CP 1493; CP 1553; CP 1693; CP 1778; CP 1829; CP 1857; CP 1881; CP 2217; CP 2271; CP 2307; CP 3146; CP 3159; CP 3165; CP 3175; CP 3198; CP 3264; CP 3413; CP 3425; CP 3430; CP 3451; CP 3533; CP 3756; CP 3758; 3762; 3764; 3765.

Negative to PVY: CP 1218, 1377, 1408, 1467, 1493, 1498, 1538, 1549, 1553, 1612, 1635, 1637, 1693, 1741, 1760, 1767, 1778, 1829, 1857, 1861, 1871, 1881, 1933, 2086, 2217, 2262, 2307, 2363, 3146, 3159, 3165, 3175, 3198, 3264, 3265, 3391, 3393, 3397, 3413, 3425, 3451, 3499, 3533, 3558, 3591, 3592, 3756, 3758, 3762, 3764, 3765.

Negative to both PVX and PVY: CP 1493, 1553, 1693, 1778, 1829, 1857, 1881, 2217, 2307, 3146, 3159, 3165, 3175, 3198, 3264, 3413, 3425, 3451, 3533, 3756, 3758, 3762, 3764, 3765.

Twenty one accessions found resistant (negative) to PVX, PVY in the previous season were again screened by inoculating with these viruses during 2007. CP: 1496, 4578, 1990,

2246 and 2362 were negative to both VPX and PVY infection hence were declared as resistant to both these viruses. Besides, CP 2066 also tested negative to PVX alone.

Screening of potato hybrids for resistance to PVY°

Forty hybrids carrying PVY extreme resistance, and 3 other potato cultivars were tested for their resistance to PVY°. All the hybrids except LBY-17, QB/A-9-12, SM-93-237, SM-93-237 XYY showed extreme resistance to PVY°. Kufri Shailja and Kufri Chipsona-3 were susceptible to PVY° while Kufri Himalini showed hypersensitive resistance to PVY°.

Testing for PSTVd

One hundred seventy eight mericlones of 3 germplasm accessions CP 1319, CP 1429, CP 1800 received in two lots were tested with NASH for PSTVd freedom and all tested positive to PSTVd. Thereafter meristem tip culture technique was not enough to get rid of PSTVd infection. One lot of 70 germplasm accessions (DUS reference Collection) was tested with NASH for PSTVd freedom, all except the five accessions viz. CP 1874, CP 2042, CP 2083, CP 2179 and CP 2182 were free from PSTVd infection.

Ten potato varieties imported by M/S KF Bioplants Pvt. Ltd., Pune were tested for PSTVd infection and all were found free from infection thus cleared for release to the importer. Sixty two accessions of wild *Solanum* spp. received from The Netherlands were tested for PSTVd infection by employing the non-radio active based and all DIG labelling kit were free from PSTVd infection. Similarly 12 TPS lines imported from CIP, Lima were checked and all except two lines viz 901041 and 901042 tested negative to PSTVd.

Screening of microplants and mericlones of potato varieties

Nine mericlones of the potato culture Kufri Pushkar were checked for PVX infection by ISEM and only one was free from the virus. Virus checking sub-cultures of this particular mericlone also confirmed absence of all potato viruses including PVX in this clone of Kufri Pushkar. Eleven microplants of the hybrid J-93-86 (Kufri Khayati) which tested negative to PVX in ELISA at CPRS Jalandhar were cross-checked with IEM and were found to have high concentration of PVX. Similarly, microplants of K-22 and Gulmarg Special also had a high titre of PVX and PVS.

PCR Based detection of viruses

Leaf samples of potato variety Katahdin carrying the RB gene and showing chlorotic blotching and curling were tested for the presence of ToLCNDV. They tested positive to the virus (Fig. 29). The parent material had been multiplied at CPRIC Modipuram in the polyhouse.

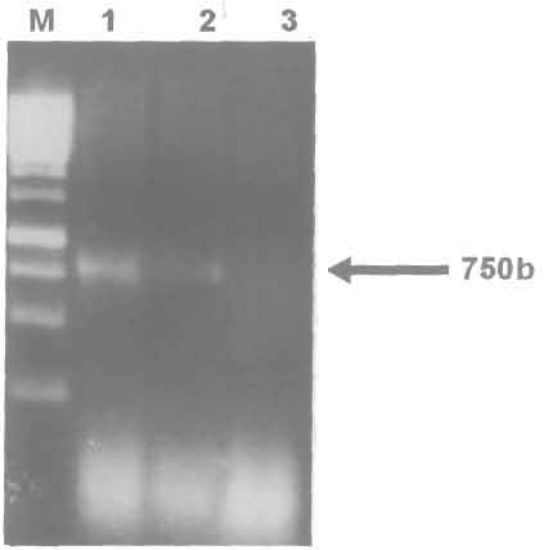


Fig. 29.Amplification of PALCV CP-gene in RB transformed plant showing virus disease symptoms. Lane 1: 1 kb marker, Lane 2: known positive; Lane 3: virus infected RB transformed plant; lane 4: healthy control.

Eight leaf samples from potato seed crop of Kufri Jyoti which tested positive to PLRV in ELISA were examined with RT-PCR by using PLRV CP gene specific primers. Only two samples tested positive to PLRV (Fig. 30).

Detection of viruses in dormant potato tubers

PVX, PVS, PVM, PVA and PVY were tested in infected dormant potato tuber with RT-PCR;

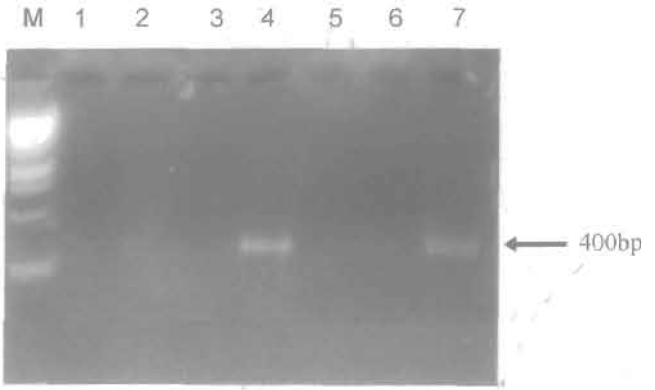


Fig. 30. RT-PCR- Detection of PLRV in leaf samples of potato var. Kufri Jyoti by amplifying a segment of CP-gene of PLRV; Lane1: 1kb marker; lane 1-6: Kufri Joyti samples; lane 7: known positive.

samples were taken both from heel and rose ends; PVX, PVS and PVM were readily detected while PVA and PVY were non- detectable in dormant potato tubers. This was probably due to presence, in dormant tubers, of substances inhibitory to PCR amplification of PVA and PVY. All the viruses were readily detected in dormant tubers with IEM.

Print Capture PCR detection of GBNV

A technique has been standardised for the detection of GBNV, causal agent of stem necrosis disease, in infected tissues. This was then used to detect GBNV in thrips collected from potato and other hosts at different dates at CPRS Gwalior.

IC-RT-PCR detection of Potato virus S and M

A procedure for immuno-capture PT-PCR has been standardized. It comprised of trapping virus particles in PCR tubes with homologous antisera and release of viral RNA in distilled water or 1% Triton X-100 by heating at 95°C for 10min. The viral RNA thus released was reverse transcribed to obtain template DNA for amplification of CP genes of PVS and PVM.

RT-PCR Detection of Potato Virus M

A protocol for detection of Potato Virus M was standardized with CP gene specific primers. The PCR reaction mix (50 µl) comprised 5µl 10x PCR buffer (750mM Tris-HCl pH 8.5, 200mM $(NH_4)_2 SO_4$, 15mM $MgCl_2$, 1% Tween 20), 2.5 µl 2mM dNTP mix, Primers (200ng) each, 6µl cDNA template and 5U of *Taq* DNA polymerase. The cycling conditions were optimized by performing an initial denaturation at 95°C for 4 min followed by 35 cycles each comprising 1min at 94°C, 1 min at 58°C and 1 min at 72°C and then final extension for 10 min at 72°C. The expected size (900bp) of coat protein gene was obtained.

PCR detection of PVS^A, PVX $_{HB}$, PVX$_{MS}$ Strains

Coat protein genes of these strains were amplified using degenerate coat protein gene specific primers of PVS and PVX. These primers were the same which were used for the detection of PVX^O and PVS^O. The expected PCR products of 892bp for PVS^A and 714bp for PVX strains were obtained.

Cloning CP genes of PVM, PVS^A, PVX $_{HB}$, PVX$_{MS}$ Strains

The amplified products of these CP genes viruses were A-T cloned into pDrive vector and authenticity of the cloned genes were confirmed by polymerase chain reaction. Clones are being sequenced.

Maintenance of transgenic lines

14 transgenic lines were maintained by periodic sub-culturing on MS medium. The *in vitro* growth of the transgenic lines PK-3, PK-4, PK-5, PK-6, PK-9, PK-11 and PK-14 was weak (narrow and lanky stems and leaves) while those of lines Kp-1, Kp-2, Kp-7, Kp-8, Kp-10 Kp-12 and Kp-13 was excellent with bold stem and leaves. The transgenic lines showing excellent growth were screened for the presence of PLRV CP insert.

Screening of PLRV CP transformed lines for the presence of insert

PCR amplification of PLRV coat protein gene, using the gene specific primers was carried out for the presence of transgene in putative transformants. Two or three leaves were randomly selected from each independent

events and control plant for DNA isolation. The genomic DNA was isolated by CTAB method. Each PCR was performed in 50µl (total volume) reaction mix containing 10X reaction buffer, 100ng of DNA, 0.2mM dNTPs, 100ng of each primer and 1 unit of Taq DNA Polymerase. The following thermocycling conditions were used: denaturation at 94°C for 5 min, followed by 30 cycle of denaturation at 94°C for 1 min, annealing at 60°C for 1 min and extension at 72°C for 1 min. The reaction was allowed for final extension at 72°C for 10 min. The PCR product was analyzed in 1% agrose gel stained with ethidium bromide (Fig. 31). To confirm the specificity, PCR product was blotted in the positive charged nylon membrane and hybridized with randomly labeled probe to CP gene.

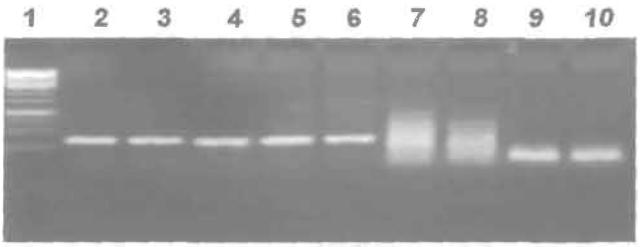


Fig. 31. Analysis of transgenic potato lines transformed with coat protein (CP) gene of PLRV by PCR; Lane1:marker, 2:positive control: 3:KP1; 4:P2; 5:KP7; 6:KP8; 7:KP10; 8:KP12; 9: KP13and 10:negative control.

PCR analysis of the seven putative transgenic plants using CP gene specific primers confirmed the presence of the transgene (0.4kb) in all the lines (Pk-1,Pk-2,Pk-7,Pk-8) except in line PK-13. Very faint amplification was observed in lines Pk-10 and Pk-12. Hybridisation of PCR product with radio-labeled probe to CP gene of PLRV showed good hybridisation signal (Fig.31).Hybridization of PCR products with the probe showed specificity of the PCR amplification. Further confirmation for the presence of insert in the transgenic lines was done by sequencing of the amplified PCR product.

Stability of the transgenic plants

Four transgenic lines (Kp-1, Kp-2, Kp-7and Kp-8) were micro-propagated 7 times successively over a period of eight months and then examined for presence of transgene in three randomly selected plants of each line. PCR showed specific amplification of CP gene in all these selected plants indicating stability of transgene (Fig. 32).

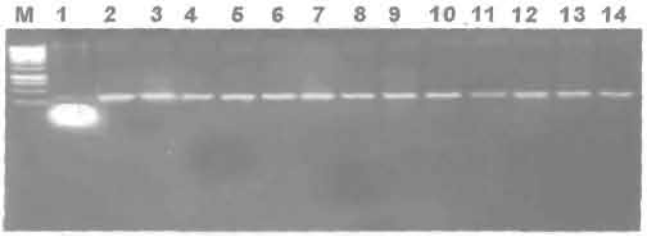


Fig. 32. Detection of CP-transgene in transgenic lines Pk1, Pk2, Pk7 and Pk8 after 8 successive micro-propagations; Lanes 1 to 14, respectively negative control(1),randomly selected plants of Pk1(2-4) of Pk2(5-7) Pk7(8-10) of Pk8(11-13) and positive control.

Management of Late Blight

The danger of climate change on crop production is looming large at the global level including India. If this is not managed with scientific acumen it may create situation that may lead to food shortage. Both agricultural crops and the pests/pathogens have intrinsic ability to adapt to the changing situations. This climatic change needs to be monitored and corrective measures taken wherever required. Like any other disease, late blight affecting potato and tomato is no exception to this. Of late, frequent epidemics of late blight have been observed even in warmer climates which calls for closer monitoring of the pathogen population in relation to temperature and, if need be, redefining the epidemiology of the disease in its entirety. The pathogen is also adapting quickly to the fungicides deployed for its management thereby making their use infructuous. It is, therefore, pertinent that pathogen population is monitored in relation to fungicide applied and necessary corrections made wherever required.

Population structure, epidemiology and management of *Phytophthora infestans*

Disease and pathogen profile: Attack of late blight was very severe in the state of Karnataka where disease severity ranged from 80-100 % leading to an average crop loss of 43 %. The disease was more severe in the districts of Hasan and Belgaum. Analysis of weather data revealed heavy rains right from planting which led to development of congenial weather right throughout the crop season. The *rabi* crop in the sub-tropical plains was comparatively free from the disease. In the state of UP, disease severity ranged from 5-40 % in the districts of Moradabad, Badaun, Meerut and Ghaziabad. It was in traces only in Punjab.

***P. infestans* population for mating types, physiological races and metalaxyl resistance:** The metalaxyl-based compounds are increasingly becoming less effective in managing late blight disease. Consequently, alternative molecules in the form of cymoxanil and dimethomorph were found effective. To investigate the sensitivity of the pathogen population to metalaxyl, *P. infestans* isolates were collected across the country *viz.,* UP, Karnataka, Himachal Pradesh, Meghalaya, Punjab and Bihar. Results revealed that the pathogen population has acquired tolerance to metalaxyl across the country at varied level from region to region. Highest tolerance was recorded in isolates collected from HP hills (11% at 400 ppm) while it was up to150 ppm (4.5 %) in isolates from NE hills. In plateau region tolerance was up to 400 ppm (23.2 %). Highest tolerance in subtropical plains was recorded in Punjab (6 % at 300 ppm) followed by UP (45 % at 200 ppm) and Bihar (16.7 % at 150 ppm). As compared to last year, there has been a steep decline in metalaxyl tolerance in the state of UP and Punjab. The tolerance this year was to the tune of 300 ppm in Punjab and 200 ppm UP compared to 400 ppm recorded last year in these states.

The frequency and distribution of A2 mating type was almost similar to that of last year. Hills of HP and NE have witnessed complete displacement of the old mating type (A1) which

is being maintained over the years. New strain (A2 mating type) continues to maintain low profile (0-15 %) in the subtropical plains. In Bihar and Punjab, there was no record of A2 mating type.

The pathogen population was also monitored for prevalence of different physiological races in HP, Punjab, Meghalaya, UP and Karnataka. Results revealed that complex races (7-11 gene frequency) dominated in all the parts of the country. In HP hills, frequency of 11 gene race was highest (85 %) followed by 10 gene race (10 %). Same was true in the case of Meghalaya and Punjab. Eight gene complex races was highest (40 % each) in the state of UP and Karnataka.

Response of P. infestans populations to temperature regimes: The aggressiveness of *P. infestans* isolates varied at different temperature regimes. Sixty percent of the isolates were reported to be infective even at 28°C. The zoospores of some of the isolates could germinate successfully even at 34 °C a very high range as far as *P. infestans* is concerned. It would be interesting to note their disease epidemiology.

Disease forecasting: Precision agriculture calls for development of technology relevant in all spheres including plant protection. Late blight, a known notorious disease, causes loss worth billions of rupees across the globe. Although large number of fungicides are known to suppress it but their effectiveness is governed by their timely application. It is in this context that development of 'Decision Support System' (DSS) becomes imminent. Models for applying need-based fungicides and assessment of yield losses were developed. The concept of accumulated congenial temperature and relative humidity worked very well this year also. The regression models for HP hills were found accurate to the tune of 87-92 %. As part of DSS, yield loss assessment models were developed for hills and the plains. Regression models based on three year pooled data predicted yield loss to the tune of 88 % in the plains and 94 % in the hills.

Regression models for predicting yield loss at Shimla (pooled data of 2006-2007)

$Y = 3.48912624 + 6.593554\ X1 - 5.443361X2 + 5.275647\ X3 + 0.754896\ X4 + 1.8894545\ X5 + 0.6830347\ X6 - 3.664775\ X7 + 0.20080927\ X8;$

$R^2 = 0.941^{**}$ where Y = yield loss %; X_1, X_2, ... X7 are the late blight disease severity increment

Regression models for predicting yield loss at Modipuram (pooled data of 2004-2005 to 2007-2008)

$Y = -2.9275 + 23.7029x1 - 3.2896x2 + 2.16643x3 + 0.61792x4 + 0.08902x5 + 0.31045\ x6$; $R^2 = 0.88^{**}$ where Y = yield loss %; X_1, X_2——— X_6 are the late blight disease severity increment

Management through botanicals: During last year, 10 plant species showed promise in managing late blight in detached leaf method. Consequently, fractions were carried out and evaluated for their effectiveness. Acetone and methanol extract of one of the pant species were highly effective in suppressing late blight in detached leaf method. Similar results were obtained when tested on whole plant. Crude extracts of 10 species was tested under field conditions. Results revealed that methanol extract of one of the plant species gave moderate level of disease control (DI 63.3 %) comparable to standard fungicide check (mancozeb).

Breeding for high yielding, late blight resistant cultivars for Indian hill

With the increased pressure from the green lobby, there is a growing concern of environmental pollution and health hazards resulting from excessive use of chemicals in managing pests and diseases. World over, especially in developed world, 14-15 sprays are applied for the management of late blight. It is in this context that emphasis is given on exploitation of host resistance for reducing the use of chemicals. The institute had taken an initiative long back in meeting this objective.

Both conventional and biotechnological approaches are being employed for development of late blight transgenics using RB gene construct and Marker Assisted Breeding. Since potato virus Y is equally damaging in Indian

context, efforts have been initiated for combining resistance to late blight and PVY. Based on resistance to late blight and PVY and better agronomic traits, 13 hybrids out of 32 were selected for further evaluation. Efforts were also initiated for development of parental lines having PVY extreme resistance gene in triplex/quadruplex condition. The seedlings from 10 cross combinations were raised and their DNA extracted for analysis by SCAR marker tightly linked to *Ryadg* gene in imparting resistance to PVY.

As part of general breeding programme, 10 cross combinations were screened by challenge inoculation and a total of 1420 resistant seedlings were selected for further testing. In the initial evaluation (F_1C_1 to F_1C_4), 433 genotypes were evaluated out of which 98 clones were selected based on tuber characters. Similarly, 14 advanced generation hybrids (F_1C_5 to F_1C_7) were evaluated for their agronomic traits and resistance to late blight. Based on the desirable trait, 5 hybrids were selected from F1 C5 generation, two hybrids from F1C6 and one hybrid from F_1C_7 generation. Five advanced late blight resistant hybrids from hill breeding progenies were evaluated for their adaptation under short days at CPRI Modipuram. Among these, SM/92-338 giving highest yield was selected for further test along with Kufri Jyoti, Kufri Bahar and Kufri Sadabahar as control. One advanced hybrid SM/93-237 (Fig. 33-34), based on its multi-locational trial (Table 22 and 23), has been recommend for release in the name of Kufr Girdhari at the 26th Group Meeting of Potato Workers of All India Co-ordinated Research project (Potato) held at Rajendra Agricultural University, Pusa (Bihar) on 7-9 September 2007.

Table 22. Tuber yield (t/ha) of SM/93-237

Hybrid/ Control	Kufri	Ooty	Ranichauri	Shillong	Srinagar	Mean	Increase over (%)
SM/93-237	30.0	51.8	35.9	27.0	40.0	37.0	-
K Himalini (c)	22.6	13.3	19.1	20.8	30.6	21.3	73.7
K Giriraj (c)	3.8	6.8	8.3	12.8	40.5	14.5	155.7
K Jyoti (c)	11.6	-	-	-	-	11.6	219.7

Table 23. Late blight resistance level

Hybrid/ Control	Kufri	Ooty	Ranichauri	Shillong	Srinagar	Mean
SM/93-237	8	7	7	7	4	6.6
K Himalini (c)	5	5	2	1	7	4.0
K Giriraj (c)	1	4	1	1	7	2.8
K Jyoti (c)	1	-	-	-	-	1.0

Fig. 33.Crop of hybrid SM/93-237

Fig. 34. Tubers of hybrid SM/93-237

Integrated Disease Management

Tuber Borne Diseases of Potato

Russet Scab of Potato: Russet scab of potato is a serious problem in seed production in north-western plains. Sixteen potato cultivars were screened for their susceptibility to russet scab under field conditions. Based on disease severity these were categorized into 3 groups. Severely affected (with severity level of >50%): Kufri Sindhuri, Kufri Sherpa, Kufri Lalima and Kufri Chandramukhi; Moderately affected (25 to 50%): Kufri Bahar, Kufri Sutlej, Kufri Lauvkar, Kufri Jyoti, Kufri Badshah, Kufri Ashoka, Phulwa and Mildly affected (<25%); Kufri Giriraj, Kufri Phukhraj, Kufri Dewa and Kufri Anand (Fig. 35). Soil solarization from mid-May to mid-June was the most effective for control of russet scab as evident by reduced disease severity by 54.6% and by 59.3% when used along with incorporation of wheat straw in soil (Fig. 36).

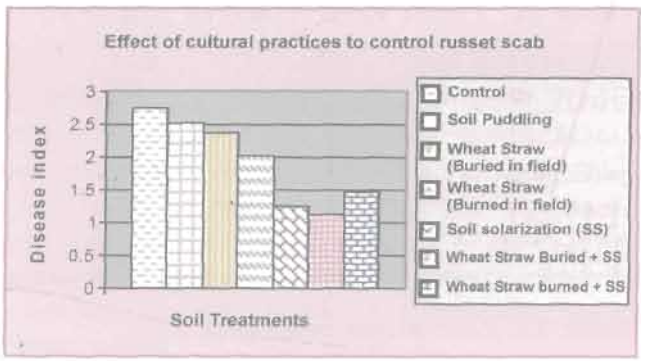


Fig. 36.

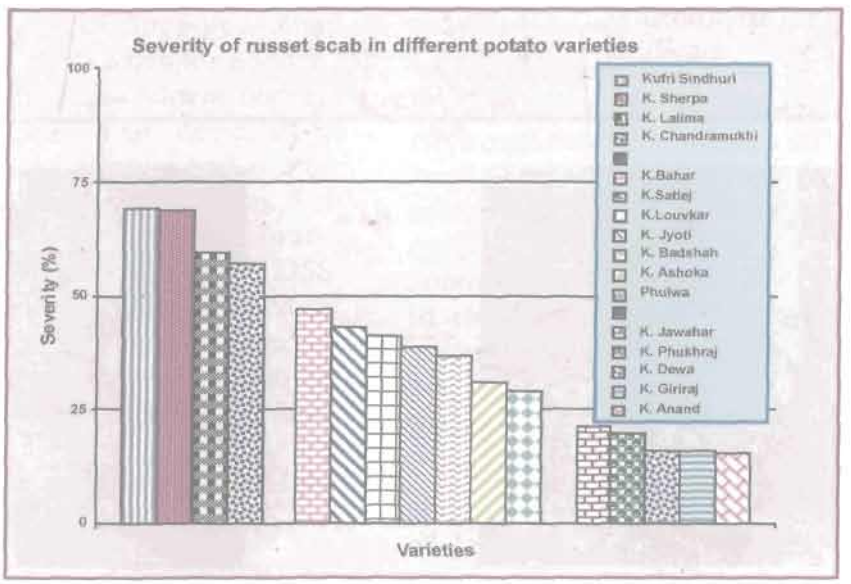


Fig. 35.

Bio-control of potato tuber borne diseases: Use of naturally occurring microorganisms along with safe chemicals was studied for control of tuber borne diseases. *Trichoderma viride* worked very well in integration with ½ dose of boric acid for control of black scurf disease of potato

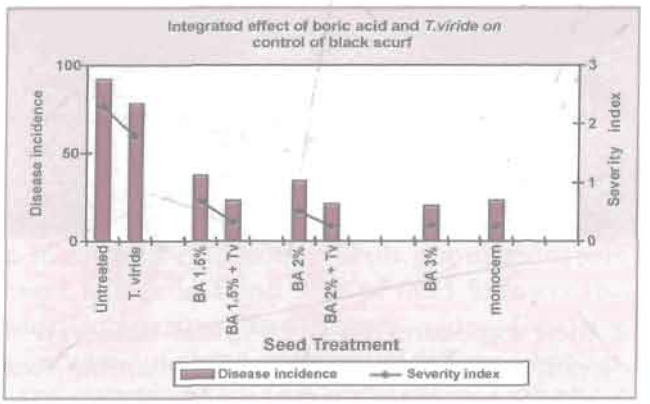


Fig. 37.

(Fig. 37). An integrated tuber treatment of *Bacillus subtilis* with boric acid, exhibited a synergistic effect on control of black scurf. The disease severity index was 2.10 in seed treated with *B. subtilis* (B5), 0.81 with 3% boric acid but only 0.16 with integrated use 3% boric acid + *B. subtilis* (B5) (Fig. 38).

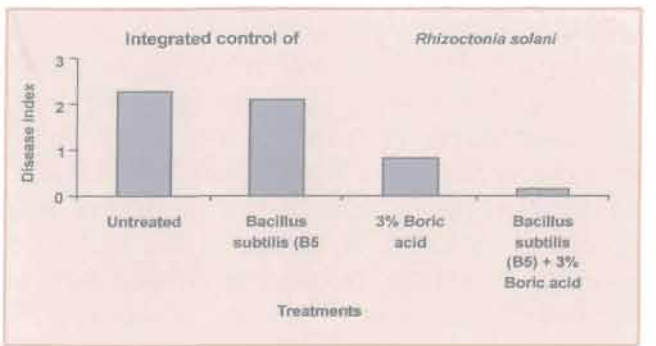


Fig. 38.

Seed spray treatment with 3% boric acid + coating of tubers with *Bacillus subtilis* (B5) @8.0 g/kg was the best for control of black scurf disease of potato. *Bacillus subtilis* B5 applied to potato seed tubers @ 0.25% by dip treatment increased the root volume by 29.0%, root mass by 47.5% and tuber yield by 12.7% at Modipuram. *Bacillus subtilis* B5 applied to paddy crop as seedling dip increased yield in variety Pusa Basmati by 27.3% and Pusa 1121 by 32.6% over the untreated control. Analysis of metabolites of *Bacillus subtilis* (B5) revealed presence of Iturin (70%), Viomycin (20%) and Chalcone (10%). *Bacillus subtilis* (B5) formulations were supplied to 14 AICRP centers and other agencies on demand.

Effect of plant extracts for control of Rhizoctonia solani: Extract of plants viz. *Vinca, Ocimum* and *Withania* spp. used as seed tuber treatment before planting significantly reduced the incidence and severity of black scurf disease caused by *R.solani* (Fig. 39).

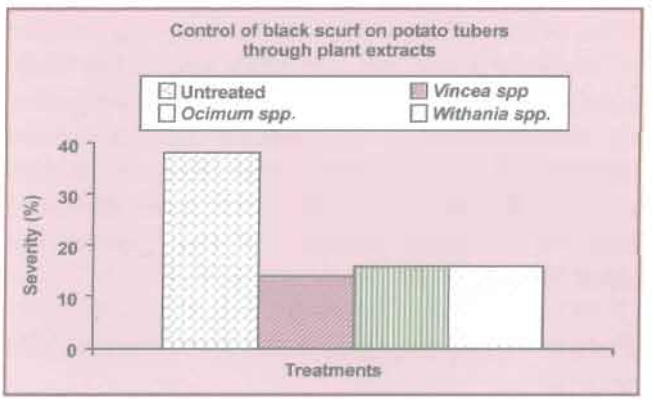


Fig. 39.

Rottage in seed treated with boric acid: Seed treatments with 2.5% or 3.0% boric acid by spray or dip methods even at higher ambient temperature did not induce any significant rottage of stocks in a large trials carried out at Gwalior. Quick dip method was however more convenient and effective than the spray method at Gwalior.

Integrated Pest Management

A great diversity of pests attacking potato exists in India due to vastly different agro-climatic zones. These pests damage the potato crop by feeding on leaves, attacking stems thus weakening the plants and by feeding on tubers. Accordingly, potato pests are grouped into soil pests, foliage feeders or defoliators, sap feeders or sucking pests, storage pests and other non-insect pests. Of these, tuber moth, white grubs, cut worms, aphids and white flies are more important. Aphids and white flies also act as vectors of potato viruses. Achievements made in respect of their biology and management are listed here.

Potato tuber moth (*Phthorimea operculella Zell.*)

North western hills: At Shimla, 42 potato germplasm accessions were re-screened in stores under high PTM pressure. Of these, 30 accessions were found susceptible after 45 days of their exposure, 10 were found moderately tolerant up to 60 days whereas remaining two *i.e.,* JEX/A-91 and CP/1851 were tolerant up to 70 days of their exposure. Another set of 44 accessions were also screened and 12 were found tolerant to PTM after 30 days of their exposure but not after 45 days. In storage trial at Shimla, tubers treated with CIPC, cypermethrin dust, *Karu* leaf powder and GV dust gave more than 90 % protection against PTM up to 90 days of storage.

White Grubs

North eastern hills: At Shillong, PTM infestation was generally very low. However, minimum infestation of 0.17% was recorded in CIPC treatment followed by heap covered with *Lantana* leaves (0.33%), while open heap storage recorded 1.50% tuber infestation. Maximum mean infestation in tubers was recorded in Kufri Himalini at the end of 5 months of storage. Infestation crossed 60% at the end of 4 months of storage. It was 11.62% in Kufri Jyoti, 1.42% in Kufri Megha (1.42%) while the other varieties were intermediate in response.

White grubs (*Brahmina coriaceae* Hope)

Surveys conducted in Shimla and Sirmaur districts of Himachal Pradesh revealed 30-70% tuber damage at Shilaroo, Kharapathar and Kherdhar with white grub population of 5 to 9 /plant at Shilaroo, 1-7/plant at Kharapathar, 1-5/plant at Kherdhar (Rajgarh) but no damage at Fagu and Shimla. Higher grub population was observed at lower elevations (below 2500m)

which were leading in higher instars (3rd instar grubs were found in August at Shimla), younger instars were collected from higher elevations (above 2,500 m). 2nd instar grubs were found at Kharapathar in mid-September. The adult beetles appeared from second week of June, maximum collection was from mid-June to end of June. At Fagu, their number with light traps ranged between 2,250-3,000 and it helped in the reduction of grubs by about 50,000. The grub population was highest in fields facing South-east mainly due to higher temperature as compared to the North-west. Incidence of white grubs was more in red and sandy soils than that in loam and clay soils. Grub population was found higher in bund side of field followed by middle portion and lower side. Rearing techniques of three apparently different species were standardized and observations on their biology and natural mortality agents recorded. Approximately 150-200 beetles/day were collected from two light traps and alternate hosts surrounding the trap.

Fresh leaves of seven plant spp. were tried for mulching while 15 different plant extracts prepared in cattle urine were evaluated both under laboratory and field conditions. Extract of *neem* seed kernel (NSK), *soap nut*, chrysanthemum leaves and *jatropha* kernel applied @ 5ml/l proved to be best oviposition deterrents as no egg was observed after 15 days of application. Although the egg laying was observed in *Eucalyptus* and *Karu* leaves, grubs did not survive after 25 days. Extract of seeds of *neem* and jatropha provided 100% mortality in 1st instars after 15 days, whereas, in case of jatropha kernel, *soap nut*, *stinging nettle* and *Eucalyptus*, on an average of 0.33 grubs were observed. *Stinging nettle* was found best as only 4.27% tuber damage and highest tuber yield (16.0 t/ha) was obtained followed by *eucalyptus* (9.24% tuber damage), whereas in others tubers damage exceeded 25%.

Disease agents of grubs

Bacteria: Twenty two bacteria from soil and 6 from diseased grubs were isolated, purified and multiplied in lab. All these bacterial isolates were tested against white grubs (2nd instar). The evaluations were done 7, 15 and 21 days after treatment. Of these 11 isolates coded as FMBL2, FMBH1, LLBT (*Bacillus thuringensis*), FTBL1, FTBL2, FLBM1, GB1, GB2, GB4, Ps (*Pseudomonas*), and BB3 at the concentration 10^7,10^8,10^9 CFU gave 100% mortality of grubs.

Fungus: Twenty three fungal isolates from soil and 8 from *diseased* and dead grubs were isolated, purified and multiplied in lab. A replicated trial with 7 of these isolates showed 100% mortality of grubs in case of *Alternaria alternata* after 21 days *Aspergillus niger, Aspergillus flavus, Aspergillus clavatus* were affective after 30 days. Eleven fungal isolates found promising have been identified from Agarkar Institute, Pune.

Entomopathogenic nematodes: Entomo-pathogenic nematodes *Steinerneima carpocapsae* and *Heterreorhabditis indica* from PDBC, Bangalore were mass multiplied in laboratory. In laboratory studies, there was more then 90% mortality in 3rd instar grubs after 7 days of treatment by *S. carpocapsae* while it was 40-60% by *H. indica.* After 15 days, mortality due to *H. indica* was 60-80%. Differences in mortality of *Brahmina coraicea* with *S. carpocapsae* and *H. indica* were also observed in the field trials at Shimla and Fagu. *S. carpocapsae* at higher dose i.e. $15X10^5$ ij was superior to others. Reduction in grub population at Fagu was 66-83% whereas it was 85-100% at Shimla.

Cutworms

At Shimla, cutworm damaged plants/plot were least (0.8%) in potato+ garlic inter crop with recommended pesticide treatment as against 2.72% in the control. In another trial, pesticides Cartap 4% granules and imidacloprid 17.8 SL n reduced the cutworm damage to less than 1.3% as against 2.95 in control. Entomopathogenic nematodes *Steinerneima sp* @ 25, 50, 75, 100 Juvenile /cutworm larva gave 100 % mortality after 5, 3, 1 and 1 day of treatment, respectively. Microbial agents, *Beauveria bassiana, Bacillus thuringiensis* and *Trichoderma viridae* were equally effective in reducing cutworm incidence by more than 50% at Patna. Neem granules (Ranker) were also found effective in checking both plant foliage and tuber damage due to cutworms.

Aphids and Leaf Hoppers

At Modipuram, first appearance of *M. persicae* was recorded in the 3rd week of November and it crossed the critical level (20 aphid/100 leaves) in 4th week of December, 2007. *Aphis gossypii* started building up in third week of October and attained peak in the first week of November and declined to minimum in December 2007. At Patna, first appearance of *M. persicae* was in the 3rd week of December 07, and it crossed the critical level in the 4th week of December (first time in the past four decades) on the unsprayed crop. Other aphid species viz., *A. gossypii, A. fabae* and *Rhopalosiphum rufiabdominalis* were observed in varying number on the crop. Aphid survey undertaken in Assam during Feb, 2008 showed comparatively lower population of *M. persicae* ranging from 24-50/ 100 leaves at Majauli, Johrat and Rowta than at Golaghat and Barpeta, where *M. persicae* population was much higher (30-150) in Kufri Jyoti and 700-1000/100 leaves in Kufri Pukhraj.

Neem granules (Ranker) were found effective for controlling both *M. persicae* (80.70% contro) and *A. gossypii* (66.92% control).

At Modipuram, *Amrasca biguttula biguttula* started building up in the 3rd week of October and peaked in last week of November and later on declined to minimum in December. However, it continued to be present in main crop which was planted on 3.11.07.

White flies and Red Ants

In 2007, the population of *Bemicia tabaci* remained low compared to previous years. Its highest level was observed during October and it started declining during November. For the management of white flies, soil treatment with Cartap 4G (20 g/plot) plus thiametoxam (0.5 g/lit) was best in keeping the white flies population at low level.

Heliothis armigera caterpillar

Management of Potato Nematodes

Potato cyst nematode (*Globodera pallida* and *G. rostochiensis*) also known as Golden Nematode is one of the most destructive pests through-out the world. It is a quarantine pest restricted to Nilgiri hills of South India. The programme aims at developing resistant cultivars for the area and to develop an integrated nematode management package for potato cyst nematodes (PCN) in Nilgiris.

Breeding for combined resistance to late blight and potato cyst nematodes

In all, 20,500 hybrid TPS were produced from six bi-parental crosses involving selected late blight and potato cyst nematode resistant parents. In the initial evaluation and selection, out of 8,500 genotypes in different generations under natural conditions of late blight, 1,025 genotypes were selected on the criteria of field resistance to late blight, cyst nematode resistance, yield and other traits of economic importance.

56 hybrids were assessed in four trials along with Kufri Giriraj and Kufri Swarna as checks. Among them, 27 hybrids were selected based on their yield, and resistance to late blight and cyst nematodes. The 5 best hybrid were OS/03-55 (24.2 t/ha), OS/03-17 (20.8 t/ha), OS/01-392 (20.4t/ha), OS/03-108 (20.2 t/ha) and OS/03-161 (19.3 t/ha). The yields were low due to adverse weather and low sunshine hours for 3 critical months.

Adaptability trials were conducted with two promising selections viz., OS/93-D-204, OS/94-L-956 and 3 check varieties K. Giriraj, K. Swarna and K. Jyoti, respectively at four locations viz. Nanjanad, Fern Hill, Gandhipet and Theettikal in 5 rows of 15 tubers each. The trials were harvested at 110 days in all the locations. At Nanjanad and Fern Hill, the hybrid OS/93-D-204 yielded significantly higher than

OS/93-D-204 Tubers

OS/93-D-204 crop

the best control variety K.Swarna in total and marketable yields while at Gandhipet and Theettikal it yielded at par with the best control Kufri Swarna both in total and marketable yields.

In all the locations both the hybrids were found to be resistant to both species of potato cyst nematodes and field resistant to late blight.

Integrated management of potato cyst nematodes

Observations on distribution of PCN in the Nilgiris revealed higher PCN population (124.08 cysts/100 g soil) in Kothagiri, (70.13 cysts/100 g soil) in Coonoor and (39.50 cysts/100 g soil) in Kundah areas. In general mean PCN populations was less than the PCN populations in Ooty area observed in earlier studies.

Fig. 12. PCN infected crop

Evaluation of chemical and biological nematode management practices on effect of nematicides showed that carbofuran and phorate @ 2 kg a.i /ha reduced the multiplication of PCN and improved the potato yield compared to the untreated control in Kufri Jyoti, Kufri Giriraj and Kufri Swarna. Among the two nematicides, carbofuran performed better than phorate in suppressing PCN and improving potato yield.

Among organic amendments, neem cake recorded maximum increase in yield and reduction in PCN multiplication followed by spent mushroom alone or in combination with *T. viride*. Organic amendments in combination with *T. viride* performed relatively better than organic amendments. Among the nematode biocontrol agents, *Pseudomonas fluorescens* gave maximum reduction in PCN multiplication and improvement in potato yield followed by *Paecilomyces lilacinus*. Carbofuran performed better than organic amendments and biocontrol agents in reducing PCN multiplication.

Three different crops were rotated with summer season potato to study the effect of crop rotation on PCN populations. *Solanum nigrum* performed better in terms of potato yield and reducing PCN populations. The rotations involving cabbage and wheat were also effective in reducing the multiplication of PCN in comparison with that of continuous cropping of susceptible potato. A long term crop rotation trial has been initiated during 2007 with seven rotations, which are traditionally being practiced with the local crops to study their effect on PCN population build up. Initial results showed that growing cabbage or radish after susceptible potato has been effective in containing the PCN population to a considerable extent. Intercropping with French beans showed that the PCN count was more when the fertilizer dose was low and a reduction in nematode population was recorded when the fertilizer dose was increased. Lowest cyst count was recorded in NPK dose of 125% recommended level.

DIVISION OF

CROP PHYSIOLOGY & POST HARVEST TECHNOLOGY

- Traditional method of potato storage in heaps and pits was improved with single spray application of CIPC. CIPC residues in peels of treated potatoes was only 0.11-3.22 ppm after 100 days of storage.
- Reconditioning of potatoes at 20°C for 15 days after 120 days storage at 4°C improved the chip colour to acceptable level in Kufri Chipsona-1.
- The acrylamide content in chips prepared from Kufri Jyoti tubers was significantly higher than that in Kufri Chipsona-1 and Kufri Chipsona-2 and there was a positive correlation (r=0.80 **) between acrylamide content and chip colour score.

Diversified Utilization of Potatoes

Nutrient composition of fresh fried chips and nutrient loss during processing

To quantify nutritional losses during the preparation of chips, fresh fried chips from 8 potato varieties/advanced hybrids immediately after harvest were processed. Chips from Kufri Jyoti contained maximum reducing sugars (67 mg/100 g fresh wt), free amino acids (160.7 mg N/100 g fresh wt) and total phenols (249.1 mg/100 g fresh wt), while chips from an advanced hybrid MP/2K-625 had highest sucrose content of 232.3 mg/100 g fresh wt. The average losses in reducing sugars, sucrose, free amino acids and total phenols during preparation of chips were 83.8, 77.3, 65.2 and 45.3% respectively.

Yield and quality characteristics of flakes

Potato flakes were prepared from 10 varieties including Indian potato varieties, advanced hybrids and an American variety after 120 days of storage at 10-12 °C. Atlantic gave maximum yield (20.1%) followed by Kufri Chipsona-3 (19.3%). Flakes prepared from all the cultivars were acceptable in colour. These flakes were analysed for soluble protein and L-ascorbic acid along with two commercial brands of flakes available in the market. The average losses in soluble protein and L-ascorbic acid during preparation of flakes were 29.1 and 68.1% respectively. The commercial brand flakes contained higher soluble protein content which may be due to better production control in the automatic flakes line while the ascorbic acid content was comparable.

Textural properties of chips and frozen French fries

Textural properties of chips and frozen French fries from Indian varieties were determined using the Texture Analyser (Micro Stable Systems, UK). Texture of chips from 75 day harvested crop of Kufri Surya was most crispy (91 peaks) followed by MP/2K-625 (82 peaks) and Kufri Chipsona-1 (72 peaks) (Table 24). Analysis of texture of frozen French fries made from 100 days heap stored tubers indicated that fries from MP/98-71 and K. Chipsona-1 were firmer in texture having 1.531 and 1.529 kg force, respectively compared to 1.373 kg force for Kufri Surya and 1.258 kg force for Kufri Chipsona-1.

Table 24. Textural quality of chips (crispness) after 75 days

Variety/hybrid	Tuber dry matter (%)	Chip colour[1]	Crispness[2] (No of peaks)
K. Chipsona-1	19.0	2.5	72
K. Chipsona-3	18.3	4.5	69
K. Himsona	17.8	3.5	61
K. Surya	16.6	2.7	91
Atlantic	17.4	3.5	69
MP/98-178	17.0	6.0	61
MP/2K-516	16.6	6.0	67
MP/2K-625	16.6	6.5	82

[1] On a 1-10 scale of increasing dark colour, chip colour score >3 was unacceptable
[2] Higher number of peaks indicate more crispness

Table 25. Effect of pressure cooking on the changes in anti-oxidants*

Variety	Total phenol(mg)		L-ascorbic acid(mg)		Total carotenoids (ug)	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
K. Chipsona-1	36.6	30.0	7.2	11.5	71.3	63.6
K. Jyoti	70.9	75.1	11.5	12.1	61.6	100.2
K. Pukhraj	51.2	53.7	12.1	10.5	231.1	188.8
K. Surya	66.3	85.4	12.1	15.3	163.7	188.8
Atlantic	38.6	43.1	10.5	12.1	69.3	136.8
Mean	52.7	57.46	10.68	12.30	119.4	135.64

(per 100 g fresh wt)

Further, blanching treatment prior to par frying, an essential step in making of French fry, improved the texture of the French fries significantly besides making them firmer and crispier (1.316 kg force) compared to the 0.887 kg force for the un-blanched ones.

Changes in antioxidant compounds

Influence of pressure cooking of potatoes on 3 important antioxidants viz., total phenols, L-ascorbic acid and total carotenes, was studied in 5 varieties stored at 10-12 °C with CIPC for 150 days. Pressure cooking increased total phenols and L-ascorbic acid contents in the tubers irrespective of the storage temperature, while the total caroteniods increased in the cold stored tubers but declined in the potatoes stored at 10-12 °C (Table 25).

Acrylamide content in potato chips:

Acrylamide formed during the frying of potato chips is considered as an undesirable contaminant in processed foods. Fresh fried chips prepared from Kufri Jyoti, Kufri Chipsona-1 and Kufri Chipsona-2 were analyzed for acrylamide formation before and after 60 and 120 days of storage (DOS) at 12°C with CIPC treatment. The acrylamide content in chips from Kufri Jyoti tubers was significantly higher than other two varieties (Table 26). There was an increase in the acrylamide content in chips prepared from Kufri Jyoti tubers after 60 and 120 DOS. It showed an increase after 60 DOS but not after 120 DOS, in Kufri Chipsona-1 but there was no increase in Kufri Chipsona-2. The chip colour score was significantly higher in Kufri Jyoti (Table 26). There was a highly positive correlation (r=0.80 **) between acrylamide content and chip colour score.

Physicochemical properties of potato starch

Physicochemical properties of starch were determined in 6 potato cultivars from Modipuram, 8 from Patna and 9 from Kufri. The dry matter content and starch recovery were higher in Kufri Chipsona-3 from Modipuram. The amylose content was higher in Kufri Chipsona-3 starch followed by Kufri Chandramukhi. The viscosity was higher in Kufri Badshah starch followed by Kufri Chandramukhi and Kufri Chipsona-3 whereas starch from Kufri Lauvkar and Kufri Chipsona-3 showed higher swelling volume. The starch clarity was higher in Kufri Chipsona-3 but lower in Kufri Sindhuri. At Patna, the tuber dry matter and starch content were higher in Kufri Chipsona-2, Kufri Chipsona-1 and Kufri Lalima. The amylose content of starch was higher in Kufri Pushkar and Kufri Ashoka, while the viscosity and swelling volume were higher in Kufri Lalima starch. The starch clarity was higher in Kufri Pukhraj but the viscosity was lower. At Kufri, maximum tuber dry matter and starch content were observed in Kufri Chandramukhi followed by Kufri Lalima.

Table 26. Acrylamide content (ng/g chips) in potato chips and chip colour score in chips prepared from three varieties after storage at 12°C.

Variety	Acrylamide content (ng/g chips) during storage			Chip colour score (1-10 scale) during storage		
	0 days	60 days	120 days	0 days	60 days	120 days
Kufri Jyoti	275	341	410	7.3	7	8
Kufri Chipsona-1	80	128	146	5	6.6	6
Kufri Chipsona-2	95	130	153	5	5.6	7
Mean	150	200	236	5.8	6.4	7

The amylose content of starch was higher in Kufri Anand and lower in Kufri Lalima, while the starch viscosity was higher in Kufri Lalima and lower in Kufri Anand. Kufri Chandramukhi starch showed higher swelling volume. The starch clarity was higher in Kufri Pukhraj and lower in Kufri Chipsona-2. These results show that while significant differences were observed among cultivars, it is difficult to draw conclusions on the location effect, as comparison becomes difficult when different cultivars are grown at different locations. However, generally, the tuber dry matter content, and amylose content and viscosity of starch were higher in tubers grown under rainfed conditions at Kufri.

Effect of crop maturity on physico-chemical properties of starch

Crop maturity had a significant effect on the physicochemical properties of starch. The dry matter and starch contents increased with increase in crop maturity. While the difference between 100 and 115 days was not significant, the dry matter content at 130 days was significantly higher than that at 100 days. Amylose content and swelling volume showed a significant increase with crop maturity and the values were much lower in immature tubers (Fig. 40). The differences in starch clarity were also significant with the starch from matured tubers showing lower optical density and therefore, higher clarity. The viscosity was 1556, 1661 and 3579 cP after 100, 115 and 130 days of planting, respectively, in Kufri Jyoti. In Kufri Giriraj, the corresponding values were 1540, 1697 and 2813 cp. Significant difference in viscosity was observed only at full maturity at 130 days, with Kufri Jyoti showing higher viscosity. The swelling volume was significantly higher in Kufri Giriraj at all the three stages of maturity.

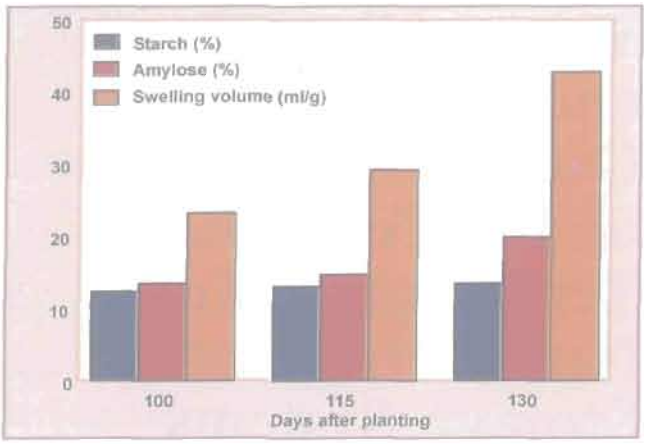


Fig. 40. Effect of crop maturity on starch content and its properties (values are mean of two cultivars)

Glycoalkaloids and phenols contents in potato tubers

A study was conducted on the glycoalkaloids and total phenols contents in peels and flesh of tubers of Kufri Chipsona-1, Kufri Bahar and Kufri Jyoti. Higher content of glycoalkaloids was observed in peels as compared to flesh (Table 27). The glycoalkaloids content in peels of Kufri Bahar was significantly higher than other two varieties. However, there was no significant difference in the glycoalkaloids content of flesh. When the tubers were stored in light and dark at room temperature for 60 days, significant difference was observed only in Kufri Bahar with peels and flesh of tubers exposed to light showing higher values. The phenols content was higher in peels compared to flesh and the values were highest in Kufri Jyoti (Table 27). In tubers stored in light and dark at room temperature for 60 days, significant differences were observed only in Kufri Bahar. In peels, the phenols content was higher in tubers stored in dark but in flesh, it was higher in tubers stored in light.

Table 27. Glycoalkaloids and phenols content in tubers of three varieties

Variety	Tuber part	Glycoalkaloids(mg/100 g dry wt)			Phenols(mg/100 g dry wt)		
		0 day	60 days		0 day	60 days	
			Light	Dark		Light	Dark
K Chipsona-1	*Peels*	57.0	47.8	87.9	617.6	611.4	579.6
	Flesh	9.3	19.3	28.0	151.9	243.7	221.8
K Bahar	*Peels*	94.7	307.1	111.4	622.8	868.6	1018.2
	Flesh	10.2	38.1	28.8	204.9	379.0	348.8
K Jyoti	*Peels*	56.4	100.6	109.3	880.8	986.9	990.0
	Flesh	10.7	28.5	32.6	363.9	470.2	617.2
Means	*Peels*	69.4	151.8	102.9	707.1	822.3	862.6
	Flesh	10.1	28.6	29.8	240.2	364.3	395.9

Storage Behaviour and Processing Quality of Potatoes under Controlled Temperature and Non-Refrigerated Storage Systems

Work on evaluation of potato genotypes for their storability and processing quality under elevated storage temperatures, enzymatic changes associated with it and development of variety specific techniques for storage of processing potatoes was continued. In addition, large scale confirmation storage trials on improved traditional storage methods using sprout inhibitor CIPC ((isopropyl N (3-chlorophenyl) carbamate) were conducted. Residue level of chemicals in treated foods has been a matter of health concern therefore studies on the use of eco-friendly compounds as sprout suppressants were also continued.

Improvement of traditional storage methods with CIPC

Spray of CIPC (Oorja, UPL, Mumbai, 50% a.i.) @ 50 ml/t, effectively controlled sprouting in 6 potato cultivars stored in bulk under heap and pit storage. Pre-storage factors *viz.*, maturity of tubers, curing of skin, sorting out of damaged tubers, timely storage of potatoes and proper ventilation, significantly reduced total storage losses up to 90 days in CIPC treated tubers in pit storage and there was no need to desprout the treated tubers after storage (Figs.41-42). In heaps, chip colour of all the cultivars except Kufri Pushkar was acceptable after storage while CIPC treated tubers of only Kufri Chipsona-1, Kufri Lauvkar and Kufri Surya could produce acceptable chips under pit storage.

In another study involving 4 processing varieties/hybrids, CIPC treated tubers showed

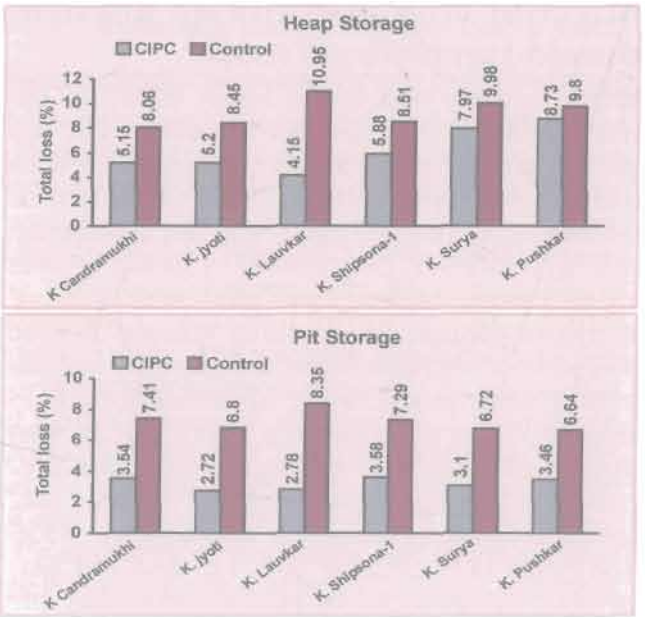


Fig. 41. Total losses in six potato cultivars up to 90 days of storage in heaps and pits.

lower mean total weight loss, dry matter loss, peeling loss, reducing sugars, sucrose and total phenols up to 100 days of storage (DOS) in heaps. Tubers from Kufri Chipsona-1, Kufri Chipsona-3 and one advanced hybrid, MP/99-322 were found suitable for processing. Spray application of Oorja @ 50 ml/t in methanol and water and of Grostop Basis, Luxan, UK (EC, 30.24% a.i.) in water @ 80 ml/t of potatoes were equally effective in controlling sprouting in 4 cultivars under heap storage. CIPC residues in peels of treated tubers ranged between 0.22-6.58 ppm after 50 days which further decreased to 0.11-3.22 ppm after 100 days of storage.

Fig. 42. Sprout suppression in potatoes with CIPC spray after 90 days of storage in heaps

Improvement in the storability of potato: CIPC spray alone and CIPC in combination with boric acid (3%) significantly reduced sprouting, sprouting index, sprout weight and total losses in 3 average keepers as compared to control up to 120 DOS in heaps (Table 28). Botanical extracts and bioagents, 3% sodium metabisulphite + CIPC, 3% boric acid spray alone and 3% boric acid in combination with CIPC were effective in controlling the rots in cv. Kufri Sutlej for 90 days under heap storage.

Effect of storability on processing quality: Results from storability of 4 advanced processing hybrids *viz.* MP/98-71, MP/98-172, MP/99-322 and MP/99-406 at room temperature revealed maximum total weight loss (18.57%) in Kufri Chipsona-3 up to 120 days of storage while it was minimum (10.66%) in Kufri Surya. Hybrid MP/98-71 had the minimum loss (14.04%) and MP/99-322 had the maximum total losses (20.84%) during storage.

Four advanced hybrids were evaluated periodically along with 8 cultivars for processing into chips up to 180 DOS at 10-12°C with CIPC. Acceptable quality chips were produced from Kufri Chipsona-1, Kufri Chipsona-3 and MP/98-172 up to 90 days, whereas Atlantic produced good quality chips up to 120 days. In another study on frozen French fries, good quality fries was made from Kufri Chipsona-1 and Kufri Chipsona-3 up to 180 DOS compared to Atlantic which produced acceptable fries up to 150 days. Both Kufri Surya and hybrid MP/98-71 produced fries of acceptable colour only up to 120 days.

Effect of temperature on processing quality: Tubers of 4 cultivars obtained from Jalandhar were kept in walk-in-chambers at 20°C and the temperatures were brought down by 0.5°C per day till storage temperatures of 4, 8 and 12°C were reached. Processing quality parameters were determined at the time of loading and after 120 DOS. Reducing sugar contents increased

Table 28. Effect of CIPC and boric acid spray on storability of potatoes after 120 days of storage in heaps (16.5-33°C and 44-95% RH)*

Treatment	Sprouting (%)	Sprouting index	Sprout weight (g/kg tuber weight)	Rottage (%)	Total weight loss (%)
Boric acid (3%)	100.0	6.00	15.92	5.02	23.57
CIPC (50ml/t)	8.39	1.27	0.24	5.69	17.08
Boric acid + CIPC	6.52	1.31	0.24	4.93	16.36
Control	100.0	6.00	19.79	6.63	25.20
CD (0.05)	1.73	0.14	3.51	NS	3.39

*Mean of 3 cultivars *viz.* Kufri Bahar, Kufri Badshah and Kufri Pukhraj

during the pre-holding period in all the cultivars stored at 4 and 8°C except Kufri Bahar, but was almost constant at 12°C. The reducing sugars increased linearly up to 120 days of storage with maximum increase recorded at 4°C. Chip colour score too increased during the pre-holding period and the storage. The chip colour was unacceptable in all the cultivars. To improve the chip colour, reconditioning of stored potatoes at 20°C was tried after 90 and 120 DOS. Reconditioning of potatoes for 15 and 21 days improved the chip colour to acceptable level in Kufri Chipsona-1 after 120 DOS. Reconditioning although increased weight loss in potatoes (1-2%), but the losses were within the acceptable range of 10% with no visible shriveling in tubers.

Rate of tuber respiration increased with the temperature and time of storage in all the varieties (Table 29). Significantly higher rate of tuber respiration recorded in Kufri Chipsona-2 compared to Kufri Chipsona-1 and Kufri Jyoti indicated that higher respiratory losses may be one of the reasons for its poor keeping quality. Percent ion leakage from tuber tissue also increased during storage and maximum leakage was observed in Kufri Chipsona-2 stored at 8°C after 180 DOS.

Carbohydrate metabolism: Studies on changes in the activities of two enzymes along with important metabolites revealed increased activities of basal invertase and sucrose phosphate synthase up to 180 days of storage at 4°C and 10-12°C with CIPC and were significantly higher in the tubers stored at 4°C. Increased activity of enzymes correlated with higher accumulation of reducing sugars and sucrose, respectively at 4°C. Sucrose, free amino acids and total phenols content also increased during storage (Table 30).

Changes in anti-oxidant system: In studies on the effect of storage temperature (4 and 12°C) on anti-oxidant system of potato tuber, ascorbic acid content in tubers decreased after 3 days at 4°C while total phenol did not show any specific pattern during storage. The activity of ascorbate peroxidase increased with storage

Table 29. Rate of respiration (mg CO_2/kg/hr) in potato tubers stored under different temperatures

Variety/ Temperature	Before storage	30 *DOS	60 DOS	90 DOS	120 DOS	150 DOS	180 DOS
Kufri Jyoti							
4°C	14.8	6.1	7.8	15.8	24.1	29.1	29.8
8°C	13.8	7.8	10.5	20.0	30.8	35.8	38.3
12°C	21.2	11.3	12.2	24.1	36.6	35.8	37.4
Mean	16.6	8.4	10.2	19.9	30.5	33.6	35.2
Kufri Chipsona-1							
4°C	11.1	4.3	7.0	14.1	24.1	28.3	29.1
8°C	15.7	12.2	12.2	21.6	30.8	40.0	40.8
12°C	24.9	19.2	21.0	34.0	40.8	47.4	49.9
Mean	17.2	11.9	13.4	23.3	31.9	33.8	39.9
Kufri Chipsona-2							
4°C	13.8	11.3	11.3	10.8	27.4	35.8	47.4
8°C	16.6	21.0	19.2	16.6	38.5	44.2	47.4
12°C	23.1	23.6	28.0	24.1	46.6	54.9	60.8
Mean	17.8	18.7	19.5	17.2	37.5	44.9	51.9
$LSD_{0.05}$							
Variety	1.1	1.5	2.0	1.0	1.6	1.4	1.6
Temperature	1.1	1.5	2.0	1.0	1.6	1.4	1.6
V x T	1.3	2.6	3.4	1.8	2.7	2.4	2.8

*DOS= Days of storage

Table 30. Changes in the activities of enzymes of carbohydrate metabolism and certain constituents in potato tubers during storage (mean of five cultivars)

Days of storage	Storage condition	Basal invertase[1]	Sucrose phosphate synthase[2]	Soluble protein[3]	Reducing sugar[4]	Sucrose[4]	Free amino acid[4]	Chip colour score[5]
0	-	0.050	0.307	4.49	106	131	61.6	4.3
90	4 °C	0.065	0.770	5.23	1013	564	77.3	8.1
	10-12 °C	0.023	0.365	5.26	217	135	77.8	4.5
180	4 °C	0.339	0.922	4.63	1131	620	81.6	8.9
	10-12 °C	0.059	0.513	4.48	319	559	86.3	6.3

[1]umol hexoses formed mg^{-1} protein hr^{-1}, [2]umol sucrose formed mg^{-1} protein hr^{-1}, [3]mg g^{-1} fresh wt [4] mg./100 g fresh wt
[5]on a 1-10 scale of increasing dark colour, chip colour score >3 was unacceptable

duration and was higher at lower temperature than at 12°C (Fig. 43). The glutathione reductase also showed an increased activity at 4°C till 14 days indicating that the active oxygen species are produced in greater quantity during the initial days of potato storage at lower temperatures.

Naturally occurring volatile compounds as sprout suppressants: Salicylaldehyde treatment (300 ppm for 10 days) found effective in laboratory studies was evaluated on large scale in combination with boric acid (3%) spray. The treatments significantly reduced sprouting (52%), sprout weight (65%) and total losses in tubers (36%) up to 110 DOS without any increase in rottage (Table 31). No discoloration in the tuber and any change in taste or flavour of boiled potatoes were detected during storage and chip colour was acceptable after 110 DOS (Table 31).

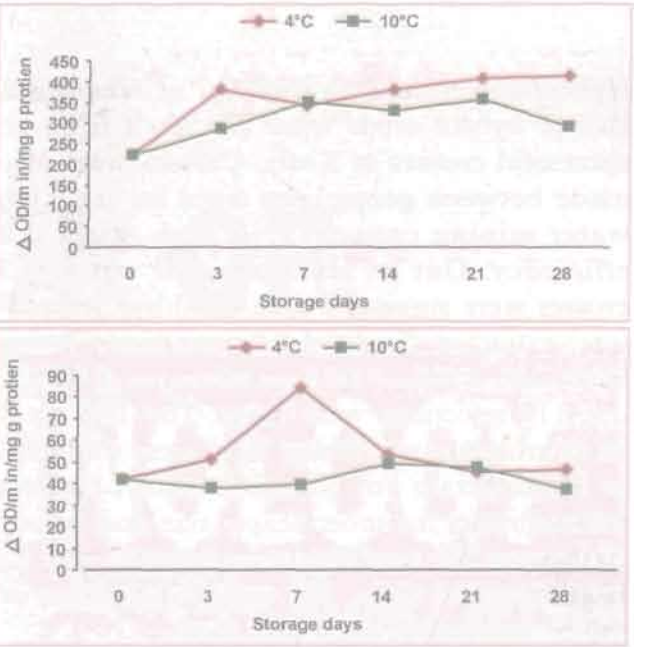


Fig. 43. Changes in ascorbate peroxidase (A) and *glutathione reductase* (B) activity in Kufri Chipsona-1

Table 31. Effect of salicylaldehyde on processing quality of potatoes in cv. Kufri Chipsona-1

Treatment	Reducing sugar**		Sucrose**		Free amino acid**		Phenol**		*Chip colour score	
	60**	110	60	110	60	110	60	110	60	110
Salicylaldehyde	108.5	79.6	267.4	504.6	70.4	99.3	90.6	91.1	4.0	2.5
Salicylaldehyde+ Boric acid	50.3	119.5	304.0	544.8	80.4	94.8	74.6	114.5	6.0	2.5
Control	52.7	63.3	326.7	574.6	71.9	85.9	57.7	71.4	6.0	2.5

*on a scale 1-5, score up to 5 is acceptable, ** Days of storage at 24 ±2°C
**(mg/100g fresh wt)

Physiological Response of Potato Plants to Heat and Water Stress

Hybridization and Evaluation of seedlings:, 14,046 hybrid seeds were extracted from 14 successful crosses at Kufri. Crosses were also made between germplasm lines having high water mining capacity and high water use efficiency. Out of six attempted crosses, 3 crosses were successful and 4,320 hybrid seeds were extracted. Seeds of 4 crosses made during 2006 were screened for heat tolerance at Shimla and 110 selections were made. The TPS seeds of 13 crosses made during 2007 were evaluated at Modipuram for identification of better recombinants for tuber shape, size and colour. At harvest 292 seedlings were selected, 191 for heat tolerance while, 101 drought tolerance on the basis of tuber traits and yield.

Performance of Kufri Surya under hot climate at Goa: Results from replicated trial conducted at ICAR Research Complex Goa with 4 varities, *viz.* Kufri Surya, Kufri Pukhraj, one heat tolerant hybrid HT/99-722 and Kufri Surya (hill produce) for their yield performance under high temperature conditions (Temp: Max. 31-35° C /min18-24° C) showed highest tuber number and yield in HT/99-722 (62 q/ha) followed by K. Surya (59 q/ha). The average tuber weight was highest in Kufri Surya followed by HT/99-722 (Fig. 44). The results indicated that coastal areas can be exploited for undertaking potato cultivation by growing heat tolerant genotypes/cultivars particularly HT/99-722 and Kufri Surya. Region specific improved agro-technology can further increase the tuber yield.

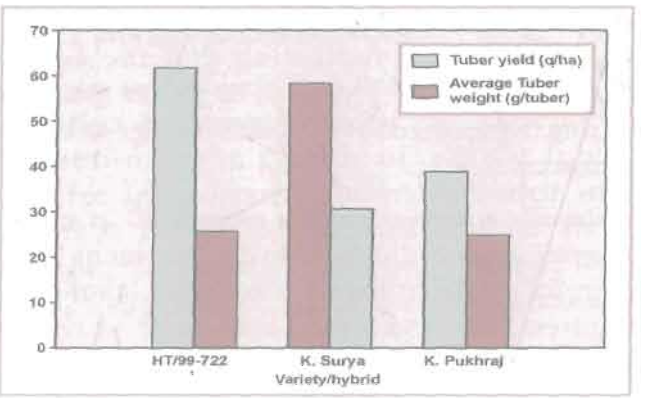


Fig. 44

Out of 23 germplasm lines (CP-1160, 1366, 1384, 1427, 1436, 1486, 1604, 1668, 1672, 1748, 1760, 1765, 1798, 1982, 1988, 1990a, 1990b, 2063, 2067, 2348, 2378, 3158), only 7 could produce tubers at Goa. Moreover, the tuber yield and average tuber was very low. None of the germplasm line was found suitable under hot climate.

Optimization of fertilizer requirement for Kufri Surya: Optimum fertilizer requirement for early crop of Kufri Surya was found to be 180 kg N/ha, 50 kg/ha P_2O_5 and 100 kg K_2O /ha (Fig 45).

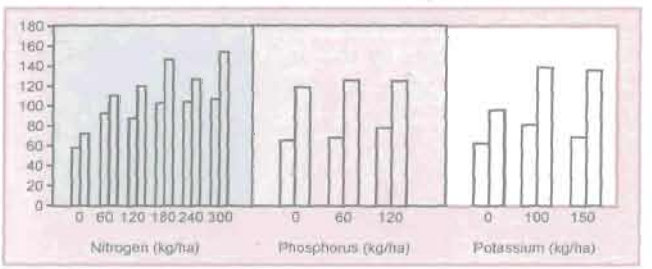


Fig. 45

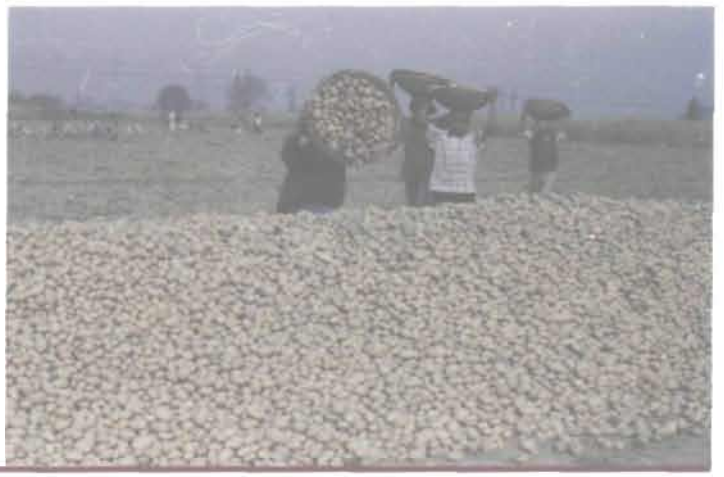
DIVISION OF

SEED TECHNOLOGY

- Approximately 2,515 metric tones (MT) of Breeders' seed was produced from an area of 130.73 ha out of which 2,035 MT was supplied to different stakeholders. At CPRS, Ooty a total of 115 MT quality seed was produced in an area of 8.75 ha and 74 MT was supplied to the farmers.

- It was the third year of targeted achievement of 100% breeder seed production through micro-propagated nucleus material. In this year, 12.3% area for Breeders' seed production was covered with tissue culture raised material and 255 MT seed was produced. This material will cover 71% of the total area next year.

Seed Science & Production Technology



The conventional seed potato production programme involving tuber indexing and multiplication of breeder seed through different stages was continued. However, to improve the virus freedom in the stocks, augmentation of micropropagation was strengthened by producing large number of *in vitro* plants, microtubers and minitubers at Modipuram, Jalandhar, Swalior, Patna, Kufri, Ooty and Shimla. Since, the mini tubers of < 3 g weight have high mortality rate in field, a recycling technique of their multiplication was introduced under protected conditions at CPRIC, Modipuram, CPRS, Jalandhar, Gwalior and Patna to make judicious use of precious seed material. Further, virus free buffer stocks of new varieties were developed for *in vitro* mass multiplication for a complete switch over of breeder seed production through micropropagation. The progress report on these activities is as under.

I. Conventional Seed Production Technology

i) Tuber indexing, testing and inspection: Indexing of 23,272 tubers of 24 varieties was done at Modipuram (4,692), Jalandhar (3,660), Gwalior (5,560), Patna (2,144), Kufri (4,092) and Shimla (3,124) through ELISA in glass/net houses and in field in stage-I. The field inspection of crop was undertaken at all the stations. The percentage of healthy tubers in tuber indexing of clones at Modipuram, Jalandhar, Gwalior, Patna, Kufri and Shimla (Manipur, Goa) was 83.97, 91.80, 95.80, 81.34, 86.60 and 100% respectively.

ii) Breeder seed production

a) Stage-I (clonal multiplication): The clonal multiplication was undertaken in 3.016 ha in plains and 0.37 ha in hills and a production of 323.11 and 43.83 q respectively was obtained. The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was120.35, 134.55, 77.34, 88.46 and 108.24q/ha respectively.

b) Stage-II (clonal increase): The production programme was taken in 8.77 ha and a total production of 1,392.93 q was achieved at all stations in the plains. In hills only 0.88 ha area was planted and a production of 84.20 q was obtained. The average production at Modipuram, Jalandhar, Gwalior, Patna and Kufri was 174.58, 210.78, 99.74, 170.70 and 95.68 q/ha respectively.

c) Stage-III (bulk increase): In this stage 20.21 ha was planted at all the four stations in the plains and a total production of 4,058.78 q was achieved; whereas, in the hills the production obtained was 397.60 q in 2.01 ha. The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 220.12, 216.00, 141.58, 206.40 and 197.81q/ha respectively.

d) Stage-IV (breeder seed): At all stations in the plains 90.83 ha was planted and 18,301.40 q production was achieved; whereas, in the hills the production was 551.12 q from 4.65 ha. The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 216.26, 213.15, 146.99, 216.87 and 118.52 q/ha respectively. In hills due to unfavorable weather conditions the yield were less in general.

iii) Production and supply of breeders' and quality seed: A total production of 25,152.97 q of 21 varieties was achieved in hills and plains from 130.73 ha (Table 32). Out of which, a total of 19,569.86 q of 20 varieties was supplied from plains and 782.42 q of 4 varieties from hills (Table 33). About 4,800.69 q was kept for own planting in the plains and hills (Table 34-35) At CPRS, Ooty a total of 1,149 q quality seed was produced in 8.75 ha during summer and autumn. Out of which 741 q was supplied and the remaining 408 q was used in subsequent seasons for raising the autumn and summer seed crops.

Table 32. Station, variety and stagewise area (ha) planted and production (q) obtained during 2006-07

Station/variety	Stage-I		Stage-II		Stage-III		Stage-IV		Total	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod	Area	Prod.
Modipuram										
Kufri Anand	0.10	15.95	0.40	59.20	0.50	129.05	3.00	732.73	4.00	936.93
Kufri Arun	0.05	6.10	0.14	25.70	0.20	40.25	1.20	229.05	1.59	301.10
Kufri Badshah	0.10	14.55	0.45	86.00	0.50	100.00	1.45	293.68	2.50	494.23
Kufri Bahar	0.55	58.45	2.25	366.00	5.00	1092.75	23.50	5196.35	31.30	6713.55
Kufri Chip.-1	0.17	19.25	0.77	122.40	1.50	298.35	6.50	1484.40	8.94	1924.40
Kufri Chip.-2	0.01	2.70	0.08	14.40	0.20	36.35	0.50	86.00	0.79	139.45
Kufri Chip.-3	0.04	4.25	0.08	14.80	-	-	-	-	0.12	19.05
Kufri Pukhraj	0.05	8.85	0.17	42.85	0.40	109.45	2.00	470.00	2.62	631.15
Kufri Sutlej	0.12	15.35	0.42	98.80	0.60	150.25	3.40	463.10	4.54	727.50
Kufri Surya	0.06	6.45	0.14	25.30	0.16	37.80	1.00	246.63	1.36	316.18
MP/97-644	0.02	0.95	-	-	-	-	-	-	0.02	0.95
Total	**1.27**	**152.85**	**4.90**	**855.45**	**9.06**	**1994.25**	**42.55**	**9201.94**	**57.78**	**12204.49**
Jalandhar										
KCM	0.025	4.00	0.06	12.45	0.40	72.00	2.00	411.75	2.49	500.20
Kufri Jyoti	0.385	47.23	0.60	130.55	2.20	445.60	12.00	2183.26	15.19	2806.64
Kufri Badshah	0.070	10.46	0.17	33.25	1.00	228.80	3.00	683.28	4.24	955.79
Kufri Sutlej	0.010	2.00	0.02	4.15	0.10	17.60	0.40	88.99	0.53	112.74
Kufri Pukhraj	0.070	11.66	0.15	30.38	1.00	251.20	3.00	859.03	4.22	1152.27
Kufri Pushkar	-	-	-	-	-	-	2.00	548.35	2.00	548.35
Total	**0.56**	**75.35**	**1.00**	**210.78**	**4.70**	**1015.20**	**22.40**	**4774.66**	**28.66**	**6075.99**
Gwalior										
KCM	0.17	14.11	0.40	42.70	0.90	159.08	4.14	490.34	5.61	706.23
Kufri Jyoti	0.24	15.22	0.65	63.04	0.90	102.40	4.56	526.03	6.35	706.69
Kufri Lauvkar	0.19	14.99	0.50	49.10	0.60	85.60	2.35	358.51	3.64	508.20
Kufri Sindhuri	0.08	6.45	0.37	40.40	1.20	212.00	4.50	882.48	6.15	1141.33
Kufri Chip.-1	0.09	8.14	0.06	5.52	0.05	8.80	1.78	261.80	1.98	284.26
Kufri Chip.-2	0.13	10.70	0.32	28.64	0.70	48.00	0.70	148.27	1.85	235.61
Kufri Surya	-	-	-	-	-	-	0.10	12.46	0.10	12.46
Kufri Arun	-	-	-	-	-	-	0.10	10.82	0.10	10.82
Kufri Pukhraj	-	-	-	-	-	-	0.10	14.22	0.10	14.22
Kufri Kanchan	-	-	-	-	-	-	0.10	4.17	0.10	4.17
Total	**0.90**	**69.61**	**2.30**	**229.40**	**4.35**	**615.88**	**18.43**	**2709.10**	**25.98**	**3623.99**
Patna										
Kufri Arun	0.057	4.55	-	-	-	-	-	-	0.06	4.55
Kufri Ashoka	0.028	2.65	0.077	17.50	0.40	105.00	1.75	357.00	2.255	482.15
Kufri Pukhraj	0.072	7.15	0.143	31.80	0.80	144.70	2.00	387.35	3.015	571.00
Kufri Jyoti	0.057	5.30	0.168	25.75	0.45	75.85	2.25	575.60	2.925	682.50
Kufri Kanchan	0.072	5.65	0.182	22.25	0.42	104.90	1.45	295.75	2.124	428.55
Kufri Lalima	-	-	-	-	0.03	3.00	-	-	0.030	3.00
Total	**0.286**	**25.300**	**0.570**	**97.30**	**2.10**	**433.45**	**7.45**	**1615.70**	**10.406**	**2171.75**
Total A:	**3.016**	**323.110**	**8.770**	**1392.930**	**20.210**	**4058.780**	**90.830**	**18301.400**	**122.826**	**24076.220**
B. Hills										
Kufri/Fagu										
Kufri Jyoti	0.30	34.00	0.70	68.00	1.60	295.00	3.70	446.82	6.30	843.82
Kufri Giriraj	0.04	7.50	0.12	10.50	0.39	98.15	0.75	88.00	1.30	204.15
Kufri Kanchan	0.02	0.88	0.02	0.90	0.02	4.45	0.10	2.30	0.16	8.53
Kufri Shailja	0.01	1.45	0.04	4.80	-	-	0.10	14.00	0.15	20.25
Total B:	**0.37**	**43.83**	**0.88**	**84.20**	**2.01**	**397.60**	**4.65**	**551.12**	**7.91**	**1076.75**
Total A+B	**3.39**	**366.94**	**9.65**	**1477.13**	**22.22**	**4456.38**	**12.10**	**18852.52**	**130.73**	**25152.97**

Table 33. Agencywise and varietywise breeders' seed supplied from plains and hills during 2006-07

A. State/ Agency Plains	Kufri Badshah	Kufri Bahar	KCM	Kufri Jyoti	Kufri Surya	Kufri Lauvkar	Kufri Sindhuri	Kufri Sutlej	Kufri Lalima	Kufri Ashoka	Kufri Anand	Kufri Chip.-1	Kufri Chip.2	Kufri Giriraj	Kufri Pukhraj	Kufri Pushkar	Kufri Kanchan	Kufri Arun	Total		
Himachal	-	-	200.00	700.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	900.00
J&K	38.01	-	17.60	50.40	-	-	-	13.60	-	-	-	-	8.00	-	-	-	-	-	-	-	127.61
MP	-	-	25.60	-	-	-	-	50.40		-	50.00	-	344.00	260.00	-	-	-	-	-	-	730.00
Punjab	200.00	-	100.00	250.00	-	-	-	100.00	100.00	-	30.00	-	-	-	-	-	100.00	-	-	-	880.00
U.P.	302.00	4026.00	100.00	-	-	-	-	300.00	210.00	-	-	340.00	792.00	-	-	20.00	100.00	-	25.10	80.00	6295.10
Haryana	150.00	50.00	-	-	-	-	-	-	150.00	-	-	-	25.00	20.00	-	-	100.00	-	-	-	495.00
Uttaranchal	-	15.00	-	100.00	-	-	-	0.80	-	-	-	-	9.60	1.60	-	30.00	-	-	-	-	157.00
West Bengal	-	-	94.40	335.60	-	-	-	-	-	-	30.00	-	-	-	-	-	132.00	-	-	-	592.00
Manipur	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	0.05
Chhatisgarh	-	-	-	-	-	-	-	-	-	-	-	-	-	10.00	-	-	20.00	-	-	-	30.00
Bihar	-	-	-	-	-	-	-	50.40	-	-	-	-	-	-	-	-	-	-	-	75.00	125.40
NSC	90.00	150.00	90.00	310.00	-	-	-	-	-	-	-	-	-	-	-	-	110.00	200.00	-	-	950.00
SFCI/CSF	45.00	45.00	-	40.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	130.00
NHRDF	-	-	-	-	-	-	-	-	-	-	145.00	260.00	-	-	-	-	-	312.00	-	-	717.00
Total A:	**825.01**	**4286.00**	**627.60**	**1786.00**	**-**	**-**	**515.20**	**460.00**	**-**	**255.00**	**600.00**	**1178.60**	**291.60**								
	-	**50.00**	**562.05**	**512.00**	**25.10**	**155.00**	**12129.16**														
B. Others																					
CPRI, Stn./ICAR	28.00	1.00	-	11.00	8.25	-	-	-	-	-	30.00	0.25	62.00	3.00	-	-	3.00	-	0.25	5.00	151.75
University	14.75	7.00	10.00	79.95	10.28	-	-	-	0.32	-	14.00	0.35	6.50	-	-	-	40.32	-	49.00	2.00	234.47
Society/Pvt Agencies	-	-	42.00	31.00	77.00	15.00	-	42.00	-	-	-	-	208.00	6.00	-	-	-	5.00	-	0.50	426.50
Farmers	442.23	936.00	183.49	1178.90	68.50	341.40	-	258.90	84.08	3.00	125.85	87.05	286.10	82.15	0.50	-	1093.82	269.61	219.80	51.10	5712.48
Market	0.10	-	0.05	0.15	-	-	-	-	-	-	-	-	-	-	-	-	0.10	0.10	-	-	0.50
Auction	104.50	470.50	-	-	6.80	-	-	-	61.50	-	-	49.20	95.00	59.00	-	4.20	49.10	-	-	14.20	914.00
AICPIP	-	-	-	-	0.50	-	-	-	-	-	-	-	0.50	-	-	-	-	-	-	-	1.00
Total B:	**589.58**	**1414.50**	**235.54**	**1301.00**	**171.33**	**356.40**		**300.90**	**145.90**	**3.00**	**169.85**	**136.85**	**658.10**	**150.15**	**0.50**	**4.20**	**1186.34**	**274.71**	**269.05**	**72.80**	**7440.70**
Total A+B:	**1414.59**	**5700.50**	**863.14**	**3087.00**	**171.33**	**356.40**	**-**	**816.10**	**605.90**	**3.00**	**424.85**	**736.85**	**1836.70**	**441.75**	**0.50**	**54.20**	**1748.39**	**786.71**	**294.15**	**227.80**	**19569.86**
Hills																					
A. State/Agency																					
HP	-	-	-	215.00	-	-	-	-	-	-	-	-	-	-	-	10.00	-	-	-	-	225.00
Utranachal	-	-	-	50.00	-	-	-	-	-	-	-	-	-	-	-	40.00	-	-	-	-	90.00
Manipur	-	-	-	80.00	-	-	-	-	-	-	-	-	-	-	-	10.00	-	-	-	-	90.00
Meghalya	-	-	-	50.00	-	-	-	-	-	-	-	-	-	-	-	10.00	-	-	-	-	60.00
Mizoram	-	-	-	20.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.00
J&K	-	-	-	55.00	-	-	-	-	-	-	-	-	-	-	-	10.00	-	-	-	-	65.00
Sikkim	-	-	-	30.00	-	-	14.00	-	-	-	-	-	-	-	-	14.00	-	-	4.00	-	62.00
Arunachal	-	-	-	25.00	-	-	-	-	-	-	-	-	-	-	-	10.00	-	-	-	-	35.00
Total	-	-	-	**525.00**	-	-	**14.00**	-	-	-	-	-	-	-	-	**104.00**	-	-	-	-	**643.00**
B. Others																					
CPRI, Stn.	-	-	-	17.00	-	-	-	-	-	-	-	-	-	-	-	14.00	-	-	-	-	31.00
Pvt./Farmers	-	-	-	62.27	-	-	-	-	-	-	-	-	-	-	-	42.15	-	-	-	-	104.42
Total B:	-	-	-	**79.27**	-	-	-	-	-	-	-	-	-	-	-	**56.15**	-	-	**4.00**	-	**139.42**
Total A+B:	-	-	-	**604.27**	-	-	**14.00**	-	-	-	-	-	-	-	-	**160.15**	-	-	**4.00**	-	**782.42**
Grand total:	**1414.59**	**5700.50**	**863.14**	**3691.27**	**171.33**	**356.40**	**14.00**	**816.10**	**605.90**	**3.00**	**424.85**	**736.85**	**1836.70**	**441.75**	**0.50**	**214.35**	**1748.39**	**786.71**	**298.15**	**227.80**	**20352.28**

Table 34. Varietywise production,seed supplied and seed used for planting at CPRI stations during 2006-07 (stageI-IV)

Station	Kufri Anand	Kufri Ashoka	Kufri Arun	Kufri Badshah	Kufri Bahar	KCM	Kufri ChIP.-1	Kufri Chip.-2	Kufri Chip.-3	Kufri Giriraj	Kufri Jyoti	Kufri Kanchan	Kufri Lalima	Kufri Lauvkar	Kufri Pukhraj	Kufri Pushkar	Kufri Shailja	Kufri Sindhuri	Kufri Sutlej	Kufri Surya	Kufri Himsona	Total
Modipuram																						
P	936.93	-	301.10	494.23	6713.55	-	1924.40	139.45	19.05	-	-	-	-	-	631.15	-	-	-	727.50	316.18	0.95	12204.49
S	734.45	-	220.20	663.26	5699.50	-	1516.40	118.00	-	54.20	-	-	-	-	725.07	-	-	-	520.32	163.33	-	10414.73
OS	202.48	-	80.90	*	1014.05	-	408.00	21.45	19.05	*	-	-	-	-	*	-	-	-	207.2	152.85	0.95	
Jalandhar																						
P	-	-	-	955.79	-	500.20	-	-	-	-	2806.64	-	-	-	1152.27	548.35	-	-	112.74	-	-	6075.99
S	-	-	-	751.33	-	332.63	-	-	-	-	2024.95	-	-	-	959.45	461.51	-	-	85.58	-	-	4615.45
OS	-	-	-	204.46	-	167.57	-	-	-	-	781.69	-	-	-	192.82	86.84	-	-	27.16	-	-	1460.54
Gwalior																						
P	-	-	10.82	-	-	706.23	284.26	235.61	-	-	706.69	4.17	-	508.20	14.22	-	-	1141.33	-	12.46	-	3623.99
S	2.40	9.70	7.60	-	1.00	530.51	320.30	323.75	0.50	-	501.80	-	-	356.40	11.67	13.20	-	816.10	-	8.00	-	2902.93
OS	*	*	3.22	-	*	175.72	*	*	*	-	204.89	4.17	-	151.80	2.55	*	-	325.30	-	4.46	-	
Patna	-	482.15	4.55	-	-	-	-	-	-	-	682.50	428.55	3.00	-	571.00	-	-	-	-	-	-	2171.75
P	-	415.15	-	-	-	-	-	-	-	-	560.25	294.15	3.00	-	364.20	-	-	-	-	-	-	1636.75
S	-	67.00	4.55	-	-	-	-	-	-	-	122.25	134.40	0.00	-	206.80	-	-	-	-	-	-	535.00
OS																						
Kufri																						
P	-	-	-	-	-	-	-	-	-	204.15	843.82	8.53	-	-	-	-	20.25	-	-	-	-	1076.75
S	-	-	-	-	-	-	-	-	-	160.15	604.27	4.00	-	-	-	-	14.00	-	-	-	-	782.42
OS	-	-	-	-	-	-	-	-	-	44.00	239.55	4.53	-	-	-	-	$ 6.25	-	-	-	-	294.33
G.Total																						
P	936.93	482.15	316.47	1450.02	6713.55	1206.43	2208.66	375.06	19.05	204.15	5039.65	441.25	3.00	508.20	2368.64	548.35	20.25	1141.33	840.24	328.64	0.95	25152.97
S	736.85	424.85	227.80	1414.59	5700.50	863.14	1836.70	441.75	0.50	214.35	3691.27	298.15	3.00	356.40	1748.39	786.71	14.00	816.10	605.90	171.33	-	20352.28
OS	200.08	57.30	88.67	35.43	1013.05	343.29	371.96	*	18.55	*	1348.38	143.10	0.00	151.80	620.25	*	6.25	325.23	234.34	157.31	0.95	4800.69

*Seed also supplied from produce of Coordinated unit and generations.

Table 35. Varietal preference, indent, production and supply during 2006-07

Variety	Indent	Production	Supply
Kufri Bahar	4960	6713.55	*5700.5
Kufri Jyoti	4230	5039.65	3691.27
Kufri Pukhraj	1370	2368.64	1748.39
Kufri Chandramukhi	1260	1206.43	863.14
Kufri Chipsona-1	1095	2208.66	*1836.70
Kufri Ashoka	875	482.15	*424.85
Kufri Badshah	840	1450.02	*1414.59
Kufri Lauvkar	625	508.2	356.40
Kufri Sindhuri	580	1141.33	816.10
Kufri Anand	450	936.93	*736.85
Kufri Chiposna-3	380	19.05	*0.50
Kufri Chipsona-2	370	375.06	*441.75
Kufri Sutlej	350	840.24	605.90
Kufri Pushkar	200	548.35	*786.71
Kufri Jawahar	185	-	-
Kufri Giriraj	50	204.15	*214.35
Kufri Kanchan	25	441.25	298.15
Kufri Kuber	20	-	-
Kufri Surya	5	328.64	171.33
Kufri Himsaona	-	0.95	-
Kufri Shailja	-	20.25	14.00
Kufri Arun	-	316.47	*227.8
Kufri Lalima	-	3.00	3.00

***Seed also supplied from produce of Coordinated unit and generations.**

Production of breeder seed under NSP: A total production of 1,422.55 q of three varieties was achieved from 6.15 ha area under NSP.

Production of nucleus and breeder seed under MM-I: A total production of 94 q of three varieties was achieved from 0.70 ha under Mini Mission-I.

II. Hi-Tech Seed Production Technology

i) Hi-tech seed production

a) Production and supply of microtubers, microplants and buffer stocks: A total of 23,212 microtubers of 15 potato cultivars *viz.*, Kufri Anand, Kufri Arun, Kufri Ashoka, Kufri Badshah, Kufri Bahar, Kufri Chandramukhi, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Giriraj, Kufri Kanchan, Kufri Lauvkar, Kufri Jyoti, Kufri Shailja, Kufri Sindhuri and Kufri Sutlej were produced in *in vitro* at Shimla and supplied to Modipuram (1,057), Jalandhar (2,927), Gwalior (13,715), Patna (3,818) and Ooty (1,695) for multiplication in net house to produce minitubers. In addition, a total of 17,375 microplants of 19 potato cultivars viz. Kufri Anand, Kufri Badshah, Kufri Bahar, Kufri Chandramukhi, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3, Kufri Giriraj, Kufri Girdhari, Kufri Jyoti, Kufri Kanchan, Kufri Lauvkar, Kufri Pukhraj, Kufri Himalini, Kufri Himsona, Kufri Shailja, Kufri Sindhuri, Kufri Sutlej and Kufri Surya were produced at Shimla. These plantlets were planted at Modipuram (2,645), Jalandhar (3,620), Kufri (10,270), Patna (240), Gwalior (480) and Ooty (120) for minituber production. A total of 7,248 buffer stock tubers of above-mentioned varieties were produced at Shimla and supplied to Modipuram (355), Jalandhar (309), Patna (1,947), Gwalior (814) and Ooty (3,823) for multiplication.

At Modipuram a total of 40,968 microplant hills and 4,303 microtubers of ten varieties viz. Kufri Bahar, Kufri Surya, Kufri Anand, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3, Kufri Sutlej, Kufri Sadabahar, Kufri Himsona, Kufri Girdhari were produced and utilized for production of minitubers in nethouses.

b) Performance of microtubers and microplants: A total of 36,778 microplants and 17,673 microtubers of different varieties were planted at different stations in poly/net house conditions. The stocks were tested randomly (1%) by ELISA. The total number of minitubers produced from microplants and microtubers were

1,94,790 and 73,767 having an establishment of 77.46 and 67.18% and multiplication rate of 6.84 and 6.21 per hill respectively.

Multiplication of <3g tubers: A total of 75,239 <3 g mini tubers were recycled under protected conditions at different stations (Modipuram, Jalandhar, Gwalior, & Patna). The emerging plants were check-tested by ELISA to maintain the disease freedom. A production of 3,42,590 tubers was achieved with a rate of multiplication 4.94 times. It will cover about 4.25 ha area @ 1.1 lacs tubers/ha.

ii) Maintenance and multiplication of virus free buffer stocks: Disease free buffer stock tubers of 22 varieties viz., Kufri Anand, Kufri Arun, Kufri Ashoka, Kufri Badshah, Kufri Bahar, Kufri Chandramukhi, Kufri Chipsona 1, Kufri Chipsona 2, Kufri Chipsona-3, Kufri Giriraj, Kufri Himalini, Kufri Himsona, Kufri Jyoti, Kufri Jawahar, Kufri Kanchan, Kufri Lalima, Kufri Lauvkar, Kufri Pukhraj, Kufri Shailja, Kufri Sindhuri, Kufri Surya and Kufri Sutlej were planted under controlled conditions in the polyhouse in pots. During their growth, samples were collected on single plant basis and tested for viruses PVX, PVS, PVY, PVM and PVA by ELISA. In all, 1,560 samples were tested and were found free from all the viruses except in Kufri Sutlej where only 4 samples were found infected with PVX. A total of 11,535 disease free buffer stock mini tubers were produced and stored in walk-in chamber for supplying to the stations.

iii) Supply of microplants to private seed producing organizations: 396 disease free microplants (132 test tubes) of eleven varieties were supplied to 17 private seed producing organizations and a revenue of Rs.1,48,500/- was generated.

Generation.1: A total area of 3.5 ha was planted and 714.30 q (more than 12,35,513 tubers) was produced at different stations in the plains and hills with an average production of 204.08 q/ha under different varieties. This will cover about 27.0 ha in next generation (G2) with an approximate seed rate of 26.0 q/ha.

Generation 2: It was a third year of targeted achievement of 100% breeder seed production through micro-propagated material. In this generation, only 12.51 ha was planted under different varieties and a production of 2547.81 q was achieved. This seed will be sufficient for about 73 ha if multiplied once more by the Institute in next generation. Out of 130.73 ha a total of 32.5 ha was under pre nucleus & nucleus stages and 95.48 ha under breeder seed production which included 16.0 ha under Generation 1 & 2. It comes to 12.3%. in the year 2007-08. In fourth year of introduction of breeder seed production through micropropagated matrial it will increase to 71 % in 2008-09 if Gen-2 seed is used for further multiplication in Gen-3.

Seed Research

Experiments were conducted to investigate the effect of (i) enclosure type, spacing and fertilization on minituber production from microplants, (ii) cut vs. whole, scooped eye vs. whole, and normal vs. dormancy broken tubers on yield of seed-sized tubers, (iii) phorate and carbofuran for management of cyst nematode. The major findings are listed below.

1. Minituber production from microplants planted inside poly net house was higher (6-8 times multiplication) than planting inside polyhouse (4.5-5.5 times multiplication).
2. Planting of microplants at a spacing of 10 x 10 cm gave maximum yield (5.06 t/ha) under nethouse condition at Ooty. Higher dose of NPK (135:203:135) resulted in higher minituber production (5.62 t/ha) than recommended dose (90:135:90). In Kufri also, denser spacing (60 x 10 cm) of minitubers gave higher yield, but nitrogen dose gave positive response up to 120 Kg/ha.
3. For production of seed tubers of Kufri Jyoti, use of scooped eye gave higher yield (30.31 t/ha) than whole tuber (27.40 t/ha). Similarly, use of naturally sprouted tubers gave higher yield of seed-sized tubers (8.22 t/ha) compared to freshly harvested tubers (2.40 t/ha) used after breaking dormancy. Use of naturally cut/damaged tubers as seed in the subsequent season, gave higher yield (13.82 t/ha) compared to artificially cut and stored (11.14 t/ha), freshly cut before planting (11.36 t/ha), and whole tuber (11.36 t/ha).
4. Split application of the recommended dose (65 kg/ha) of Furadan, i.e. 25% as basal dose and soil drenching of the remaining dose at 15 days interval after 30 days of planting gave maximum protection from cyst nematode at Ooty. Phorate @ 3 kg a.i. /ha was more effective than Carbofuran for management of cyst nematiode.

DIVISION OF

SOCIAL SCIENCES

- Internal Rate of Return (IRR) to the research cost for developing the two processing varieties, Kufri Chipsona 1 and Kufri Chipsona 2 was estimated to be as high as 55.28%. Multiyear financial transaction was converted into their present value using Consumer Price Index (CPI). Present Net Worth (NPW) at 0, 5 and 10% rate of interest was Rs 210.92, Rs 96.85 and Rs 46.11 crore respectively. The benefit-cost ratio of K. Chipsona 1 was 1.91 against 1.61 for the average of all potato varieties grown on the farmers' fields in UP.
- An average yield of 230 q/ha was obtained in the demonstration plots at Kharapathar and Koti areas of the Shimla district of Himachal Pradesh compared to 140 q/ha in farmers' plots. The incidence of late blight and white grubs in farmers' plots were 8% and 11% as against 5% and 2%, respectively in demonstration plots.
- The institute held 3 Kisan Melas/Field Days where approx. 2,000 farmers participated. Besides, about 3,000 persons visited the ATICs for collecting information on potato.

Impact of Potato Technologies Developed by the Institiute

Economic Impact of Potato Production Technologies in India

Economic surplus (partial equilibrium) method was employed to assess the returns on research cost for processing varieties *viz.*, Kufri Chipsona -1 and Kufri Chipsona-2. Internal Rate of Return (*IRR*) to the research cost for developing the two processing varieties was as high as 55.28%. Multiyear financial transaction was converted into their present value using Consumer Price Index (CPI). Present Net Worth (NPW) at 0, 5 and 10% rate of interest was Rs 210.92, Rs 96.85 and Rs 46.11 crore respectively.

The economic returns for the two processing varieties compared to the average returns of potato farms in UP state showed higher net profit. Under size of tubers and their differential price was taken into consideration of K. Chipsona. The difference in cost of cultivation for Kufri Chipsona 1 was due to higher seed and fertilizer cost, additional irrigation, higher machine cost and less plant protection expenditure. Overall, the cost of cultivation for Kufri Chipsona 1 was although 10% higher than the average potato cultivation in the study area, gross and net income for Kufri Chipsona 1 was 22% and 30% higher than the average returns of other varieties. The benefit-cost ratio of Kufri Chipsona 1 was 1.91 against 1.61 for all potato varieties grown on the farmers' fields in UP.

Impact Assessment of Extension Strategies for Potato Technology Dissemination

Technological gap at farmers' field

Rainfed crop: The survey on the technological gap at the farmers' fields from Kharapathar and Koti in Shimla district revealed 55% gap in adoption of potato technologies w.r.t. late blight management, white grub management and healthy seed potato production. Maximum knowledge gap (70%) was found in case of integrated pest management. Unavailability of good quality seed was perceived as the biggest constraint for potato production.

Fifteen farm level demonstrations, 5 each on late blight management, white grub management, and healthy seed potato production, were conducted using the institute technology and compared with that of farmers' practice. The results revealed that the incidence of late blight and white grubs in farmers' plots were 8% and 11%, whereas that in demonstration plots were 5% and 2%, respectively. With the adoption of institute technologies, farmers were able to harvest on an average 230 q/ha yield as against 140 q/ha obtained from farmers' own practice.

At Shillong in eastern hills, results from77 on-farm demonstrations laid in the farmers' field in East Khasi Hills with potato variety Kufri Giriraj gave an average yield of 108.8 q/ha, against 23.7q/ha obtained from the local variety used by the farmers. An average 359% yield

increase was achieved over the farmers' practice in these demonstrations.

Irrigated crop: In eastern Indo-Gangetic plains 15 demonstrations were laid out at Phulwarisharif and Neoraganj villages of Bihta block in Patna on balanced fertilizer application and late blight management and compared with the farmers' practices. The results revealed yield advantage of 35% in case of balanced fertilizer application and 26.8% in case of late blight management.

Impact of Extension Training

A total of 22 participants from 11 states attended the 8-days Model Training Course on "Recent Advances in Potato Production Technology" from July 13-20, 2007 organized at CPRI, Shimla. A variety of training methods were used to provide rich learning experience to the trainees and also to improve the knowledge and skill of extension officers working in state departments of agriculture/horticulture. These included lecture-cum-discussions, practical sessions, field visits and video film shows. Pre-and post-training evaluation of the trainees showed the overall improvement by 15%. Maximum gain in knowledge was in Biotechnology (25 per cent), followed by Seed Technology (24 per cent) and General Information (21 per cent).

Transfer of Technology

Trainings

Model Training Course: The Division of Social Sciences organized 8-days Model Training Course on "Recent Advances in Potato Production Technology" from July 13-20, 2007 at Shimla sponsored by Directorate of Extension, Ministry of Agriculture, Govt. of India. A total of 22 participants from 11 states attended the training course. The training included 24 lecture-cum-discussions, practical sessions, skill demonstrations, field visits and video film shows.

Entrepreneurship Development in Biotechnology: A five-day training programme by Biotech Consortium India Limited, New Delhi on Entrepreneurship Development was organized at Shimla from June 11-15, 2007. The programme was aimed to train the prospective entrepreneurs on various technical and management topics relevant for biotechnology projects. Thirty two prospective entrepreneurs from the states of Himachal Pradesh, Punjab, Haryana and Uttrakhand attended the training. The Entrepreneurship Development Programme (EDP) was structured to initially provide training on management aspects such as finance, accounting, marketing, etc followed by biotech projects suitable for small and medium scale set up, containing both technical and economic details.

On-farm Training for farmers from eastern hills : On-farm training on the management of potato diseases with special emphasis on late blight and bacterial wilt was held during 22nd to 25th May 2007 in East Khasi Hills district of Meghalaya. Dr. BP Singh, Joint Director, CPRI, Modipuram and Dr. PH Singh, CPRI, Shimla were the resource persons for the training. On 22nd May, 162 farmers from Sadew and Banium villages participated at Sadew. Another 154 farmers from four villages, viz., Mawklot, Myrkhan, Nongpim and Laitmynsaw attended the training at Laitmynwaw on 23rd May. On 24thMay, a total of 157 farmers from Myllium village while on 25th, 163 farmers from Mawkhan and Mawnianglah villages attended the programme. The farmers were given training with the help of well designed lectures and practical demonstrations about the role of disease free seed, sanitation, resistant varieties, high ridging and earthing up, prophylactic and need based spray schedules and other management practices for late blight, brown rot and other important potato diseases.

Live Phone-in Programme on Doordarshan

The Shimla Doordarshan telecasts *live phone-in* programme of 'Krishi Darshan' on every Monday and Thursday. In this programme burning issues related to crop, animal husbandry, fishery, etc. are discussed by the studio-invited experts and the viewers (farmers) can ask questions from the experts by dialling the phone number announced just before the start of the programme. Drs. PS Naik, ID Garg, VK Chandla, PH Singh, VK Dua, Anil Kumar, Ashwani Kumar and Mukesh Jatav of CPRI, Shimla participated in the programme to discuss

various aspects of potato production. Field recording on seed treatment and storage of potato was undertaken at CPRS, Kufri and was telecast on Shimla Doordarshan. Drs. RP Rai, Shambhu Kumar, Manoj Kumar, SK Singh and Barsati Lal of CPRS, Patna participated in similar programme telecast by Patna Doordarshan.

Potato School on AIR

Two *Potato Schools* on All India Radio - one by CPRIC, Modipuram at AIR, New Delhi and the other by CPRI, Shimla at AIR, Shimla were organized during the year. The *Potato School* at AIR, New Delhi was broadcast from 26th October, 2007 to 18th January, 2008 which was of the nature of live phone-in and consisted of 13 episodes with each having 15-20 queries on different aspects of potato. The farmers of Western UP, Haryana and Rajasthan interacted with the studio-invited experts of CPRIC. The *Potato School* at AIR, Shimla is being coordinated by the Division of Social Sciences and consists of 20 episodes of pre-recorded talks on various aspects of potato by the scientists of CPRI, Shimla. Out of 20 episodes, 3 are scheduled to be broadcast in the month of March, 2008 and the remaining during April-July, 2008.

Kisan Melas/ Field Days

Kisan Mela at CPRS, Kufri: Kisan Mela was organized at CPRS, Kufri on 27th May, 2007 which was attended by over 400 farmers from different districts of Himachal Pradesh. The Mela was inaugurated by Dr. HP Singh, DDG (Hort.), ICAR, New Delhi who emphasized on commercialization of agriculture under the changed scenario. A total of 16 stalls exhibiting technologies generated by different agricultural organizations draw large number of farmers. The farmers also put up their exhibition stalls to display their products. Attractive prizes were given for the best display by the stalls of institutions and farmers. Scientists-farmers interaction meet were also held to suggest solutions to the farmers' problems.

Field Day at Kharapathar, Shimla: A Field Day was organized at Kharapathar, a major potato belt in the Shimla district, on 12th June, 2007 to provide on-farm training to the farmers on scientific potato cultivation. The area has been showing declining trend in potato acreage due to competition from more remunerative crops like cabbage and peas. About 150 farmers from this area participated in the programme and they were imparted training on preparation of vermicompost and home-made fungicides.

Kisan Mela at CPRIC, Modipuram: The Campus organized 2-days Kisan Mela on 8-9 February, 2008 at Modipuram in which about 1,500 farmers from adjoining areas of UP, Haryana and Rajasthan participated. The Mela was inaugurated by Dr. HP Singh, DDG(Hort.), ICAR, New Delhi. He advised the farmers for diversification of agriculture to ensure higher income. On this occasion, the closing ceremony of Potato School on AIR, New Delhi during the year was also held. A total of 60 stalls were put up to exhibit technologies generated by different agricultural organizations. Kisan gosthi was also held at the end to suggest solutions to the farmers' problems.

Potato Exhibits

Exhibition in Horticulture Summit- 2007: A potato stall was put up during **Horticulture Summit-2007** held at CISH, Lucknow during 16-19th June 2007. This summit, jointly organized by CISH, Lucknow and the Confederation of Indian Horticulture, was attended by Drs. BP Singh, SV Singh, PC Pande and Anil Kumar of the Institute and put up potato exhibition stall. The 4-day summit consisted of presentation of production technologies by the Directors of horticultural institutes of ICAR followed by discussion by the participating farmers. More than 3,000 farmers from different parts of the country attended the summit. About 100 exhibition stalls were put up on this occasion and there was a special exhibition of 'Mango Show' in which more than 200 varieties of mango were displayed.

Exhibition in Kisan Mela at Solan: An exhibition stall of potato technologies was put up at the Kisan Mela organized by National Research Centre for Mushroom, Chambaghat, Solan on September 10, 2007. The stall was visited by more than 200 farmers from different parts of

state and they were briefed about the potato technologies. This endeavour proved worthy in getting first hand information from the farmers and transferring the potato technologies to them. Besides, a number of priced publications of the Institute were sold to the farmers and scientists visiting the stall.

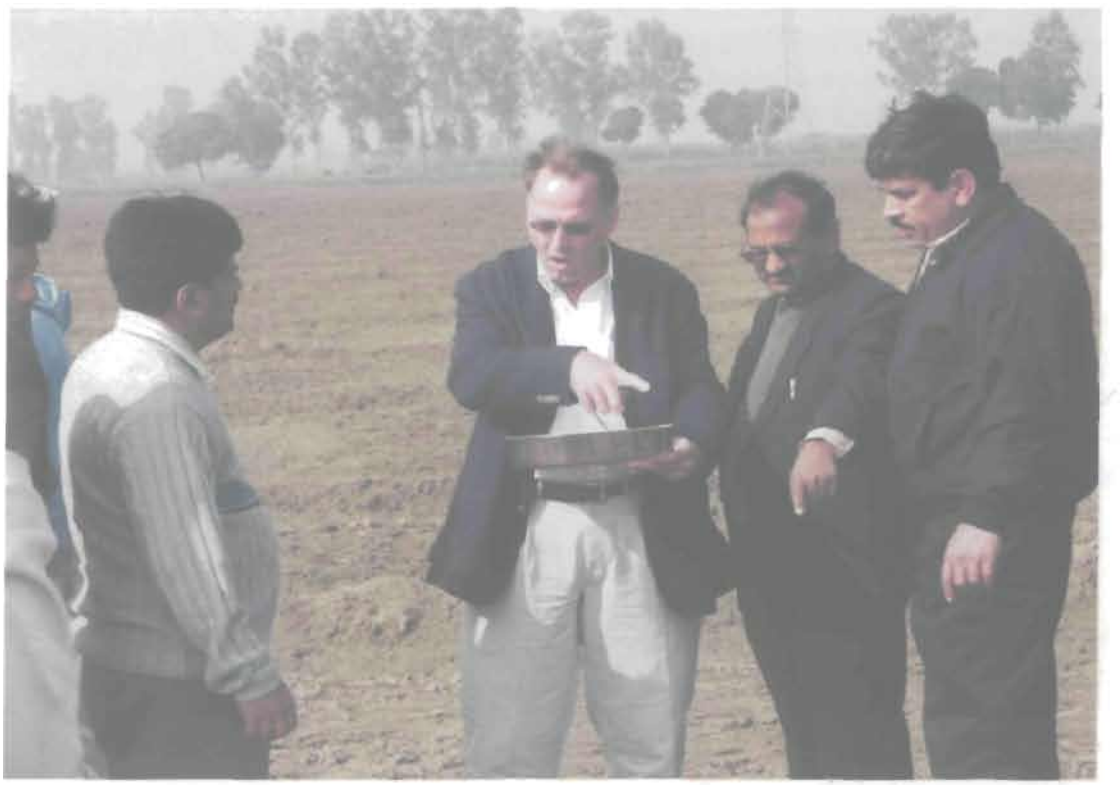
Exhibition in Farmers' Fair in North-east: The CPRS, Shillong put up exhibition stalls on potato technologies at the farmers' fair entitled *"AAHAR"* organized by Ministry of Food Processing Industry and Government of Meghalaya from 29th October to 1st November 2007 at Polo ground, Shillong and in *North-east Agriculture Fair 2008* organized by College of Veterinary Sciences & Animal Husbandry, Central Agricultural University, Selesih, Aizawl at Aizawl during 6th - 9th February, 2008.

Exhibition in Kisan Mela at Meerut: The CPRIC, Modipuram put up an exhibition stall on TPS and potato varieties and products at the Kisan Mela organized by SVBPUA&T, Modipuram during October 8-11, 2007. The exhibition stall of CPRI was attended by over 600 farmers from different parts of UP who were given package of practices for potato cultivation.

Activities of ATIC

A total of 308 farmers visited the Institute at Shimla, 770 farmers at CPRIC, Modipuram and 615 farmers at CPRS, Patna during the year to get first-hand information about potato technologies. In addition, 44 scientists/teaching staff, 792 UG and PG students and 308 farmers were attended by the ATIC staff at Shimla. They were shown potato film and museum besides briefing from the extension scientist about the programmes and activities of the institute.

The ATIC staff maintains the record of Institute's technical bulletins and extension bulletins. During the year, an income of Rs. 36, 530/- was generated from sale of publication to the visitors. Besides, a number of extension bulletins were also supplied free of cost to the visiting farmers, students and extension officers.



Externally Funded Projects

1. National Test Guidelines for DUS Testing of Potato Varieties in India (*funded by Govt. of India)*

The work on DUS testing at the CPRI was initiated from 2002-03. All released varieties of the CPRI were planted at Kufri and Modipuram statations every year and observations were recorded on morphological and tuber characters as per standard descriptors for characterization. During 2007-08, two trials were planted under each of two agro-climatic conditions i.e. plains (Modipuram & Macchari) and hills (Kufri & Shimla) with 42/39 Indian potato varieties in a RBD with 3 replications in a plot size of 14.40 m^2. The harvesting was done at 90-100 days after planting. Observations were recorded on quantitative as well as categorical characters. Photographs of sprouts, tubers and leaves in different varieties were taken. Also, observations were recorded on tuber dormancy, sprouting, rottage etc. after storage at ambient temperatures. During the year three new varieties viz. Kufri Sadabahar, Kufri Himsona and Kufri Girdhari, released recently were added to the collection and observations were completed as per morphological descriptors for characterization of these varieties. Collection of reference varieties was augmented by adding all farmers and exotic varieties presently grown in India. All CPRI varieties and other reference varieties were maintained *in vitro* as well as under cold condition.

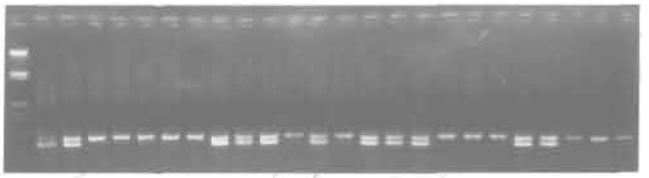
2. Project: Engineering late blight resistance in susceptible but commercial potato cultivars of India (*Collaborative project with ABSP II*).

Development of LB resistant potato variety by crossing: The F_1C_1 clones obtained from the cross Kufri Bahar X RB-transgenics SP904/SP951 were screened under controlled environment chamber. One hundred twenty six hybrids showing different levels of resistance were planted in a nethouse at CPRIC, Modipuram for making further selection on the basis of tuber characteristics and yield. Twenty seven lines

Kufri Sadabahar

Kufri Himsona

Kufri Girdhari



PCR confirmation of RB gene in F_1 hybrids obtained from the cross Kufri Jyoti X SP951. The left most lane shows molecular marker; second lane from left is the parent SP951; right most lane is the parent Kufri Jyoti; and the lane before that is non-transgenic Katahdin. Other 21 lanes are from F_1 hybrids. The upper band represents the internal control RP2 and the lower band is from RB gene amplified by MAMA primer set. 10 out of 21 hybrids in this photo are positive for the RB gene.

have been selected for further evaluation at Shimla. Genomic DNA from 214 F_1 seedlings of the cross Kufri Jyoti X SP951 was checked for RB gene presence using MAMA primers. One hundred six clones were positive for the RB gene. Tubers from these seedlings have been harvested for checking these for late blight reaction.

Development of LB resistant potato variety by transformation: One hundred ninteen putative RB-transgenic lines of Kufri Bahar and Kufri Jyoti were checked for RB gene integration using three pairs of primers. Most of the lines were negative for the full length RB gene. Positive PCR amplification using the internal MAMA primers was observed in case of 19 putative transgenic lines of Kufri Bahar and 6 of Kufri Jyoti. Tubers harvested from the selected 25 lines were planted in a transgenic green house. The plants after 45 days of growth were inoculated with *P. infestans*. Six lines of Kufri Bahar (KBRB-129, KBRB-145, KBRB-163, KBRB-169, KBRB-172, KBRB-180) and 2 lines of Kufri Jyoti (KJRB-2, and KJ-RB-34) were found promising for late blight resistance.

3. Molecular tagging of extreme resistance to potato Y potyvirus (PVY) and horizontal resistance to late blight in potato (*ICAR Network Project*).

A SCAR marker tightly linked with the *Ryadg* gene was validated and putative duplex clones were identified from segregation analysis of their progeny. Five putative triplex clones identified on the basis of band intensity were crossed with nulliplex commercial cultivars/ advanced hybrids. The genomic DNA from 227 seedlings from 10 crosse were checked by PCR amplification for a control amplicon from the rDNA gene. Samples producing the expected rDNA band were further analyzed for the presence of the SCAR marker. Out of five putative multiplex clones evaluated, one clone i.e. YY-6/3 C11 appears to be a putative triplex clones as the segregation ratio in its progeny was 30:1 that is quite close to the expected segregation ratio of 27:1 in the progeny of a nulliplex x triplex cross following random chromatid assortment.

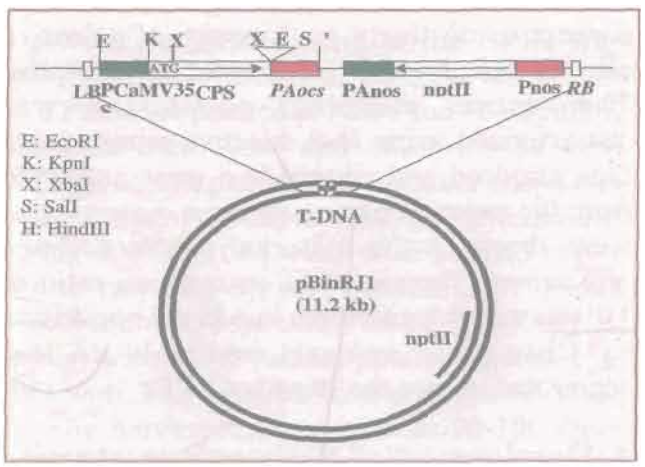
A mapping population consisting of 126 progenies from the cross *Solanum spegazinni* X *Solanum chacoense* was genotyped using 37 AFLP selective primer combinations. A total of 2,542 loci were amplified from the two parents using thirty seven pairs of selective primers out of which 1,880 were polymorphic. The entire mapping population was characterized using four selective primer pairs. One hundred and sixteen loci were amplified from the paternal parent *Solanum chacoense* that were absent in the maternal parent *Solanum spegazzinni*. The expected segregation ratio of 1:1 was tested for all these loci in the population by Chi-square analysis and only 23 loci segregated as per the expected ratio.

4. Development of transgenic potato with resistance to major viruses (*ICAR Network Project*).

The CP gene cloned from the Indian PVY^{O} strain and the replicase gene from the ToLCNDV are being used for conferring resistance to the respective viruses. Binary vectors carrying the CP gene of PVY in sense, antisense and non-translatable orientations were designed. Cloning of the CP gene in desired frame was checked by sequencing using a CaMV 35S promoter based primer. DNA sequences at the cloning site of the binary vector pBinAR showed perfect orientation of the cloned gene. The binary vector carrying the CP gene in sense, antisense and non-translatable forms were named as pBinRJ-1, pBinRJ-2, and pBinRJ-3 respectively. The vectors were mobilized into

the *Agrobacterium tumefaciens* strain EHA105 and *Agrobacterium* cultures positive for the desired gene fragment was used to transform potato cultivar Kufri Bahar. In all 40, 23, and 6 shoots have been regenerated for sense, non-translatable, and antisense constructs of the CP gene.

Similarly, transformation vector based on the binary vector pBinAR containing the antisense, sense, and hairpin loop constructs of the replicase gene of ToLCNDV have been designed and checked by sequencing. The binary vectors with sense and antisense constructs have been mobilized into the *Agrobacterium* strain EHA 105. The potato variety Kufri Badshah has been transformed with the antisense construct of the replicase gene and 60 putative transgenic shoots have been regenerated.



Map of pBinRJ1 harboring the PVY CP gene in sense orientation. The ATG codon was inserted in frame. E: EcoR1, K: Kpn1, X: Xba1, S: Sal1, H: HindIII. The vector is based on the binary vector pBinAR.

5. Engineering viral gene derived resistance in Indian potato cultivars against viruses (*AP Cess fund*).

Maintenance of transgenic lines: Fourteen transgenic lines were maintained by periodic sub-culturing on MS medium.

Presence of the PLRV coat protein gene in the transformed Kufri Pukhraj lines was confirmed through PCR amplification of the gene followed by southern hybridization.

Four transgenic lines (Kp-1, Kp-2, Kp-7and Kp-8) were micro-propagated 7 times successively over a period of eight months and then examined for presence of transgene in three randomly selected plants of each line. PCR showed specific amplification of CP gene in all these selected plants indicating stability of transgene.

6. Biotechnological approaches for reduction of cold-induced sweetening in potato (*DBT funded*).

Several transgenic lines of Kufri Chisona-1 and Kufri Jyoti were developed employing two different strategies of over-expression of tobacco invertase inhibitor gene and RNAi-mediated post-transcriptional silencing of vacuolar invertase gene for reduction of cold-induced sweetening in potato. In addition, a vector cassette was developed habouring tobacco invertase inhibitor gene under tuber specific promoter and invertase inverted repeat RNAi gene construct under constitutive promoter.

7. Artificial microRNA and small interfering RNA-mediated silencing of UDP-glucose pyrophosphorylase and vacuolar acid invertase gene for reduction of cold-induced sweetening in potato(*DBT funded project*).

Artificial miRNA (amiRNA)-mediated silencing of potato UDP-glucose pyrophosphorylase (*UGPase*) and vacuolar acid invertase (*INV*) gene has been planned for development of cold-chipping transgenic potato lines. Stem-loop sequence of *Arabidopsis* pre-miRNA164a and miRNA164b has been used to incorporate amiRNAs against *UGPase* and *INV* genes.

8. Purification and characterization of an essential ribonucleoprotein complex-ribonuclease P from potato (*DBT funded*).

The long term goal of RNase P work is to exploit the enzyme in gene silencing by introduction of tRNA like External Guide Sequence (EGS) against targeted mRNA. Two model EGSs, one wild and one mutant type, based on the

Synechocystis sp. precursor tRNA glutamine ($ptRNA^{Gln}$) were designed for *in vitro* characterization of bipartite substrate cleavage by partially purified potato RNase P. In addition, four wild-type and four mutant EGSs were also designed against potato vacuolar invertase mRNA. A pUC19 based *in vitro* transcription vector (pUC19IVT) was developed for precise run-off transcription of EGSs, ptRNA and vacuolar invertase mRNA. All the EGSs and $ptRNA^{Gln}$ were synthesized by primer extension and cloned into pUC19IVT vector. Partial potato vacuolar invertase cDNA corresponding to first 300 nucleotide of the invertase mRNA was amplified by RT-PCR and cloned into pUC19IVT vector. Sequences of all the constructs were confirmed by sequencing. Bipartite substrate RNA for Gln EGSs was custom synthesized. EGS, $ptRNA^{Gln}$ and partial invertase RNAs were obtained by run-off transcription. *In vitro* labeled $ptRNA^{Gln}$ was perfectly cleaved by reconstituted *Escherichia coli* RNase P.

9. Development of dwarf potato cultivars suitable for cultivation in hills and Peninsular India through recombinant DNA technology (*DBT funded project*).

Potato plants when grown under long days or high temperatures conditions accumulate gibberellic acid and grow very tall leading to reduced partitioning of dry matter to the tubers. To reduce internal gibberellic acid content and consequently excessive vegetative growth, we have silenced *GA20-oxidase1* gene (involved in the synthesis of gibberellic acid) through post transcriptional gene silencing (PTGS) to obtain plants with reduced GA content. About 400 transgenic plants were created by using inverted repeat sequence of *GA20-oxidase1* (IRGA), *GA20-oxidase1* fragment in sense orientation and *GA20-oxidase1* fragment in antisense orientation. Based on the yield performance for three years as well as plant height, 10 IRGA lines, 5 sense lines and 5 antisense lines have been selected for field trials.

Fig. 50. Control and transgenic plant (dwarf)

10. Diagnostics of Emerging Plant Viruses (*ICAR Net work project*)

A protocol for detection of Potato Virus M was standardized with coat protein gene specific primers. The expected size (900 bp) of coat protein gene was obtained .

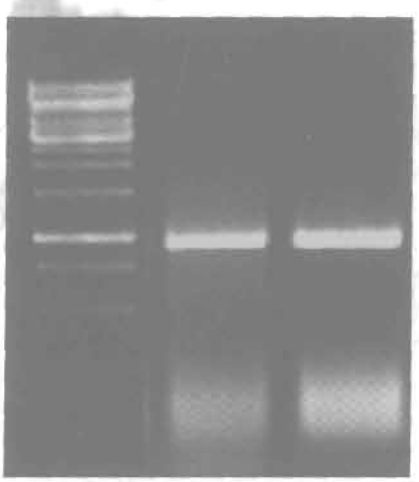
Protocol for the IC-RT-PCR detection of PVS and PVM was standardized. The procedure does not need costly RNA extraction kit.

Coat protein genes of PVS^{A}, PVX_{HB}, PVX_{MS} were amplified using degenerate coat protein gene specific primers of PVS and PVX. These primers were the same which were used for the detection of PVX^{O} and PVS^{O}. The expected PCR products of 892bp for PVS^{A} and 714 bp for PVX strains were obtained.

Cloning of PVM, PVS^{A}, PVX_{HB}, PVX_{MS}: The amplified products of viruses were A-T cloned into pDrive vector and authenticity of the cloned genes was confirmed by polymerase chain reaction.

11. Evaluation, characterization and formulation development of botanicals for the management of fungal diseases and sprouting in potato (*funded by ICAR*)

Seventy two plant species were tested against late blight pathogen *P. infestans*, out of which 11 plant species were found highly effective when tested by detached leaf method. One plant species gave moderate effect when tested under



Amplification of CP gene of PVM using RT-PCR; Lane1: 1 Kb marker; Lane 2,3: Amplified CP gene product of PVM (900bp;arrow)

field condition and was comparable to mancozeb. Ethyl acetate fraction of the same species was able to protect against late blight when tested by slice method.

12. Mega Seed Project (*National Seed Project*)

The project supplements the efforts of seed agencies to enhance seed replacement rate in the country and fast spread of high yielding new varieties/hybrids. Rapid multiplication and sapling production including tissue culture plantlets were planted during the year 2007-08 on an area of 17.45 ha. From this 3134.15 q of breeder seed was produced, of which 1474.45q seed was supplied to different states/agencies. A total of 570.21q of quality seed was produced from an area of 8.72ha, out of which 345.40q was supplied. A total revenue of Rs.48,68,009.00 was generated.

13. Production and supply of tissue culturally developed disease free nucleus seed potato (*MM-I of Technology Mission*)

Meristem tip culture in combination with indexing and micro-propagation helps in developing virus free mericlones. Their multiplication *in vitro* and under protected conditions, reduces the number of field exposures from four to two crop years and allows mass multiplication of virus free nucleus seed round the year under controlled conditions.

During the year 10,433 microplants, 20,851 microtubers, and 1,44,620 minitubers were produced. Training for seven days was conducted in which three trainees participated.

14. Virus vectors and pathogen pressure study in potato production regions of five states of North-East India (*CIP-CPRI*)

Sites have been identified and marked through GIS in the states of Arunachal Pradesh, Mizoram, Meghalaya, Nagaland and Sikkim to monitor vector population both in the crop and also from the installed water and sticky trap as well as leaf samples for identification of viruses prevalent in the locality. Degeneration trials have been laid out in Meghalaya, Nagaland, Arunachal Pradesh and Sikkim with Kufri Jyoti, Kufri Giriraj and one TPS family (TPS-C-3).

Central Potato Research Station, Shillong promoted the "Mylliem Potato Farmers' Club"

Mr. P. Kharkongor, Commissioner Agriculture, Government of Meghalaya addressing the delegates at CIP-CPRI Methodology Workshop at CPRS, Shillong

in East Khasi Hills district of Meghalaya in collaboration with the Mylliem branch of Meghalaya Rural Bank with financial assistance from National Bank for Agriculture and Rural Development (NABARD), Meghalaya Regional Office. The Farmers' Club is a grassroot level informal forum and is organised by Meghalaya Rural Bank with the support and financial assistance from NABARD for the mutual benefit of the banks and rural people. The broad functions of the Farmers' Club include coordination with banks to ensure credit flow among its members and forge better bank borrower relationship, arranging interface with subject matter specialists in the fields of agriculture and allied activities, fostering liaison with corporate input suppliers to purchase bulk inputs on behalf of members, organising joint activities like value addition, processing, collective farm produce marketing for the benefit of members, sponsoring Self Help Groups (SHGs), undertaking socio-economic and community developmental activities and marketing rural produce and products.

15. Popularising low cost storage technology for table potato and potato seed (*NABARD RIF*)

Four villages and five farmers in each village have been identified for construction of household level storage structures and Madan Ïng Syiem village in Mylliem block of East Khasi Hills district for construction of community level storage structure. Extension folder on storage entitled "KA RUKOM BUH/ SUMAR PHAN SYMBAI BAD PHAN BAM" in Khasi language has been printed.

16. Integrated Development of Horticulture in NEH Region (*Mini-Mission–I of Technology Mission*)

A total of 11,850 microplants were produced (Kufri Jyoti-200 and Kufri Giriraj-6,000, K. Kanchan-4,000, K Megha-150, and others varieties 1,200) in an attempt to produce nucleus/basic seed and planting material. Micro-plant production of newly released potato varieties K. Himalini (100), K. Himsona (50) and K. Girdhari (50) was also started. A total of 141.0 q of quality seed from various field generations were obtained and out of total quantity, 55 q seed was given for demonstrations to farmers and farmers clubs in Tripura and Meghalaya. Studies on the effect of inorganic and organic sources of nutrients on the yield of Kufri Giriraj revealed that germination percentage, plant height, number of branches and tuber yields were maximum in treatment where the nutrients were supplied through inorganic sources, but crop growth and yields were also comparable when nutrients were supplied through one third each of FYM, vermicompost and inorganic fertilisers. The effect of different dates of planting (Aug 2nd week to September 2nd week) during the autumn season in 2007 revealed that planting by August 2nd week was better as it resulted in better germination, taller plants and more number of branches/hill. But the crop was affected by late blight and no yields were recorded. A total of 30 on-farm demonstrations were carried out in the farmers' field in East Khasi Hills district with K. Giriraj and 6 On-farm Farmers' Training on Disease Management of Potato was also organized. A total of 208 farmers participated in these trainings conducted at six locations. An average yield increase of 280% was recorded over the farmers' practice in these demonstrations. One on-station farmers' training on "Improved Potato Production, Protection and Storage Technologies" was also organized.

A woman farmer receiving the training certificate during Farmers' Training under MM-I

All India Co-ordinated Research Project on Potato (AICRP)

During 2005-06 and 2006-07 following activities were undertaken in AICRP (Potato).

Crop Improvement

Evaluation of potato germplasm was carried out at Dharwad and 16 germplasm accessions performing well under rainfed *kharif* conditions have been identified. Similarly, 98 potato germplasm accessions were screened against apical leaf curl virus at Hisar. Kufri Bahar was observed to be immune to this virus and eight germplasm accessions showing fairly low disease incidence were identified.

In hills, three hybrids in on-farm trials and four hybrids in replicated trials were evaluated. In on-farm trials, hybrid SM/93-237 has consistently performed better as far as late blight resistance and yield was concerned.

In early maturity group, two hybrids were evaluated in on-farm trials and hybrid J/93-86 consistently performed better over controls in different agro-climatic regions.

No hybrid performed better than controls under medium maturing group as well as in red tuber group.

Potato processing sector in the country is emerging fast and four processing hybrids were evaluated for total yield, processable yield, dry matter and other processing attributes. None of these hybrids were superior to existing processing varieties.

In order to extend potato cultivation in new areas, varietal trials were conducted in four tribal belts of Rajashtan with four potato varieties. These tribal belts were Udaipur, Chittorgarh, Banswara and Dungarpur. Varieties Kufri Pukhraj and Kufri Pushkar were observed to be promising in these areas.

Following two hybrids viz., J/93-86 and SM/93-237 were recommended for release as varieties in 26th Group Meeting of AICRP (Potato) held at RAU, Pusa during September 7-9, 2007.

Hybrid Details and salient features

J/93-86	Hybrid bred at CPRS, Jalandhar was evaluated at 16 AICRP centers located in the plains at Bhubaneshwar, Chhindwara, Deesa, Dharwad, Dholi, Faizabad, Hassan, Hisar, Jalandhar, Jorhat, Kalyani, Kota, Modipuram, Pantnagar, Patna and Raipur for 5 years before recommending for release.J/93-86 is an early maturing white tuber hybrid with moderate resistance to late blight. This hybrid yields higher than existing early cultivars both at 60 and 75 days after planting. This hybrid is recommended for entire Indian plains.
SM/93-237	Hybrid bred at CPRI, Shimla was introduced under AICRP in 2002. This hybrid was evaluated at 5 AICRP centers located in the hills at Kufri, Ooty, Ranichauri, Shillong and Srinagar for 4 years before recommending for release. SM/93-237 is a medium maturing white tuber hybrid with high level of resistance to late blight. It yields higher than existing cultivars for hills. This hybrid is recommended for all Indian hills.

Crop Production

The predominant potato based crop rotations in Karnataka were potato-cabbage; potato-French bean; potato-maize; potato-carrot; potato-ragi; potato-red gram; potato-wheat; potato-sorghum and potato-caster and important mixed crops were potato + red gram and potato + caster.

Under evaluation of potato based cropping systems, various cropping systems were evaluated at Bhubaneshwar and Dharwad. Potato–okra-paddy at Bhubaneshwar and potato-beans at Dharwad is the most profitable potato based cropping system in terms of yields and net returns.

At Srinagr, potato + French bean in the ratio of 2:1 gave highest net return followed by potato+ methi in 2:1 ratio.

In an attempt to develop agro-techniques for increasing productivity of rice-potato-wheat system, dehaulming of potato at 70 and 80 days followed by application of varying doses of NPK to subsequent wheat crop was tried at Faizabad. It was observed that application of 100% of recommended doses of NPK through inorganic fertilizers along with 20 t/ha FYM to potato and only 75% recommended dose of nutrients to wheat was found to give optimum yields. Subsequent rice crop needed 100% recommended dose of nutrients in the sequence.

For the sustainability of cropping systems it is important that the application of nutrients from all sources should be judiciously pooled. It is also essential and always useful to recycle the farm nutrients instead of exporting them. Therefore, an experiment on integrated nutrient management in potato based cropping system was conducted at 15 locations using two levels of fertilizers i.e. 75% and 100% recommended dose of NPK with three levels of organic amendments. At Hisar, in potato-bottlegourd crop sequence, application of FYM @ 20 t/ha along with incorporation of crop residues and use of biofertilizers to potato was beneficial while subsequent bottlegourd crop required only 75% recommended dose of nutrients. At Modipuram in western Uttar Pradesh in potato-greengram sequence, application of 100% recommended doses of N + FYM @ 20 t/ha gave higher yield of potato, while subsequent green gram in the sequence required only 75% recommended doses of nutrients after this treatment.

In the rain-fed conditions, optimum planting time for any crop is important to have higher productivity. With this view, a trial on potato planting at different dates was conducted at Dharwad during *kharif* season. The highest tuber yield and net return in potato was recorded when it was planted on 30th June followed by planting on 20th June.

An experiment on role of phosphobacteria on P economy was conducted at 13 locations using six treatments. At Chhindwara, Hassan, Hisar, Kalyani, Ooty and Patna, the dose of P could be reduced to 75% with the use of phosphobacteria while at Bhubaneshwar, Jorhat, Dholi, Kota, Modipuram and Pantnagar, recommended dose of P was required to get optimum yield and economic returns.

In an experiment on soil test based "P" application conducted at 13 locations, higher potato yields and net returns were obtained with soil test based "P" application at Chhindwara, Deesa, Dholi, Hisar, Kalyani, Kota and Pantnagar. There was need to apply 125% of recommended P in the soils having < 10ppm P, 50% of recommended dose of P in the soils having 10-20 ppm P and 25% of recommended dose of P in the soils with > 20ppm P.

An experiment was conducted at 10 locations for identification of nitrogen efficient potato cultivars for different zones. At most of the centres in the plains, variety Kufri Pukhraj was the most nitrogen efficient cultivar than other varieties tested, as it gave higher yields at lower as well as higher levels of nitrogen while in the hills at Ooty, Kufri Swarna was the most nitrogen efficient potato cultivar that gave higher tuber yield at all the levels of N followed by Kufri Giriraj and Kufri Jyoti.

Experiment on water management in potato was conducted at 8 locations in the plains and one location in the hills at Ooty. At Dholi, Faizabad, Kalyani, Kota and Modipuram maximum tuber yield and highest net returns

of potato were recorded with the treatment having mulching and one extra irrigation at stolon formation, tuber initiation and tuber development stages.

Following recommendations were brought out in 26th Group Meeting of AICRP (Potato)

1. In Orissa at Bhubaneshwar, rice-potato-okra is the most profitable crop sequence followed by rice-potato-jute while in Dharwad areas of Karnataka, potato-beans is the most profitable crop sequence followed by potato-sorghum.
2. In Gujarat (Deesa area) only 75% recommended doses of nutrients through inorganic sources are needed for bajra in potato-bajra crop sequence, when residue incorporation of all the crops + biofertilizers along with 100% recommended doses of NPK in the form of inorganic fertilizers is applied to potato.
3. At Faizabad in Uttar Pradesh in rice-potato-wheat crop sequence, application of 100% recommended doses of NPK through inorganic fertilizers along with 20 t FYM/ha to potato and only 75% recommended dose of nutrients to wheat grown after potato is required, while subsequent rice crop needed 100% recommended dose of nutrients in the sequence.
4. In Haryana at Hisar in potato-bottle gourd crop sequence, application of 20 t FYM/ha along with incorporation of crop residues and use of biofertilizers to potato is needed while subsequent bottle gourd require only 75% recommended dose of nutrients.
5. At Modipuram in western Uttar Pradesh in potato-green gram sequence, application of 100% recommended dose of N + 20 t FYM/ha gave higher yield of potato, while subsequent green gram in the sequence require only 75% recommended doses of nutrients after this treatment.
6. In Dharwad area of Karnataka 20th-30th June is the optimum planting time for potato (varieties Kufri Jawahar and Kufri Surya) for getting higher yields and economic returns.
7. At Chhindwara, Hassan, Hisar, Kalyani, Ooty and Patna, the dose of P could be reduced to 75% with the use of phosphobacteria.

Crop Protection

Monitoring of late blight and A_2 mating type was done at 15 locations. It was observed that except at Bhubaneshwar, Dharwad, Faizabad, Hassan and Kota, late blight appeared in moderate to severe form throughout the country. Severity of late blight was high in Jalandhar, Jorhat, Ooty, Patna and Shillong. New A_2 strain has almost displaced the old A_1 strain in hilly regions, whereas, its frequency was low in the plains.

Scheduling of fungicide applications for the management of late blight was done at 4 locations. It was observed that under high disease pressure, a minimum of 3 sprays of mancozeb or 1 spray each of mancozeb and cymoxanil (0.2%) were required to manage late blight on susceptible cultivars, while, under low disease pressure two sprays of mancozeb were sufficient.

Experiments on biocontrol of bacterial wilt and brown rot were conducted at 3 locations. At Bhubaneshwar, boric acid treatment of seed tubers was highly effective against bacterial wilt followed closely by bioagents *Bacillus cereus* and *Bacillus subtilis*. At Jorhat, wilt incidence was significantly high in the local seed and was lowest in tubers treated with *B. subtilis*. Wilt incidence was almost negligible at Shillong in boric acid treated seed tubers in both the years.

Experiments on control of sclerotium wilt were conducted at Dharwad. Seed tuber treatment with *Trichoderma harzianum;* application of 10 t FYM/ha and 300 kg neem cake/ha; crop rotation with *rabi* sorghum; and deep ploughing in summer provided better management schedule of sclerotium wilt at Dharwad.

Studies on degeneration in different potato varieties due to viruses were carried out at 5 locations. Highest incidences of viruses were recorded in ware crops followed by crop raised through seed plot technique and were least in the crop raised from fresh breeder's seed.

Bacterial wilt is a problem in Karnataka, therefore, experiment on management of bacterial wilt of potato with soil solarization was conducted at Hassan. Soil solarization after one irrigation was found effective in reducing bacterial wilt incidence.

To reduce seed rot during emergence, experiments were conducted at Dharwad and Hassan. Seed tuber treatment with mancozeb (0.2%) + benzimidazole (0.2%) reduced tuber rottage during emergence and provided good plant stand in both the years.

Stem necrosis is emerging as a major problem in central India. Therefore, screening of potato genotypes was done at 3 locations viz. Deesa, Dharwad and Kota. Hybrids PS/F-220, HPS/25-13, JN-189 and OP-1 were highly resistant to stem necrosis. Hybrids PS/F-220 and JN-189 have been registered with NBPGR as novel parental lines under registration numbers INGR 04059 and INGR 07040, respectively.

Experiments on eco-friendly management of black scruf and common scab were conducted at 5 locations. At Faizabad, Boric acid plus *B. subtilis* was not only effective against common scab but it was also best for controlling black scurf. This treatment was also effective at Hisar and Kota.

Potato Apical Leaf Curl Disease (PALCD) spread by whiteflies is an emerging disease in central and western Indo-Gangetic plains. Experiments conducted at Hisar, Jalandhar, Kalyani and Modipuram revealed that seed treatment with imidacloprid followed by its 2 sprays at an interval of 15 days after emergence reduced whitefly population as well as apical leaf curl virus significantly.

Following recommendations were brought out in 26th Group Meeting of AICRP (Potato).

1. Treatment of cut seed pieces with 0.2% mancozeb + 0.2% benzimidazole for 10 minutes is recommended for the effective control of seed piece decay at Dharwad. This treatment also resulted in significant increase in tuber yield.
2. Delayed planting of seed crop by 10 to 15 days, seed treatment (dipping of chitted tubers for 10 minutes) with 0.04% (imidacloprid 200 SL 4 ml/10 liters) of imidacloprid plus spray of imidacloprid @ 60 g a.i./ha at emergence and another spray of thiamethoxam 25WG @ 100 g a.i./ha after 15 days of emergence is recommended for the effective control of whitelies and potato apical leaf curl disease (PALCD) in potato seed growing areas.

Library and Documentation Services

CPRI Library and Documentation Services unit was established in the year 1956 to act as national repository of scientific information relevant to potato with a modest collection of 256 documents. Since its inception, this library has acted as repository and clearinghouse of potato literature and information. At present; with more than 55 thousands documents it has attained the position of most sought-after library on potato R & D in India. It continually provided scientific and technical information supports and services towards attainment of research mission of the institute. Efforts were made for strengthening and developing the information resources and services through undertaking various activities given here below:

Resource Development: At the headquarter (Shimla), a total of 294 documents were purchased, procured and added to library resources. The total collection at Shimla stand at 33,656 documents comprising of 13,033 books, 13,678 back volumes of journals, 2,401 serials, 2,008 annual reports, 581 theses, 251 standards, 41 maps/atlases and 1,663 reprints. The six regional stations and one campus at Modipuram have their own library collection of 21,822 books, journals back volumes and other documents i.e. AR/Reprints and Bulletins etc as per the details below:

Periodicals and Serials Management: Twenty-six serials title i.e. advances, annual reviews, reference annuals, yearbooks and statistical data publications etc. were purchased. A total of 191 current journals comprising of 34 foreign and 157 Indian have been subscribed at Shimla. Out of which 20 foreign and 138 Indian journals were subscribed on payment basis and rest on exchange or gratis. In all 1,133 issues of such

Regional Stations	Books	Back vols. Journals	Other Documents	Total	Current Journals subscribed	
					Indian	Foreign
CPRIC, Modipuram*	3441	3072	1241	7754	40	5
CPRS, Jalandhar*	2715	1337	1176	5228	32	5
CPRS, Patna*	1766	1121	11	2898	18	5
CPRS, Gwalior*	463	4	300	767	17	5
CPRS, Ooty*	1308	1806	528	3642	15	5
CPRS, Shillong*	1256	-	133	1389	-	5
CPRS, Kufri*	144	-	-	144	-	-
Total	11093	7340	3389	21822	122	30

*Figures available up to 31-03-08

journals were received, marked and kept in library for use. Beside 140 titles of various journals were subscribed for regional station's libraries. 294 entries of library documents were made in Library Automation Software and 203 books were classified, catalogued, labeled, pasted and transcribed for use. The library has the complete series of CABCD, AGRICOLA (NAL), AGRIS (FAO), Current Contents – AB&ES, Derwent Biotech Abstracts, FSTA (IFIS), ISA on CD, and Nucssi on CD, CDROM databases for retrospective and current scientific literature search and use of scientists.

Computerized & Net Based Services: The library resources e.g. library catalogue (OPAC), foreign journals, CD Net searching, and other services like Recent Articles on Potato (RAP) and Current Journals Received Last Week were regularly updated and maintained on library web page. Now scientists were making use of library resources mostly online from their desktop. Many relevant web sites were visited and information and data were downloaded for scientists' use.

Readers and Reference Service: A total of 1,159 documents were borrowed for home studies and 5,800 readers consulted 20,640 documents within the library. Besides, 60 outside scientists and research scholars of various research organizations consulted the library resources. A total of 1,073 job requests were received for 1.29 lakhs copies of photocopying work. Besides 50 job requests for different official works/documents were also received and 1,15,090 impressions were done on copy printer. At present 144 readers are active members of library. Library received 8,550 reference queries from the users of the library and responded to them satisfactorily.

Documentation and Information Services; 1,133 issues of journals (817 issues of national and 316 issues of international journals) were scanned for potato literature. Besides, in-house documentation services i.e. Current Periodicals Received Last Week (Weekly) and Recent Articles on Potato (Monthly) were brought out regularly and updated on the library website for users of library.

Resource Generation: The library generated Rs.1,27,018.00 from CDROM searching & photocopying services, IGNOU computer practical and library discount in addition to normal 10% GOC discount saved on purchase of library books and journals through CPRI Book store.

CDS/ISIS Practical Training: A 15 days computer, IT, and database creation and operation practical session was organized in September, 2007 for 13 MLIS and 9 BLIS students of IGNOU Study Center, Shimla.

Institute Research Council Meeting

The Institute Research Council (IRC) Meeting, 2007 held at CPRI, Shimla on 27th – 29th July, 2007 was attended by 70 scientists from the Headquarters, institute campus at Modipuram and regional stations. The basic objective was to review the achievements of 2006-07 and formulate future plan of work for 2007-08 of various research programmes:

1. Presentation of progress reports for the year 2006-2007 by the Project/Programme Leaders.
2. Presentation of work plan/technical programme for 2007- 08 by the Programme/Project Leaders.
3. Presentation of new programme/project proposal if any by the scientists.

Dr. SS Lal, Secretary, IRC welcomed the participants. After the opening remarks by Dr. SK Pandey, Director, CPRI and Chairman, IRC, Heads of Division presented action taken report on the decisions and recommendations taken in the last IRC. All programme Leaders and participating scientists highlighted the major activities and achievements during 2006-07. Thorough discussions were held on each of the above items and various recommendations have been included in the IRC Proceedings of the Institute.

Some of the important recommendations of IRC

A list of germplasm accessions found promising over the years, for different traits individually or with multiple resistances, should be supplied to all the PI's and Heads of Stations for use in respective breeding programmes.

For pre-breeding of late blight resistance, we should concentrate on species other than *S. demissum* to diversify the source of resistance involving polygenes.

The andigena parental lines should be improved for the tuber traits such as eye depth, stolon length, tuber shape, earliness, culinary traits' *etc.* This was recommended by RAC also.

All the hybrids proposed for inclusion into AICRP (P) multi-location trials should be evaluated for their late blight resistance at Kufri and keeping quality at room temperature at respective locations. In future, the respective project leaders should generate the data on these two important traits also and only after that the hybrids will be introduced into AICRP (P) trials.

The parameters which could be correlated with input use efficiency should be included in the breeding programme.

Evaluations of advanced processing hybrids for chips will be done at 75 and 90 DAP, while for French Fries at 110 DAP.

Since the sources of bacterial wilt resistance are not available in the germplasm and conventional breeding would not help in developing bacterial wilt resistant varieties, the transgenic approach being tried at CPRI should be accelerated so as to come out with bacterial wilt resistant transgenic lines.

Efforts should be made to improve classification accuracy of the potato acreage forecast through remote sensing and GIS in collaboration with SAC (ISRO), Ahmedabad. The genetic coefficients of newly released varieties should be worked out for use in INFOCROP POTATO model.

Decision Support Systems developed at the institute should be given to the extension agencies like KVKs *etc.* after fixing the price for the same.

Potato production is suffering from huge post-harvest losses every year. Therefore, suitable potato cultivars and methodologies should be developed to minimize post-harvest losses. A small film on modified storage technology is to be made in consultation with Division of Social Science.

The cysts from resistant varieties should be collected to ascertain the pathotypes. There are resistance breaking strains which should be tried for screening.

To improve the quality of ELISA kits and to dispense with the conventional method of virus purification for antiserum production, we should plan for the *in vitro* production of coat proteins of various viruses and use them for antiserum production.

The demand for French fries is increasing day-by-day. The existing processing cultivars do not have the capacity to fulfill the growing demand. Therefore, institute should identify good cultures suitable for making French fries, build up their seed stock and release as varieties.

Division of Seed Technology has made good progress on generation of seed through tissue culture. This Division should now aim generating 100% potato seeds through tissue culture.

Most of the farmers have become small and marginal due the fragmentation of land holding. The institute should develop input efficient potato cultivars and technology to bring down the cost of production.

Climate is changing gradually and its effect has become apparent. Potato is very much sensitive to temperature change. Therefore, institute should identify potato genotypes insensitive to temperature change and develop technology against the changes towards global warming.

Interface with farmers and industries need to be developed and strengthened further. Provision and efforts need to be made for meeting with industrialists at every station.

RESEARCH ADVISORY COMMITTEE

The fifth RAC for the Central Potato Research Institute, Shimla reconstituted by the Director General, ICAR and Secretary DARE for the period June 2007 to May, 2009 vide council's letter No. F. 9-7/2007-I.A.V. dated 19-6-2007 had the following composition:

Dr. Mahadevappa Madappa, Ex-Chairman, ASRB	Chairman
Dr. P.C. Gaur, Former Head Division of Crop Improvement	Member
Dr. A. N. Maurya, Ex-Director Institute of Agricultural Sciences, B.H.U., Varanasi	Member
Dr. M. Kalia Prefessor & Dean Post Harvest Technology, CSHPKVV, Palampur	Member
Mr. Prakash Lohia Managing Director Century Laminating Co. Ltd., Hapur	Member
Dr. S.N. Pandey Asstt. Director General (Hort.I) Krishi Anusandhan Bhawan-II New Delhi	Member
Sh. Devadatta J. Nikam Tal. Ambagaon Distt. Pune	Member
Chaudhary Mann Singh Khandoli, Agra	Member
Dr. S.K. Pandey Director, CPRI	Member
Dr. R. Ezekiel Head, Division of CP & PHT, CPRI	Member Secretary

The last RAC meeting held on 25th and 26th July, 2007 gave the following recommendations pertaining to the 22 Research Progammes :

Programme 1. Collection, conservation, evaluation and documentation of potato germplasm and development of parental lines

- Population of S. *tuberosum subsp. andigena* as a whole should be improved through recurrent selection, for early maturity, short stolon, tuber shape and colour.
- Since S. *demissum and* S. *tuberosum subsp. andigena* have been used extensively as a source of late blight resistance, other sources should be tried for incorporating late blight resistance.
- Collection and maintenance of wild species should be need based.

Programme 2. Breeding potato cultivars for Indo- Gangetic plains

- The percentage selection at F1 stage should be increased.
- Hybrids JEX-722 and JEX-732 should be utilized as parents in the breeding programme for baby potatoes.
- All the hybrids should be evaluated for their keeping quality.

Programme 3. Development of varieties and technology for processing

- In the case of promising hybrids, the number of years in multi-location trials should be reduced by increasing the number of locations.
- The release of hybrid MP/98-71 selected for French fries should be expedited.
- The fertilizer recommendation for the hybrid MP/97-644 should be worked out in the hills, as it is proposed for release for the hills.

Programme 4. TPS technology for potato production

- Better parent selection is required for improving the performance of TPS populations.
- Uprooted seedlings should be treated with ascorbic acid / nutrient solutions before transplanting, in order to increase the survival rate.
- TPS programme should be strengthened at CPRS, Shillong.

Programme 5. Biotechnology in potato improvement

- Attempt should made to transfer late blight resistant gene from S. *bulbocastanum* to a popular cultivar.

Programme 6. Development of haploids and their utilization in potato improvement

- Dihaploids should be used in germplasm enhancement.

Programme 7. Cell biology and somatic cell genetics in potato improvement

- No recommendation

Programme 8. Physiological response of potatoes to heat stress

- Seedlings should be raised in field at CPRIC, Modipuram and screening done in the field itself.

Programme 9. Develop sustainable potato based cropping systems

- No recommendation

Programme 10. Low input technology for potato production

- In cropping system experiments, *bajra* should not be used.
- Shillong should be included as one of the locations for low input technology experiments.
- This programme should be merged with some other programme in the Division of Crop Production.

Programme 11. Integrated nutrient and water management in potato

- Work on drip irrigation should be strengthened.
- The information collected on phosphorus status of the soil should be confirmed and brought out as a recommendation.

Programme 12. Studies on long term manurial and fertilizer application and organic farming in potato production

- Soil health should be maintained in long term experiments by taking suitable measures.

Programme 13. Mechanization of potato cultivation

- No recommendation

Programme 14. Management of potato late blight

- Hybrid SM/93-237 was recommended by RAC for release.
- All promising hybrids with late blight resistance should be tested with two controls i.e. Kufri Jyoti unsprayed and Kufri Jyoti sprayed with fungicides.

Programme 15. Diagnostics and detection of pathogens

- No recommendation

Programme 16. Integrated disease management

- Future work in this programme should concentrate on pathogens causing russet scab.

Programme 17. Integrated pest management

- The term 'plant extracts' should be used instead of 'botanicals'.

Programme 18. Management of potato nematodes

- Cysts should be collected, resistance breaking pathotype should be identified, and effort should be made to identify resistance to that pathotype.

Programme 19. Storage behaviour and processing quality of potatoes under controlled temperature and non-refrigerated storage systems

- Activities of ascorbic acid peroxidase and glutathione reductase should be determined in potatoes stored under different conditions.

Programme 20. Diversified utilization of potatoes

- The economics of different potato products should be worked out and efforts made to popularize them.

Programme 21. Seed Technology

- Mini-tuber production should be increased in order to reduce one field multiplication.
- Scooped eyes should be compared with cut tubers.

Programme 22. Impact of potato technologies developed by CPRI

- No recommendation

QUINQUENNIAL REVIEW TEAM (QRT)

The present review is the, fifth covering the period 1-1-2001 to 31-12-2005 constituted by the ICAR vide its Office Order F.No.9-4/2006-I.A.V dated 28-8-2006:

Dr. V.P. Gupta Former, Vice Chancellor, RAU	Chairman
Dr. S.J. Singh Former, Head, IARI Regional Station Pune	Member
Dr. R.P. Sharma Former Director, NRCPB New Delhi	Member
Dr. M.L. Lodha Ex-Head, Division of Biochemistry IARI, New Delhi	Member
Dr. H.C. Sharma Ex-Director of Research, HAU, Hisar	Member
Dr. Seema Wahab Advisor, Deptt. of Biotechnology New Delhi	Member
Dr. R. Ezekiel Head, Post Harvest Technology, CPRI	Secretary

The Quinquennial Review Team (QRT) met at CPRI, Shimla on 18-10-2006 to review the Institute work. The team visited the headquarters and regional research stations of CPRI and saw the laboratories and field facilities available in the institute. It also interacted with scientists, farmers and held a final meeting on 5-9-2007 at New Delhi to finalize the report, which was submitted to the Council. The recommendations of QRT are:

Recommendation of QRT

Crop Improvement

1 Germplasm conservation and characterization must be strengthened in addition to *ex situ* conservation of genotypes. Gene pool in the form of DNA can be conserved.

2 It would be necessary to identify novel genes in the germplasm collection and utilize them in the institute's breeding programme for developing improved varieties.

3 Special breeding programmes must be initiated keeping in view the processing requirements for chips and French fries.

4 In north-west plain zone (NWPZ) of the country, frost caused severe damage to potato crop during 2005-06 season. Such cycles of severe frost repeat at least once or twice in a period of 5 years. Therefore, efforts should be made to screen/develop frost resistant varieties at Modipuram/ Jalandhar.

5 Genetics of water use efficiency and nutrient use efficiency should be worked out, efficient varieties should be identified and used as parents for breeding for improved water and nutrient use efficiency.

6 Pre-breeding is crucial for a strong breeding programme. It is essential to identify gene pool and use them in crossing programmes. To be able to do this, a molecular biologist should be a part of pre-breeding programme.

7 For strengthening TPS programme and selecting TPS populations with uniform tubers, homogeneous pre-breeding populations should be developed. For this, it would be advisable to develop robust inbred populations.

8 TPS has been an important area of research at Patna and good work on TPS is being done there. However, the QRT feels that better utilization of TPS segregating population as breeding material is necessary.

9 Extensive activities are required for popularizing production of seedling tubers which can be used as seed the following year. For example, seed farms can be encouraged to produce tuberlets from TPS and distribute them.

10 TPS is not popular in many parts of the country except in states like Tripura. Research efforts should be made to address the bottle necks so that TPS can be popularized in other areas also.

11 CPRI is already working in collaboration with International Potato Centre (CIP) in areas like TPS, and CIP is sharing germplasm lines with CPRI. This collaboration may be strengthened further and more germplasm lines may be obtained from CIP, especially the lines containing genes which are of immediate use to CPRI in its breeding programme for developing varieties with disease and pest resistance and better processing quality.

12 The Institute has developed excellent research facility in Molecular Biology and also has in place well trained human resource. However, the areas being pursued, though important, should be prioritized, focussed and strengthened by providing more scientific strength.

13 In addition to transgenic efforts, the Institute must strengthen the molecular breeding approach for crop improvement with a major emphasis on agronomic traits which basically are polygenic in nature.

14 For effective molecular breeding, QTLs should be isolated and modified, and then new alleles which will have minimum environmental influence should be identified and used.

Crop Production

15 There seems to be no effective link between Crop Improvement and Crop Production Divisions. These Divisions should work together and develop a separate project for breeding for improved fertilizer use efficiency under the programme on integrated nutrient management in potato.

16 A part of F_1 material should be given to Crop Production Division to screen for fertilizer use efficiency using radio tracers at different stages of crop growth.

17 In the trials on potato based cropping systems, the rice varieties being used are not in cultivation any more. Care should be taken to use only those varieties which are being cultivated by the farmers at present. This also applies to other crops which form a part of potato based cropping systems. Varieties should be identified in consultation with the Director of Research of the SAU concerned.

18 Autumn planted sugarcane and potato can be a potential intercropping system in NWPZ of the country. Since both are high input demanding crops, complete agronomy of this system, with particular reference to nutrient management should be worked out by CPRIC, Modipuram in collaboration with PDCSR-Modipuram or IISR, Lucknow. If necessary, work at 2-3 coordinating centres located in Punjab, U.P. and Bihar can also be taken up on this aspect.

19 Medicinal plants are economically more remunerative, can repel potato pests and can be agronomically non-competitive with potato. Therefore, they should be included in potato based cropping systems.

20 Since a number of crops are being tried in potato based cropping systems at CPRIC, Modipuram, it would be of interest to see if the major crops in potato based cropping systems have any allelopathic effect. In Bihar, potato-maize is a popular cropping system. Therefore, in the cropping system experiment being carried out at Patna station, the allelopathic effect between potato (solanaceous) and maize (graminaceous) needs to be studied.

21 Fog occurrence during the potato crop season appears to be quite common at Modipuram. Therefore, it is necessary to quantify the effect of fog duration and intensity on the growth and yield of potato.

22 Higher correlation between root length- shoot weight (DM) ratio and zinc uptake efficiency has been obtained but this work has been done only with ten varieties. It is essential to use a large number of germplasm and see the extent of correlation between the above two parameters.

23 By using drip irrigation, 50% saving on water and 30-35% increase in yield has been achieved. This technology needs to be popularized by laying out suitable demonstrations at regional stations.

24 Experiments are being carried out at the headquarters, regional research stations and AICRP (Potato) centres on the effect of FYM and vermicompost on crop growth and yield but no effort has been made to get them analysed for their NPK content. Since the nutrient content of FYM and vermicompost will vary from place to place, it is recommended that in all these experiments the nutrient content should be determined and it should be clearly mentioned that how much of inorganic nitrogen is being replaced by the application of FYM and vermicompost. Further, in such experiments the nutrient status of the soil before planting and after harvesting should also be determined to get an idea about the quantity of nutrients added and the residual nutrients after the crop is harvested. This will help in making somewhat more realistic fertilizer recommendations.

25 Farm yard manure in combination with biocontrol agents may be tried.

26 Results of the experiments on Panchkavya carried out at CPRS, Muthorai should be discussed scientifically and a conclusion arrived at on scientific basis.

27 Lot of work has been done using biodynamic approach. The results should be published, even if they are negative, and such studies should be discontinued.

28 INFOCROP-POTATO model which can simulate effects of agronomic practices and yield has been developed by the Institute and validated under sub-tropical conditions. This should be taken to farmers through television and other media, so that they can benefit from the information. The Institute may explore the possibility of adopting a village for this purpose.

Plant Protection

29 In one of the trials, it has been claimed that *B. subtilis* and *B. cereus* were effective in reducing bacterial wilt incidence. The mode of action of *B. subtilis* and *B. cereus* in controlling bacterial wilt should be investigated.

30 Very severe incidence of late blight was observed by the committee members during their visit to Patna station. Therefore, it is recommended that samples should be collected from late blight affected areas in Bihar and the biotype should be identified using PCR. If existing fungicides are not effective against new biotypes, new molecules should be tried.

31 Some progress has already been made towards the use of botanicals in controlling late blight. However, there is a need to fractionate plant extracts to identify the principles, which are responsible for controlling the disease, for their further characterization in collaboration with another institution, and exploitation on a large scale.

32 The genetics of late blight virulence should be understood properly and then action should be initiated accordingly.

33 While developing a transgenic for late blight resistance against predominant late blight strain, effort should also be made to develop resistances to all other strains. Development of transgenic with RB gene from *Solanum bulbocastanum* may be strengthened.

34 A large number of non-host plants are known to produce anti-microbial proteins which are effective against plant pathogenic viruses, bacteria and fungi. Late blight being the dreaded disease of potato, efforts should be made towards isolating and characterizing the genes encoding anti-microbial proteins for controlling virulent strains of *Phytophthora infestans.*

35 The etiology of russet scab may be studied.

36 Stem necrosis (Tospovirus) is becoming a problem in Uttar Pradesh and Rajasthan. Efforts should be made to evolve suitable management practice. Movement of planting materials may be restricted in areas free from this disease.

37 It is necessary to identify priority areas for the development of transgenics with resistance to diseases and pests. For example, if a transgenic has to be developed for virus resistance, first the major virus against which resistance is required should be identified and then work should be initiated to develop a transgenic. Potato varieties having resistance to potato apical leaf curl disease caused by Tomato leaf curl New Delhi virus and potato leaf roll virus may be developed on priority.

38 Besides potato, cabbage and carrot are important horticultural crops in the Nilgiris and they form a part of potato based cropping systems recommended for this region. It is recommended that experiments should be carried out at CPRS, Muthorai on the effect of root exudates of cabbage and carrot on hatching of potato cyst nematode.

39 Electron microscope has been the core strength of CPRI diagnostics programme. Since the EM is already 27 years old, it needs replacement with a new one on priority so that the diagnostics strength is maintained.

Crop Physiology and Post Harvest Technology

40 The 'Division of Crop Physiology & Post Harvest Technology' should be renamed as the 'Division of Crop Physiology, Biochemistry and Post Harvest Technology' as the biochemical aspects of the crop are also being studied by the Biochemists at Shimla, Modipuram and Jalandhar.

41 Although CIPC is serving the purpose of sprout suppression well in potatoes stored at 10-12°C, the committee feels that work on the screening of naturally occurring volatile compounds for sprout suppression should continue in order to find an alternative to CIPC, in view of the increasing tendency among the consumers to avoid chemically treated foods.

42 During the cold storage conditions of potato, the activity of invertase enzyme increases resulting in increased sweetness due to the accumulation of reducing sugars. This is not a desirable thing to happen. Therefore, efforts should be made to screen available germplasm for invertase activity in tubers to identify the materials having low invertase activity, for breeding purpose.

43 Studies may be carried out to understand better, the relationship between chip colour and reducing sugar content of tubers.

44 To alleviate deficiency of micronutrients like iron and Vitamin C in potato consuming people, efforts are required to be made to screen potato germplasm, especially Peruvian landraces, for higher levels of iron and vitamin C.

45 Processed potato products should be popularized in potato growing areas so that whenever there is a glut in potato production, farmers do not resort to distress sale, and get remunerative price for their produce. To popularize potato processed products developed so far, out-lets/sales counter should be opened wherever possible.

46 Efforts may be made to develop products based on potato flour in combination with cereal and gram flours.

47 A post of Food Technologist, which is lying vacant should be filled, to develop more processed potato products, and to study their shelf-life and nutritional quality under different agro-climatic conditions.

Seed Technology

48 Lack of quality seed potatoes is a common constraint in all the States and this fact was brought to the attention of the QRT by all the Regional Stations of CPRI and all the AICRP (Potato) centres. The present arrangement of supplying breeder's seed to the State Governments who in turn are expected to multiply it three times and then supply it to the farmers do not seem to be working satisfactorily as judged from the response the committee got during its interaction with potato farmers in several states. The present situation wherein farmers end up with poor quality seed tubers which are a mixture of more than one variety, with severe viral infection, even after paying a high price to private traders, which is as high as Rs. 13,000 per tonne in some places, is alarming and cries for immediate attention. The committee feels that Seed Village concept should be adopted by CPRI at all its regional stations in order to supplement the role of the State Government in supplying good quality seed tubers to potato farmers.

49 Some experiments are being conducted in the Division of Seed Technology, but there is a need to strengthen seed research by formulating a well planned research programme.

Social Sciences

50 Economics of potato-maize intercropping and other cropping systems may be worked out.

51 More emphasis on transfer of technology is needed. For example, in Bihar where the productivity is low, increased extension efforts leading to increased adoption of technology can result in visible improvements in productivity as well as farmers income. The Institute should conduct transfer of technology activities on model basis through demonstrations, mass media etc.

52 The Institute has brought out a number of extension bulletins in English and Hindi for the benefit of potato farmers but the number of publications in local languages is very few. The committee recommends that all the regional stations should be encouraged to bring out popular publications in local languages.

53 For sound impact of transfer of technology activities, a separate fund is needed for farmers training and for advertisement for educating the people on nutritional qualities of potatoes.

Regional stations

54 The QRT appreciates the efforts made by the Central Potato Research Station (CPRS), Kufri/ Fagu to improve the infrastructure facilities. For example, a road has been developed through the farm at Fagu to facilitate movement of seed and fertilizers to the upper terraces located at considerable height. Efforts are also underway to build a pond for water harvesting. The committee recommends allocation of sufficient funds for construction of three polyhouses and boundary wall at Fagu farm.

55 Seed production is a major activity of CPRS, Jalandhar and it has produced 506 t of high quality breeder's seed during 2004-05. It is recommended that the station should develop tissue culture facility and use tissue culture method to skip one field multiplication.

56 Considering the staff strength of Central Potato Research Institute Campus (CPRIC), Modipuram , construction of a conference hall and a museum hall are recommended at this station.

57 Seed production is a major activity of CPRS, Patna also and efforts should be made to integrate tissue culture in seed production system.

58 Considering the importance and size of Patna station, the current scientific strength is inadequate. One scientist each in crop improvement, plant pathology and seed production should be provided.

59 The station has one extension scientist and he should intensify extension activities to popularize TPS in this region.

60 At present, Gwalior station has a modest observatory for recording weather parameters manually. It would be better if an automatic weather station is installed.

61 Existing vacancies in administrative and technical categories may be filled on priority for the smooth functioning of Gwalior station.

62 The number of persons employed by the Gwalior station for security is inadequate and the reason for this was the ceiling on the sanctioning power of the Director for this purpose. Considering the huge farm areas in regional stations like Gwalior, the power of Director for hiring security should be increased to at least Rs 20 lakh per year. Boundary wall for D - block and installation of two more submersible wells are also recommended.

63 An existing type IV quarter has been converted into a guest house at Gwalior station. This is only a temporary arrangement and is inadequate. For accommodating the visiting scientists and other staff, and also farmers who come for training, another type IV quarter may also be converted into a guest house.

64 Existing vacancies of one plant pathologist, one social scientist, one technical assistant and one driver at Muthorai station may be filled.

65 Although the farm area at Muthorai station is fenced, it is not strong enough at the base to prevent the entry of wild animals from the neighbouring forest areas. Therefore, an additional fund of Rs. 20 lakh may be provided for strengthening the fence with cement base.

66 No variety has been developed exclusively for Shillong region after 1998. Breeding activity needs to be strengthened at CPRS, Shillong with high yield combined with late blight resistance getting top priority.

67 Shillong station should have a strong linkage with the ICAR research complex for NEH region, Umiam, especially in areas like agronomy, where scientists are not available at Shillong.

68 Since CPRS, Shillong is the only station of CPRI for the entire NEH region, it is necessary to strengthen the scientific staff here. One scientist each in agronomy, plant breeding and plant pathology are needed immediately.

69 Shillong station has an extension scientist as its Head and the extension activities are quite good. The extension activities of the station can be strengthened further by organizing farmers' training more frequently, especially for farmers in villages that are located far away from the station. To facilitate this, construction of a Farmers Training Hostel with five bed rooms is recommended.

70 Shillong station has a huge farm area and it needs to be secured with a boundary wall.

71 Shillong being a hill station, housing problem exists and therefore, residential quarters need to be constructed. Two Type I quarters and one each of type II, III, IV and V are recommended.

72 Since electricity supply is not regular in Shillong, power cuts are frequent and this affects tissue culture facility and other research works. One 50 KVA generator is recommended to back up power supply.

General

87 In addition to the training based on the needs of individual scientists (as is being done now), the Institute must identify the critical areas requiring strengthening and provide need based, in depth training in those areas to selected scientists within or outside the country.

88 Though seed production is the major activity at CPRI regional stations, several experiments are being conducted by scientists under different research programmes of the Institute. But the QRT finds that not many publications have been brought out by regional stations. The headquarters should encourage research publications by scientists working at regional research stations.

Publications

A. Books and Bulletins

Annual Report 2006-07

Perspective Plan- Vision 2025

Report on QRT

Newsletter Vol. No.36 (June, 07)

Newsletter Vol. No.37 (December, 07)

Samahit (Hindi)

Beej Allo ka Utapadan (in Hindi)

AICRP (Potato)- Eco-friendly approaches for sustainable management of potato pests

AICRP (Potato)- 35 years of AICRP(Potato)

Technical bulletin No. 80- Ware & Seed Production Technologies in Nilgiris

Technical bulletin No. 81- Potato Statistics-India & World

Hindi version of Technical bulletin No.82- *Dher Gadhon mein aloo ka bhandaran*

Tecnhical bulletin No. 83- Resource management in potato based cropping systems

Technical bulletin No. 84- Potato Scenario in India –A Thematic analysis

Technical bulletin No. 85- Scenario of potato production and processing in West Bengal

Hindi version of Technical bulletin No.48- *Allo vidhayan margdarshika*

Hindi version of Extension Folder No. 38- *Allo utpadan "samashya evam samadhan"*

Extension Folder- Good agricultural practices for management of late blight and other potato diseases- A Manual

Folder- CPRS Shillong- A Glimpse

Folder- Seed and table potato storage in North Eastern India

B. PAPERS PUBLISHED IN REFEREED JOURNALS

Bhardwaj, V, SK Kaushik, SK Chakrabarti, SK Pandey, PH Singh, P Manivel and BP Singh. 2007. Combining resistance to late blight and PVY in potato. *Potato J.* **34**: 41-42.

Chandel, RS, KR Dhiman, VK Chandla and Desh Raj. 2008. Insect pests of potato-1: Root and tuber eating pests. *Pestology* **32**: 39-46.

Chandel, RS, KR Dhiman, ID Gag and Desh Raj. 2008. Insect pests of potato–II: Sap feeding pests. *Pestology* **32**: 47-53.

Chimote, VP, SK Chakrabarti, D Pattanayak, SK Pandey and PS Naik. 2007. Molecular analysis of cytoplasm type in Indian potato varieties. *Euphytica* **162**: 69-80.

Dua, VK, PM Govindakrishnan and SS Lal. 2007. Evaluation of wheat-potato relay intercropping system in the mid hills of Shimla. *Indian J. of Agric. Res.* **41**: 142-45.

Dua, VK, PM Govindakrishnan, SS Lal and SM Paul Khurana. 2007. Partial factor productivity of nitrogen in potato. *Better Crops with Plant Food* **91**: 26-27.

Ezekiel, R and Brajesh Singh. 2007. Changes in contents of sugar, free amino acids and phenols in four varieties of potato tubers stored at five temperatures for 180 days. *J. Food Science Technol.* **44**: 471-77.

Ezekiel, R, Brajesh Singh and PS Datta. 2008. Chipping quality of gamma-irradiated potatoes of three Indian cultivars stored at 8, 12 and 16C. *J. Food Science Technol.* **45**: 36-43.

Ezekiel, R, Brajesh Singh, Dinesh Kumar and Ashiv Mehta. 2007. Processing quality of potato varieties grown at two locations and stored at 4, 10 and 12°C. *Potato J.* **34**: 164-73.

Gopal, J, Vinod Kumar, SK Pandey, Raj Kumar, PC Pande and SV Singh. 2007. Morphological descriptors for DUS testing of potato varieties. *Potato J.* **34**: 59-60.

Gopal, J and K Iwama. 2007. *In vitro* screening against water-stress mediated through sorbitol and polyethylene glycol. *Plant Cell Reports* 26: 693-700.

Gopal, J, K Iwama and Y.Jitsuyama. 2008. Effect of water stress mediated through agar on *in vitro* growth of potato. *In vitro Cellular & Developmental Biology-Plant.* Springer online DOI 10.1007/s11627-007-9102-1.

Jain, N, SS Ray, JP Singh and Sushma Panigrahy. 2007. Use of hyperspectral data to assess the effects of different nitrogen applications on a potato crop. *Precision Agriculture* **8**: 225-39.

Jatav, MK, KC Sud and VK Dua. 2007. Nutrient status of soils from high hills of potato growing areas of Shimla. *Potato J.* **34**: 216-20.

Joseph, TA, SK Kaushik, BP Singh, Vinay Bhardwaj, SK Pandey, SV Singh, PH Singh and VK Gupta. 2007. Kufri Himalini: A high yielding, late blight resistant potato variety suitable for cultivation in Indian hills. *Potato J.* **34**: 168-73.

Kumar, Arvind, Dinesh Kumar and Brajesh Singh. 2007. Changes in processing quality of potato tubers occurring between haulm cutting and harvesting. *Potato J.* **34**: 239-41.

Kumar, Dinesh, SV Singh, SK Pandey, BP Singh and Sanjay Rawal. 2007. Effect of growing season on chipping quality of potatoes under sub-tropical climates. *Potato J.* **34**: 180-86.

Kumar, Dinesh, SV Singh, SK Pandey, RS Marwaha, BP Singh and Parveen Kumar. 2007. Processing potential of advanced potato hybrids stored at intermediate temperatures with CIPC. *Indian J. of Hort.* **64**: 324-27.

Kumar, Parveen, SK Pandey, BP Singh, SV Singh and Dinesh Kumar. 2007. Influence of source and time of potassium application on potato growth, yield, economics and crisp quality. *Potato Res.* **50**: 1-13.

Kumar, Parveen, SK Pandey, BP Singh, SV Singh and Dinesh Kumar. 2007. Optimizing phosphorus requirements of Chipsona varieties for west-central plains of India. *Potato J.* **34**: 199-202.

Kumar, Parveen, SK Pandey, SV Singh and Dinesh Kumar. 2007. Irrigation requirements of chipping potato cultivars under west-central Indian plains environment. *Potato J.* **34**: 193-98.

Luthra, SK, J Gopal, P Manivel, Vinod Kumar, BP Singh and SK Pandey. 2007. Screening of wild and cultivated species of potato for frost tolerance in north-central plains of India. *Potato J.* **34**: 45-46

Manivel, P, SK Pandey, Jai Gopal and Vinod Kumar. 2007. Comparison of hybridization *in -situ* and on decapitation in glass house in potato. *The Indian J. Genetics and Plant Breeding* **67**: 301-04.

Manorama, K, G Ravichandran and TA Joseph. 2007. Rainfall analysis and crop planning for the Nilgiris. *J. of Agrometeorology* **9**: 209-15.

Mehta, Ashiv, Brajesh Singh, R. Ezekiel and Dinesh Kumar. 2008. Storage of table and processing potatoes (*Solanum tuberosum*) with isopropyl N-(3-chlorophenyl) carbamate fog under heap storage. *Indian J. Agric. Sci.* **78**: 69-72.

Pande, PC, SV Singh, SK Pandey and Brajesh Singh. 2007. Dormancy, sprouting behaviour and weight loss in Indian potato (*Solanum tuberosum*) varieties. *Indian J. Agric. Sci.* **77**: 715-20.

Pandey, SK and KC Sud. 2007. Nutrient management in potato based cropping systems. *Indian J. Fert.* **3**: 91-110.

Pandey, SK, SV Singh, Dinesh Kumar, RS Marwaha, P Manivel and Parveen Kumar. 2008. Performance of newly released Kufri Chipsona-3 Indian potato variety during different crop seasons in west-central plains. *Indian J. of Agric. Sci.* **78**: 116-21.

Pandit, Arun, NK Pandey, Barsati, Lal, KP Chandran and Rajesh K Rana. 2007. Financing Agriculture: A study of Bihar and West Bengal potato cultivation. *Ind. J. Agric. Econ.* **62**: 340-49.

Rana, Rajesh K and SK Pandey. 2007. Processing Quality Potatoes in India: An Analysis of Industry's Demand. *Processed Food Industry*. **10**: 26-35

Rani, Anju, M Narayana Bhat and B P Singh. 2007. Effect of potato phylloplane fungi on potato late blight pathogen *Phytopthora infestans*. *J. Mycol. Plant Pathol.* **37**: 413-17.

Rani, Anju, M Narayana Bhat, and B P Singh. 2007. Effect of fungicides on growth and germination of zoosporangia and zoospores of *Phytophthora infestans*. *J. Mycol. Plant Pathol* **37**: 527-29.

Rani, Anju, M Narayana Bhat, and B P Singh. 2007. Prophylactic and curative effect of fungicides on *Phytophthora infestans*. *J. Mycol. Plant Pathol* **37**: 276-79.

Sharma OP, PN Sharma, Rita Rana and ID Garg. 2007. Identification and characterization of a virus associated with yellow mosaic disease of *Ageratum* in Himachal Pradesh. *Indian J. Virol.* **18:** 89-92.

Singh, Dan, RP Singh and Name Singh. 2007. Impact of trainees in relation to seed treatment of pulse crop. *Ann. Pl. Protec. Sci.* **15**: 469-539.

Singh, JP, Rachna, SS Lal, SS Ray and Sushma Panigrahy. 2007. Using leaf chlorophyll meter for N-fertilizer management in precision farming of potato. *Potato J.* **34**: 221-26.

Singh, Sukhwinder, Sanjay Rawal and Manjit Singh. 2007. Design and development of off-set type potato digger for sugarcane+ potato intercropping. *Potato J.* **34**: 227-30.

Somani AK, VS Kushwah, SM Paul Khurana and ID Garg. 2007. Integrated management of stem necrosis disease of potato in central India. *Potato J.* **34**: 231-34.

Sud, KC and MK Jatav. 2007. Response of potato to phosphorus and phosphorus solubilizing bacteria in brown hill soils of Shimla. *Potato J.* **34**: 109-10.

Sud, KC, SP Trehan and SS Lal. 2007. Performance of organic and inorganics in potato-garlic sequence under zero tillage in the mid hills of Himachal Pradesh. *Potato J.* **34**: 203-08.

Trehan, SP. 2007. Efficiency of potassium utilization from soil as influenced by different potato cultivars in the absence and presence of green manure (*Sesbania aculeata*). *Adv. Hort. Sci.* **21**: 156-64.

Institute Activities

Model Training Course: The Division of Social Sciences organized Directorate of Extension, Ministry of Agriculture, Govt. of India sponsored 8-days Model Training Course on "Recent Advances in Potato Production Technology" from July 13-20, 2007 at Shimla on improving the knowledge regarding seed potato production and certification. A total of 22 participants from 11 states attended the training course. The training included 24 lecture-cum-discussions, practical sessions, skill demonstrations, field visits and video film shows.

Entrepreneurship Development in Biotechnology: A five-day training programme by Biotech Consortium India Limited, New Delhi on Entrepreneurship Development was organized at Shimla from June 11-15, 2007. The programme was aimed to train the prospective entrepreneurs on various technical and management topics relevant for biotechnology projects. Thirty two prospective entrepreneurs from the states of Himachal Pradesh, Punjab, Haryana and Uttrakhand attended the training. The Entrepreneurship Development Programme (EDP) was structured to initially provide training on management aspects such as finance, accounting, marketing, etc followed by biotech projects suitable for small and medium scale set up, containing both technical and economic details.

On-farm Training for farmers from eastern hills: On-farm training on th e-management of potato diseases with special emphasis on late blight and bacterial wilt was held during 22nd to 25th May 2007 in East Khasi Hills district of Meghalaya. Dr. BP Singh, Joint Director, CPRI, Modipuram and Dr. PH Singh, CPRI, Shimla were the resource persons for the training. On 22nd May, 162 farmers from Sadew and Banium villages participated at Sadew. Another 154 farmers from four villages, viz., Mawklot, Myrkhan, Nongpim and Laitmynsaw attended the training at Laitmynsaw on 23rd May. On 24thMay, a total of 157 farmers from Myllium village while on 25th, 163 farmers from Mawkhan and Mawnianglah villages attended the programme. The farmers were given training with the help of well designed lectures and practical demonstrations about the role of disease free seed, sanitation, resistant varieties, high ridging and earthing up, prophylactic and need based spray schedules and other management practices for late blight, brown rot and other important potato diseases.

Live Phone-in Programme on Doordarshan

The Shimla Doordarshan telecasts *live phone-in* programme of 'Krishi Darshan' in every

Monday and Thursday. In this programme burning issues related to crop, animal husbandry, fishery, etc. are discussed by the studio-invited experts and the viewers (farmers) can ask questions from the experts by dialling the phone number announced just before the start of the programme. Drs. PS Naik, ID Garg, VK Chandla, PH Singh, VK Dua, Anil Kumar, Ashwani Kumar and Mukesh Jatav of CPRI, Shimla participated in the programme to discuss various aspects of potato production. Field recording on seed treatment and storage of potato was undertaken at CPRS, Kufri and was telecast on Shimla Doordarshan. Drs. RP Rai, Shambhu Kumar, Manoj Kumar, SK Singh and Barsati Lal of CPRS, Patna participated in similar programme telecast by Patna Doordarshan.

Potato School on AIR

Two *Potato Schools* on All India Radio - one by CPRIC, Modipuram at AIR, New Delhi and the other by CPRI, Shimla at AIR, Shimla were organized during the year. The *Potato School* at AIR, New Delhi was broadcast from 26th October, 2007 to 18th January, 2008 which was of the nature of live phone-in and consisted of 13 episodes with each having 15-20 queries on

different aspects of potato. The farmers of Western UP, Haryana and Rajasthan interacted with the studio-invited experts of CPRIC. The *Potato School* at AIR, Shimla is being coordinated by the Division of Social Sciences and consists of 20 episodes of pre-recorded talks on various aspects of potato by the scientists of CPRI, Shimla. Out of 20 episodes, 3 are scheduled to broadcast in the month of March, 2008 and the remaining are to be broadcasted during April-July, 2008.

Kisan Melas/ Field Days

CPRS, Kufri: Kisan Mela was organized at CPRS, Kufri on 27th May, 2007 which was attended by over 400 farmers from different districts of Himachal Pradesh. The Mela was inaugurated by Dr. HP Singh, DDG (Hort.), ICAR, New Delh who emphasized on commercialization of agriculture under the changed scenario. A total of 16 stalls exhibiting technologies generated by different agricultural organizations draw large number of farmers. The farmers also put up their exhibition stalls to display their products. Attractive prizes were given for the best display by the stalls of institutions and farmers. Scientists-farmers interaction meet were also held to suggest solutions to the farmers' problems.

Field Day at Kharapathar, Shimla: A Field Day was organized at Kharapathar a major potato belt in the Shimla district on 12th June, 2007 to provide on-farm training to the farmers on scientific potato cultivation. The area has been showing declining trend in potato acreage due to competition from more remunerative crops like cabbage and peas. About 150 farmers from this area participated in the programme and they were imparted training on preparation of vermi-compost and home-made fungicides.

Kisan Mela at CPRIC, Modipuram: The Campus organized 2-days Kisan Mela on 8-9 February, 2008 at Modipuram in which about 1500 farmers from adjoining areas of UP, Haryana and Rajasthan participated. The Mela was inaugurated by Dr. HP Singh, DDG(Hort.),

ICAR, New Delhi. He advised the farmers for diversification of agriculture to ensure higher income. On this occasion, the closing ceremony of Potato School on AIR, New Delhi during the year was also held. A total of 60 stalls were put up to exhibit technologies generated by different agricultural organizations. Kisan gosthi was also held at the end to suggest solutions to the farmers' problems.

Exhibition in Horticulture Summit- 2007: A potato stall was put up during **Horticulture Summit-2007** held at CISH, Lucknow during 16-19th June 2007. This summit jointly organized by CISH, Lucknow and the Confederation of Indian Horticulture was attended by Drs. BP Singh, SV Singh, PC Pande and Anil Kumar of the Institute. The 4-day summit consisted of presentation of production technologies by the Directors of horticultural institutes of ICAR followed by discussion by the participating farmers. More than 3000 farmers from different parts of the country attended the summit. About 100 exhibition stalls were put up on this occasion and there was a special exhibition of 'Mango Show' in which more than 200 varieties of mango were displayed.

Exhibition in Kisan Mela at Solan: An exhibition stall of potato technologies was put up at the Kisan Mela organized by National Research

Centre for Mushroom, Chambaghat, Solan on September 10, 2007. The stall was visited by more than 200 farmers from different parts of state and they were briefed about the potato technologies. This endeavour proved worthy in getting first hand information from the farmers and transferring the potato technologies to them. Besides, a number of publications of the Institute were sold to the farmers and scientists visiting the stall.

Exhibition in Farmers' Fair in North-east: The CPRS, Shillong put up exhibition stalls on potato technologies at the farmers' fair entitled *"AAHAR"* organized by Ministry of Food Processing Industry and Government of Meghalaya from 29th October to 1st November 2007 at Polo ground, Shillong and in *North-east Agriculture Fair 2008* organized by College of Veterinary Sciences & Animal Husbandry, Central Agricultural University, Selesih, Aizawl at Aizawl during 6th - 9th February, 2008.

Exhibition in Kisan Mela at Meerut: The CPRIC, Modipuram put up an exhibition stall on TPS and potato varieties and products at the Kisan Mela organized by SVBPUA&T, Modipuram

during October 8-11, 2007. The exhibition stall of CPRI was attended by over 600 farmers from different parts of UP who were given package of practices for potato cultivation.

Activities of ATIC

A total of 308 farmers visited the Institute at Shimla, 770 farmers at CPRIC, Modipuram and 615 farmers at CPRS, Patna during the year to get first-hand information about potato technologies. In addition, 44 scientists/teaching staff, 792 UG and PG students and 308 farmers were attended by the ATIC staff at Shimla. They were shown potato film, museum besides briefing from the extension scientist about the programmes and activities of the institute.

Distinguished Visitors

1. Dr. HP Singh, DDG (Hort.), ICAR, New Delhi, visited CPRIC, Modipuram on 2.4.2007.
2. Dr. HP Singh, DDG (Hort.), ICAR, New Delhi, visited CPRS, Shillong on 18.4.2007.
3. Dr. Kirti Singh, Ex-Chairman, ASRB, New Delhi ICAR, New Delhi, visited CPRS, Shillong on 20.4.2007.
4. Sh. PP Mathur, Additional Secretary and Finance Advisor, GIO, Department of Agriculture & Crop, New Delhi visited CPRI, Shimla on 30.4.2007.
5. Hon'ble Sh. Syed Sibtey Razi, The Governor of Jharkhand, Ranchi, visited CPRI, Shimla, on 14.5.2007.
6. Dr. NN Singh, Vice Chancellor, BAU, Ranchi, Jharkhand, visited CPRI, Shimla, on 14.5.2007.
7. Sh. Amit Khare, IAS & Principal Secretary to Governor of Jharkhand, Ranchi visited CPRI, Shimla on 14.5.2007.
8. Ray Naldar, Director of Agronomy, PepsiCo International, China visited CPRI, Shimla on 01.6.2007.
9. Dr. NK Tyagi, Member, ASRB, Pusa, New Delhi visited CPRI, Shimla on 14.9.2007.
10. Justice KJ Rohee, High Court of Bombay, Maharastra visited CPRI, Shimla on 10.9.2007.
11. Dr. SN Pandey, ADG (Hort.), ICAR, New Delhi, visited CPRI Campus, Modipuram, on 10.10.2007.
12. Dr. Umesh Srivastava, ADG (Hort.), ICAR, New Delhi, visited CPRI Campus, Modipuram, on 10.10.2007.
13. Dr. Frank Shotkoski, Director ABSP-II, Cornell University, USA, visited CPRI Campus, Modipuram, on 20.12.2007
14. Dr. Bruce S Weir, Professor, Department of Biostatistics, University of Washington, USA, visited CPRI, Shimla, on 29.3.2008.

Awards, Honours and Foreign Visits

1. **Rafi Ahmed Kidwai Award :-** Dr. SK Pandey, Director, CPRI, Shimla awarded Rafi Ahmed Kidwai Award for the biennium 2006-07 by Hon'ble Minister of Agriculture, Sh. Sharad Pawar on 16th July, 2007 on the occasion of foundation day of Indian Council of Agriculture Research, New Delhi.

2. **Dr. S. Ramanujam Award:-** Dr. SV Singh, Principal Scientist, CPRIC, Modipuram, Meerut and his five team associates, viz. Dr. SK Pandey (CPRI, Shimla), Dr. RS Marwaha (CPRS, Jalandhar), Drs. BP Singh, Dinesh Kumar and Parveen Kumar (CPRIC, Modipuram) was awarded by Dr. S. Ramanujam Award 2004-07.

3. **Best Worker Award:** Sh. Gurdev Singh, Technical Officer (T-5), CPRS, Jalandhar was awarded the CPRI Best Worker Award, 2004 in Technical Category.

4. **Best Poster Paper Award:** Drs. RS Marwaha, VK Gupta, Dinesh Kumar, SV Singh & SK Pandey, were awarded best poster paper award by Horticultural Society of India, during Horticultural Congress 2007.

5. **Dr. SK Chakrabarti**, Principal Scientist, CPRI, Shimla visited Netherlands from 18th-20th April, 2007 to attend workshop for training on software at Wageningen, Netherlands.

6. **Dr. Jai Gopal**, Principal Scientist & Head, Crop Improvement, CPRI, Shimla visited Lima, Peru from 10th-14th April, 2007 and 19th-29th June, 2007 to act as member of CGIAR/ FAO panel for external review of International Potato Centre (CIP), Lima, Peru.

7. **Dr. SV Singh**, Principal Scientist, CPRIC, Modipuram & Dr. Vinod Kumar, Sr. Scientist, CPRS, Kufri visited Lima, Peru from 3rd-18th December, 2007 to attend training on "Screening for drought tolerance/water use efficiency and related topics" at International Potato Centre (CIP), Lima, Peru.

Education and Training

Sl. No.	Name of trainee	Name of the Training
1	Drs. N. Somasekhar, Sr. Sci., TA Joseph, Sr. Sci., (Mrs.) K. Monarma, Sr. Sci., G Ravichandran, Sci. (SS), Dr. R Muthuraj, Scientist (SS), CPRS, Ooty	Workshop on "Share your experiences on seed production, marketing, trading, Intellectual property rights and its implementation" held at Sugarcane Breeding Institute, Combatore on 28th April, 2007.
2	Dr. BP Singh, JD, CPRIC, Modipuram	Workshop on "Creative excellence for individual development & organizational growth" held at NAARM, Hyderabad from 6 10 August, 2007.
3	Drs. Brajesh Singh, Sr. Scientist, D. Pattanayak, Sr. Scientist & Vinay Bhardwaj, Scientist (SS), CI, CPRI, Shimla	Awareness workshop on IPR Laws and Issues held at HP University, Summer Hill, Shimla on 14th August, 2007.
4	Sh. Shashi Rawat, Scientist (SS) & Sh. Joginder Singh Thakur, Asstt., CPRI, Shimla	Training for the Nodal officers/Data enterers of (IRS) held at IASRI, New Delhi from 10-11 September, 2007.
5	Drs. VK Chandla, PS & ID Garg, PS, Plant Protection, CPRI, Shimla	Workshop of CIP/CPRI at CPRIC, Modipuram from 10-12 October, 2007.
6	Dr. RR Burman, Scientist (SS), CPRS, Shillong	Winter school on "Advances in video and multimedia production" held at NAARM, Hyderabad from 1-21 November, 2007
7	Sh. Hira Nand Sharma, AAO (B&C), CPRI, Shimla	Course on "Improving Administrative Efficiency and Financial management" held at NAARM, Hyderabad from 13-20 November, 2007.
8	Dr. RK Arora, Sr. Scientist, CPRI, Jalandhar & Dr. Arun Pandit, Scientist, CPRI, Shimla	Training on "Advances in quantitative techniques for policy analysis in agriculture economics held at IASRI, New Delhi from 6-26 December, 2007.
9	Dr. Sanjay Rawal, Scientist (SS), CPRIC, Modipuram	Short term training programme on "Integrating spatial and non-spatial natural resources for sustainable watershed management" held at Water Technology Centre for Eastern Region (ICAR), Bhubaneswar from 9-15 January, 2008
10	Er. Sukhwinder Singh, Scientist (SG), CPRIC, Modipuram	Short term training course on "Mechanization of cultivation of horticulture crops" held at Section of Agriculture Engineering, IIHR, Banglore.
11	Sh. Ashwani Verma, SRF, CPRI, Shimla	Workshop-cum-training programme on "Bioinformatics and its application in plants sciences" held at Dr. YS Parmar University of Horticulture & Forestry, Nauni, Solan from 25-29 February, 2008.
12	Drs. VK Chandla, PS and ID Garg, PS, Plant Protection, CPRI, Shimla	Training Workshop at CPRS, Shillong from 14-15 March, 2008.
13	Dr. M.K. Jatav, Scientist, CPRI, Shimla	Training course on "Farming system an approach towards sustainable agriculture" at GP Pant University of Agriculture & Technology, Pantnager (UK) from 28th March to 17th April, 2008.

Conferences and Symposia

Sl. No.	Name	Title of the Conference/ Symposia/ Seminar	Dates & Venue
1.	Drs. SV Singh, PS, CPRIC, Modipuram, RS Marhwah, PS, CPRS, Jalandhar & RR Burman, Head, CPRS, Shillong	2nd Indian Horticulture Congress, 2007 on "Opportunities and linkages for horticulture search and development (NE Region)"	18-21 April, 2007 at ICAR Research complex for NEH region, Umiam (Meghalaya)
2.	Drs. PS Naik, PC (AICRP) & Anil Kumar, Sr. Scientist, CPRI, Shimla, BP Singh, JD, SV Singh, PS & PC Pande, CPRIC, Modipuram	Horticulture Summit-2007	16-19 June, 2007 at CISH, Lucknow
3.	Dr. SP Trehan, , Sci. (SS), CPRS, Jalandhar	Conference on "Environment and livelibood security through research management in Northern India"	29-31 October, 2007 at CSWCR&IT, Chandigarh
4.	Dr. MK Jatav, Scientist, CPRI, Shimla	National seminar on "Developments in soil sciences"	2-5 November, 2007 at Birsa Agricultural University, Ranchi
5.	Dr. Arun Pandit, Sci. (SS), CPRI, Shimla	67th Annual Conference of "Indian Society of Agricultural Economics".	5-7 November, 2007 at Bankers Institute of rural Development, Lucknow
6.	Dr. RK Arora, Principal Scientist, CPRS, Jalandhar	Symposium on "Eco-friendly disease management approaches for organic farming in horticulture crops".	16-17 November, 2007 at Dr. YS Parmar University of forestry, Nauni, Solan (HP)
7.	Drs. KC Sud, PS, MK Jatav, Scientist, CPRI, Shimla, SP Trehan, PS, CPRS, Jalandhar, MA Khan, Sr. Sci., CPRIC, Modipuram, VS Kushwah, Head & SP Singh, PS, CPRS, Gwalior	Symposium on "Organic farming and renewable sources of energy for sustainable agriculture".	19-21 November, 2007 at Rajasthan College of Agriculture, MPUA, Udaipur
8.	Dr. Rakesh Mani Sharma, Incharge, Lib. & Documentation, CPRI, Shimla	10th National Convention on "Knowledge, Library & information Networking" (NACLIN 2007)	20-23 November, 2007 at Indian International Centre, New Delhi
9.	Dr. N. Somasekhar, Sr. Scientist, CPRS, Ooty	National Symposium on "Nematology in 21st Century Emerging paradigms"	22-23 November, 2007 at Assam Agricultural University, Johrat
10	Dr. R. Ezekiel, Head, CP & PHT, CPRI, Shimla	National Seminar on "Plant Pathology".	29th November, 2007 to 1st Dec.,2007 at Dapoli, Ratnagiri (MS)

Sl. No.	Name	Title of the Conference/ Symposia/ Seminar	Dates & Venue
11.	Dr. SJ Gawande, Scientist, *Plant Protection, CPRI, Shimla*	International conference on "Emerging and re-emerging viral diseases in the tropics and sub- tropics".	11-14 December, 2007 at IARI, New Delhi
12.	Dr. ID Garg, Head, Plant Protection, Ms. Priyanka Kaundal, SRF & Ms. Nimisha Kaushal, SRF, CPRI, Shimla	Symposium on "viruses of ornamental and temperate fruits".	17-18 Dec., 2007 at IHBT, Palampur
13.	Dr. VK Chandla, PS, Ms. Yogeeta Thakur, SRF & Ms. Anupam Sharma, SRF, Plant Protection, CPRI, Shimla	National Symposium on "Plant Protection Option-Implementation and feasibility".	22-23 December, 2007 at National Chemical laboratory (CSIR), Pune (MS)
14.	Drs. BP Singh, Joint Director, CPRIC, Modipuram & JP Singh, PS, CPRS, Jalandhar	International Potato Expo-2008 Kolkata	9-12 January, 2008 at
15.	Dr. VK Chandla, PS, Ms. Yogeeta Thakur, SRF & Ms. Anupam Sharma, SRF, Plant Protection, CPRI, Shimla	Symposium on "Forest insect-pest and diseases management in Himalaya".	10-11 January, 2008 at HFRI, Shimla
16.	Er. Manjit Singh, PS, CPRS, Jalandhar	42nd Annual Convention and Symposium of "Indian Society of Agricultural Engineering (ISAE)"	30th January, 2008 to 5th February, 2008 at CIAE, Bhopal
17.	Dr. MA Khan, Sr. Scientist (Agril. Chemistry), CPRIC, Modipuram	1st International Conference on "Agrochemicals Protecting Crop, Health and Natural Environment"	8-11 January, 2008 at IARI, New Delhi
18.	Dr. Vinay Bhardwaj, Sci (SS), CPRI, Shimla	International conference on "Biodiversity conservation and management (BIOCAM-2008)"	3-6 February, 2008 at Cochin University of Science and technology, Cochin
19.	Dr. (Mrs.) Ashiv Mehta, PS, CPRS, Jalandhar & Er. Manjit Singh, PS, CPRS, Jalandhar	One day Interaction on "Tools and Machinery for development of Horticulture".	18th January, 2008 at CISH, Lucknow
20.	Dr. BP Singh, Joint Director, CPRIC, Modipuram	One day conference on "Interface with stakeholders on promotion of secondary agriculture".	30th January, 2008 at Library Avenue, IARI, New Delhi
21.	Drs. S. Ramani, Act. Head, CPRS, Shillong, R. Roy Burman, Sci. (SS) & Sh. P.R. Khounghuh, FFT, CPRS, Shillong	National Seminar on "Integrated Farming Systems Relevant to NE Region & NEA Fair, 2008"	6-9 February, 2008 at College of veterinary Science & Animal Husbandry, Aizwal, Mizoram.
22.	Drs. KC Sud, PS & MK Jatav, PS, CPRI, Shimla	National seminar on "Application of Radioisotopes and Radiation Technology (ARRT-2008)"	7-8 February, 2008 at Guru Nanak Dev Univ., Amirtsar (Pb.)
23.	Ms. Yogeeta Thakur, SRF, Plant Protection, CPRI, Shimla	2nd Congress on "Insect Science".	21-22 February, 2008 at PAU, Ludhiana
24.	Dr. RS Marwaha, PS, CPRS, Jalandhar	Seminar on "Scientific Interments for food & Agricultural Research"	26th February, 2008 to 17th March, 2008
25.	Dr.(Mrs.) V. Sunaina, PS, CPRIC, Modipuram	National conference "Showcasing cutting edge science & technology by women"	8-9 March, 2007 held at Vigyan Bhawan, New Delhi

Expenditure and Receipts 2007-2008

A. Classified abstract of expenditure in respect of 'Non-Plan' 2007-2008

Sl.No.	Head of Account	Amount (Rs.)
I.	**(A) MAIN INSTITUTE**	
1	Pay of Officers	25595439
2	Pay of Establishment	22118394
3	D.P.	23691858
4	Dearness Allowance	28548727
5	H.R.A.	6378961
6	C.C.A	2162580
7	Other Allowances	4084047
8	Ad-hoc Bonus	1025567
9	Transport Allowance	894327
10	O.T.A.	19752
11	Temporary Status	3501131
	Total Establishment Charges	**11,80,20,783**
II.	**Travelling Allowance**	**9,99,841**
III.	**Annual Maintenace and Repairs**	
a)	Office Building	3772459
b)	Residential Building	812910
c)	Minor Work	1623527
	Total Maintenace and Repairs	6208896
IV.	**Non Recurring Expentiture**	
a)	Land	0
b)	Tools, Plants & Equipments etc.	1877375
c)	Building & Other original Works	0
d)	Typewriter Accounting Machine	0
e)	Furniture, fixture & fitting work	444075
f)	Vehicle including cycles	0
g)	Livestock purchases	0
h)	Library books & Journals	1562302
	Total Assets Acquired	3883752
V.	**Other Recurring Expentiture**	
a)	i)Chemical apparatus & other consumable stores for research work	823587
	ii) Seed	99690
b)	Fertilizer	321688
c)	Feeding & upkeep of animals	24273
d)	Telephone : Office/Residence	349393
e)	Office contingencies	4823861
f)	Other contingencies/Operational Expenses	4880909
g)	Consumable stores	493162
h)	Sports & Tournaments	109654
i)	Lubricants/POL	805393
j)	Electricity charges	3368875
k)	Water charges	115996

Sl.No.	Head of Account	Amount (Rs.)
l)	Rent/Lease	0
m)	MC/Road taxes	86121
n)	Animals required for research work	0
o)	Printing & Binding	753093
p)	Postage	256062
q)	TA to members of selection committee	0
r)	TA to candidate (in the Institute)	0
s)	TA/DA to non-officials	318612
t)	Research schemes, fellowships, scholarships and awards	0
u)	Seminars & conferences	304610
v)	Stationary	387991
w)	Refreshment	28401
x)	Watch & Ward	1235906
	Total Rs.	**14,77,65,202**

B. Classified abstract of expenditure in respect of 'Plan' 2007-2008

I.	**Establishment Charges**	
1.	Pay of Officers	-
2.	Pay of Establishment	-
3.	D.P.	-
4.	Dearness Allowance	-
5.	H.R.A.	-
6.	C.C.A	-
7.	Other Allowances	-
8.	Ad-hoc Bonus	-
9.	Transport Allowance	-
	Total Establishment Charges	
	Wages	
II.	**Travelling Allowance**	**1199859**
III	**Non Recrring (Assets)**	
a)	Land	0
b)	Tools, Plants & Equipments	9529602
c)	Building & Other Original Works	9187352
d)	Typewriter Accounting Machine	0
e)	Furniture, fixture & fitting work	0
f)	Vehicles including cycles	0
g)	Livestock purchases	0
h)	Library books & Journals	2006155
	Total Assets Acquired	20723109
IV	***Other Recurring Expenditure***	
a)	Chemical, apparatus & other consumable stores for research work	3578859
	Seed	106094
b)	Fertilizer	1447865
c)	Feeding & upkeep of animals	0
d)	Telephone : Office/Residence	103889
e)	Office contingencies	1876139

Sl.No.	Head of Account	Amount (Rs.)
f)	Other contingencies/Operational Expenses	900700
g)	Consumable stores	1038620
h)	Lubricants/POL	214850
i)	Electricity charges	964563
j)	Water charges	0
k)	Rent	0
l)	MC/TC Road taxes	45042
m)	Animals required for research work	0
n)	Postage Stamp	42400
o)	Stationary	117590
p)	TA to members of selection committee	0
q)	TA to candidate	0
r)	TA/DA to non-officials	11817
s)	Research schemes, fellowships, scholarships and awards	0
t)	Seminars & conferences	41400
u)	Printing & Binding	135916
v)	Watch & Ward	0
vi)	Farm Operation Work	651097
	Total Rs.	**33199809**

C. Summary abstract of expenditure & receipts in respect of Pension, Plan, Non-Plan, RD Projects, AP-cess Schems, IRGS and RFS 2007-2008

1	Pension and other retirement benefits	29639460
2	Plan Scheme funded from Plan budget of the Council	22528000
3	Loans and Advances	1559617
4	R-Deposit	31618703
5	Revolving Fund Scheme	47025539
6	A.P. Cess Scheme	2632179
7	Transaction under IRGS	2039448
8	Schedule funded from NP Budget of Council	0
	Total	**137042946**
A.	NON-PLAN	148700549
B.	PLAN	33199809
C.	OTHERS	137042946
	Total: A +B+C	**318943304**
	Receipts 2006-2007	
A.	1. Sale proceeds from farm produce	11608131
	2 Sale proceeds of fruits/vegetable	38252
	3 Rent	571880
	4 Application fee from candidates in respect of recruitment	
	5 Interest on Loand & Advances granted to Councils employees	802075
	6 Machine & Vehicle	85850
	7 Miscellaneous	1183284
	8 Leave Salary & Pension Contribution	188736
	9 Receipts from services rendered by Institute	594100
	10 IRGS	2434123
	Total Receipts	**17506431**
B.	**Revolving fund scheme**	**36006903**
C.	**Interest on Short term deposits**	**669259**

PROMOTIONS/RETIREMENTS/TRANSFERS/DEATHS

Promotions

1. Dr. S Ramani promoted to the post of Principal Scientist under CAS w.e.f. 27.7.2006
2. Dr. NK Pandey promoted to the post of Principal Scientist under CAS w.e.f 27.07.06
3. Sh. Anil Kumar, SS Gr. III, CPRI, Shimla. promoted to T-I (FFT) under 33 ½ % quota from Group 'D' staff and joined his duties as T-I at CPRI, Shimla on 11.7.07(FN)
4. Sh. Ram Dayal, SS Gr. III, CPRI, Shimla promoted to T-I (FFT) under 33 ½ % quota from Group 'D' staff and joined his duties as T-I at CPRI, Shimla on 10.7.07 (AN)
5. Sh. Dev Raj, SS Gr. I, CPRI, Shimla promoted to T-I (FFT) under 33 ½ % quota from Group 'D' staff and joined his duties as T-I at CPRI, Shimla on 10.7.07 (AN)
6. Sh. Mohan Lal, SS Gr. I, CPRI, Shimla promoted to T-I (FFT) under 33 ½ % quota from Group 'D' staff and joined his duties as T-I at CPRI, Shimla on 10.7.07 (AN)
7. Sh.S. Nongrum, SS Gr.I, CPRS, Shillong promoted to T-I (FFT) under 33 ½ % quota from Group 'D' staff and joined his duties as T-I at CPRS, Shillong on 10.7.07 (FN)
8. Sh. Prithi Singh, SS Gr. III, CPRS, Jalandhar promoted to T-I (FFT) under 33 ½ % quota from Group 'D' staff and joined his duties as T-I at CPRS, Jalandhar on 10.7.07 (FN)
9. Ms. Teirina Nungkhla, Sr. Clerk, CPRS, Shillong has been granted IInd Financial upgradation in the pay scale of Rs. 5500-175-9000 w.e.f. 17.3.2007
10. Ms. Pomilian Syiem, Sr. Clerk, CPRS, Shillong has been granted IInd Financial upgradation in the pay scale of Rs. 5500-175-9000 w.e.f.18.3.2007
11. Sh. Didar Singh, Assistant, CPRS, Jalandhar Promoted to the post of AAO w.e.f. 20.9.2007 (A/N) at CPRS , Jalandhar.
12. Sh. Rakesh Negi, SS Gr.I, CPRI, Shimla Promoted to the post of LDC through LDCE w.e.f. 18.10.2007
13. Sh. Raghubir Singh, SS Gr.I, CPRI, Shimla Promoted to the post of LDC through LDCE w.e.f. 19.11.2007 and joined at CPRIC, Modipuram
14. Sh. Naresh Kumar, SS Gr. II, CPRI, Shimla Promoted to the post of LDC through LDCE w.e.f. 16.11.2007 and joined at CPRS, Jalandhar.
15. Sh. Jai Ram Thakur, Sr. Clerk, CPRI, Shimla granted IInd financial up gradation in the pay scale of Rs. 5500-175-9000 w.e.f. 7.1.2008
16. Sh. Rajesh Kumar, Steno Gr. III, CPRIC, Modipuram granted first Financial up gradation in the pay scale of Rs. 5500-175-9000 w.e.f. 29.2.2008
17. Sh. Sandeep Verma, LDC, CPRI, Shimla granted first financial up gradation in the pay scale of Rs. 4000-100-6000 w.e.f. 15.3.2008
18. Sh. Deep Ram, LDC, CPRI, Shimla granted first financial up gradation in the pay scale of Rs. 4000-100-6000 w.e.f. 15.3.2008

19. Sh. Basdeo Rai, SS Gr. III to IV CPRS, Patna

20. Sh. Munshi Lal, SS Gr. II to III, CPRIC, Modipuram

21. Sh. Rajbir, SS Gr. II to III, CPRIC, Modipuram

Appointments

1. Dr. S Ramani joined as Head, CPRS, Shillong in the FN of June 27, 2007

Transfers

1. Dr. KP Chandran resigned from Council's service in August 2007

2. Dr. JS Gawande transferred to CICR, Nagpur

3. Sh. Kuldeep Singh, T-2 joined at CPRI, Shimla on Inter-institutional transfer from CIFRI Regional Station Karnal on 10.4.2007 (FN)

4. Sh. Tilak Raj, T-4 (FFT), Transferred from CPRI, Shimla and joined at CPRS, Kufri on 7.3.2008 (FN)

Retirements

1. Dr. SN Singh, Sr. Scientist (Soil Science.) CPRS, Patna, retired on 30.4.2007

2. Dr. Sarveshwar Dayal, Scientist (SS), CPRS, Shillong Compulsory retired w.e.f 05.11.2007

3. Dr. Yash Gupta, Sr. Scientist, CPRS, Shillong Compulsory retired w.e.f 17.01.2008

4. Dr. Ram Kishore, PS, CPRIC, Modipuram retired after attaining the age of superannuation on 31.01.2008.

5. Sh. Shiv Dutt, T-5, CPRIC, Modipuram retired on 31.7.2007

6. Sh. Bhartji Chaturvedi, T-5 CPRIC, Modipuram retired on 31,10.2007

7. Sh. A. Kadirvelu, AAO, CPRIC, Modipuram retired on 30.4.2007

8. Sh. R.S. Yadav, AAO, CPRS, Jalandhar retired on 30.6.2007

9. Sh. Shridama Chaturvedi , Assistant, CPRS, Gwalior retired on 31.7.2007

10. Sh. Daya Ram, SS Gr. IV, CPRI, Shimla w.e.f. 31.3.2008

Personnel

Scientific, Technical (T-5 & above) & Administrative staff (AAO & above) at CPRI, Shimla & its Regional Stations as on 31.03.2008

HQ CPRI, Shimla
Director: Dr. SK Pandey

Technical Information Cell
1. Dr. KC Sud PS & PIO
3. Sh. RS Mehta, Private Secy.

AICPIP Unit
1. Dr. PS Naik, PS & Project Coordinator
2. Dr. KC Thakur, Sr. Scientist
3. Sh. Dharminder Verma, TO (T-5)

Divn. of Crop Improvement
1. Dr. Jai Gopal, PS
2. Dr. SK Chakrabarti, PS
3. Dr. SK Kaushik, Sr. Scientist
4. Dr. D. Sarkar, Sr. Scientist
5. Dr. D. Pattanayak, Sr. Scientist
6. Dr. Vinay Bhardwaj, Scientist (SS)
7. Sh. A.Chanemougasoundharam, Scientist
8. Mrs. Shelly Chopra, TO(T-5)
10. Mrs. Tarvinder Kochhar, TO(T-5)
11. Sh. V.K. Awasthy , TO (T-5)

Division of Seed Technology
1. Dr. Sarjeet Singh, PS & Head
2. Dr. EP Venkatasalam, Scientist
3. Sh. Parvesh Jassal, TO (T-5)

Division of Crop Production
1. Dr. S.S. Lal, PS & Head
2. Dr. M.C. Sood, PS
3. Dr. KC Sud, PS
4. Dr. PM Govindakrishnan, PS
5. Dr. VK Dua, Sr. Scientist
6. Sh. MK Jatav, Scientist
7. Sh.Kameshwar Sen, TO (T-5)
8. Sh. Yogesh, TO (T-5)

Division of Social Sciences
1. Dr. NK Pandey, PS & Acting Head
2. Dr. Rajesh Kumar Rana, Sr. Scientist
3. Dr. Anil Kumar, Scientist(SS)
4. Sh. Arun Pandit, Scientist
5. Sh. DC Chandel, TO, T (7-8)
6. Sh. BS Latwal, TO T (7-8)
7. Sh. Sham Sunder TO (T-5)

Division of Plant Protection
1. Dr. ID Garg, PS & Head
2. Dr. VK Chandla, PS
3. Dr. PH Singh, PS
4. Shri Ranjit Singh, TO (T-5)
5. Sh. KS Negi, TO (T-5)

Division of Crop Phy. & PHT
1. Dr. R. Ezekiel, PS & Head
2. Dr. JS Minhas, PS
3. Dr. Brajesh Singh, Sr. Scientist

ARIS Cell
1. Sh. Shashi Rawat, Scientist (SS)
2. Mrs. GVV Shyamala Jyoti, Scientist

Engineering Section
1. Shri RK Chauhan, Instrument Engineer (T-9)
2. Sh. Kana Singh,TO(T-5)
3. Sh. Gulzar Singh,TO(T-5)
4. Sh. Harvinder Singh, TO (T-5)

Library Section
1. Sh. Rakesh Mani Sharma, TO (T-6)
2. Sh. Surinder Pal, TO (T-5)

Administrative Staff
1. Sh. A.K. Singh, Sr. Admn. Officer
2. Mrs. Kamlesh Sharma, Fin. & Acct. Officer
3. Sh. RL Chauhan, Asstt. Fin. & Accts. Officer
4. Sh. AS Negi, AAO
5. Sh. AD Sharma, AAO
6. Sh. AS Keprate, AAO
7. Sh. Inder Singh Negi, AAO
8. Sh. Hira Nand Sharma AAO
9. Sh. Parveen Chandla, Asstt. Director (OL)
10. Sh. RS Mehta, PS

CPRI Campus, Modipuram
1. Dr. Birpal Singh, Joint Director
2. Dr. (Mrs.) V. Sunaina, PS
3. Dr. OP Singh, PS
4. Dr. DB Singh, PS
5. Dr. NC Upadhayay, PS
6. Dr. Satya Vir Singh, PS
7. Dr. Raj Pal Singh, PS

8. Dr. PC Pande, PS
9. Dr. Shiv Kumar, PS
10. Sh. Rambir, Sr. Scientist
11. Sh. CK Sharma, Sr. Scientist
12. Dr. (Mrs.) Kamlesh Malik, Sr. Scientist
13. Dr. SK Luthra, Sr. Scientist
14. Dr. Name Singh, Sr.Scientist
15. Dr. Dinesh Kumar, Sr. Scientist
16. Dr. Devandra Kumar, Sr. Scientist
17. Dr. Vinay Singh, Sr. Scientist
18. Dr. M Narayan Bhat, Sr. Scientist
19. Dr. RK Verma, Sr. Scientist
    (Presently working with CITH, RS,Mukteshwar)
20. Dr. Praveen Kumar, Sr.Scientist
21. Er. Sukhwinder Singh, Scientist (SS)
22. Sh. Sanjay Rawal, Scientist (SG)
23. Sh. Dhruv Kumar, Scientist (SG)
24. Dr. MA Khan, Scientist (SS)
25. Sh. RK Verma, Farm Supdt. T(7-8)
26. Sh. Islam Ahmad, (T-7-8)
27. Sh. Balak Ram Singh, TO (T-6)
28. Sh. Mahesh Kumar, TO (T-6)
29. Sh. Harvir Singh, TO (T-5)
30. Sh. Satender Kumar, TO (T-5)
31. Sh. Ashok Kumar, TO(T-5)
32. Sh. Krishan Singh, TO(T-5)
33. Sh. Ramesh Chand, TO(T-5)
34. Sh. RK Sharma TO (T-5)
35. Sh. Shiv Bir Singh Parihar TO (T-5)
36. Sh. NK Sud TO (T-5)
37. Sh. Barlbir Singh TO (T-5)
38. Sh. Nawab Ali. TO (T-5)

CPRS, Jalandhar

1. Dr. GS Kang, PS & Head
2. Dr. RK Arora, PS
3. Dr. JP Singh, PS
4. Dr. (Mrs.) Ashiv Mehta, PS
5. Er. Manjit Singh, PS
6. Dr. RS Marwaha, PS
7. Dr. SP Trehan, PS
8. Dr. Raj Kumar, Sr.Scientist
9. Er. Sunil Gulati, Scientist (SG)
10. Sh. Gurmail Singh, T-6 (Farm Supdt.)
11. Sh. Ashwani Kumar Sharma, TO (T-6)
12. Sh. Didar Singh, AAO
13. Sh. JS Jassal, TO (T-5)
14. Sh. Hoshiar Singh, TO(T-5)
15. Sh. Raj Kumar, TO (T-6)
16. Sh. YK Gupta, TO (T-5)
17. Sh. Munna Lal, TO (T-5)
18. Sh. VK Dhir, Private Secretary
19. Sh. Kapil Kumar Sharma, TO (T-5)
20. Sh. Satnam Singh Randhawa, TO (T-5)
21. Sh. Jagdish Chand, TO (T-5)
22. Sh. Tarlochan Singh, TO (T-5)
23. Sh. Surinder Singh Duala, TO (T-5)
24. Sh. Jaswinder Singh, TO (T-5)
25. Sh. Desh Raj, TO (T-5)
26. Sh. Gurnam Dass TO (T-5)

CPRS, Gwalior

1. Dr. VS Kushwah, PS & Head
2. Dr. AK Somani, PS
3. Dr. Anuj Bhatnagar, Sr. Scientist
4. Dr. Shiv Pratap Singh, Sr.Scientist
5. Sh. Vinod Kumar, Scientist
6. Sh. Athimoolan, AAO
7. Sh. AMR Sawaly, Field Supdt. (7-8)
8. Sh. Ram Charan Dass, TO (T-5)

CPRS, Shillong

1. Dr. S. Ramani, Principal Scientist & Head
2. Dr. RR Burman, Acting Head
3. Dr. Vijai Kishore Gupta, Scientist (SS)
4 Dr. KM Nagaraj , Scientist

CPRS, Muthorai

1. Dr. TA Joseph, Sr. Scientist & Acting Head
2. Dr.(Mrs.) K.Manorama, Sr.Scientist
3. Dr. N. Somasekhar, Sr, Scientist
4. Sh. G.Ravichandran, Scientist(SS)
5. Dr. R. Muthu Raj, Scientist (SS)

CPRS, Kufri

1. Dr. KR Dhiman, PS & Head
2. Dr. YK Sharma, Sr. Scientist
3. Sh. Ashwani Kumar Sharma, Scientist (SS)
4. Dr. Vinod Kumar, Sr. Scientist
5. Sh. Jagtar Singh, AAO
6. Sh. SK Awasthy, TO (T-5)
7. Sh. Brij Mohan, TO (T-5)

CPRS, Patna

1. Dr. RP Rai, PS & Head
2. Dr. Gulab Ram, PS
3. Dr. Shambhu Kumar, Sr. Scientist
4. Dr. Manoj Kumar, Sr. Scientist
5. Dr. SK Singh, Sr. Scientist
6. Dr. Barsati Lal, Scientist(SS)
7. Sh. TK Sinha, TO (7-8)
8. Dr. Kopil Dey, TO (T-6)
9. Sh. Arun Kumar Singh, TO (T-6)
10. Sh. P. Rajendran, AAO
11. Sh. SK Rastogi TO (T-5)

Staff Position as on 31.3.2008

Scientific Category

Scientific category	Shimla	Mod	Jal.	Patna	Shill.	Gwlr	Ooty	Kufri	Total
Director	1	-	-	-	-	-	-	-	1
PC	1	-	-	-	-	-	-	-	1
Pr. Scientist	12	9	7	2	1	2	-	1	34
Sr. Scientist/ Scientist(SG)	8	15	2	3	-	2	4	2	36
Scientist (Sr.Scale)	3	-	-	1	2	1	1	1	11
Scientists	4	-	-	-	1	-	-	-	7
Total	**33**	**24**	**9**	**6**	**4**	**5**	**5**	**4**	**90**

Administrative Category

Name of the Post	Shimla	Mod.	Jal.	Patna	Shill.	Gwlr.	Ooty	Kufri	Total
SAO	1	-	-	-	-	-	-	-	1
SFACO/F&AO	1	-	-	-	-	-	-	-	1
AO	-	-	-	-	-	-	-	-	-
AAO	5	-	1	1	-	1	-	1	09
AFACO	1	-	-	-	-	-	-	-	1
AD(OL)	1	-	-	-	-	-	-	-	1
Asstt.	15	2	2	2	1	-	1	1	24
Sr.Clerk	17	3	5	-	2	-	1	1	29
LDC	15	5	1	3	-	5	-	1	30
Private Secy	1	-	1	-	-	-	-	-	2
Sr.Steno.	2	-	-	-	-	-	-	-	2
PA	5	1	-	1	-	-	1	-	8
Jr.Steno.	4	1	-	-	-	-	-	-	5
Total	**68**	**12**	**10**	**7**	**3**	**6**	**3**	**4**	**113**

Technical Category

Grade	**Shimla**	**Mod.**	**Jal.**	**Patna**	**Shill.**	**Gwlr.**	**Ooty**	**Kufri**	**Total**
Instrument Engg. (T-9)	1	-	-	-	-	-	-	-	1
TO T(7-8)	2	2	1	1	-	1	-	-	7
TO (T-6)	1	3	2	2	-	-	-	-	8
TO (T-5)	15	13	13	1	-	1	0	2	45
Techn.(T-4)	8	14	4	6	1	6	3	3	45
Techn. (T-3)/T-I-3	7	4	1	4	2	-	-	1	19
Techn.(T-2)	24	6	5	8	3	4	1	3	54
Techn.(T-1)	6	2	2	-	2	1	1	1	15
Total	**64**	**44**	**28**	**22**	**8**	**13**	**5**	**10**	**194**

Supporting Staff

Grade	Sanctioned	Filled	Vacant
SS Grade-I	86	60	26
SS Grade-II	65	63	02
SS Grade-III	39	39	-
SS Grade-IV	18	17	01
Sub Total	**208**	**179**	**29**
Canteen Staff			
Cook	1	1	0
Tea Maker	1	1	0
Wash Boy	1	1	0
Grand Total	**211**	**182**	**29**

Station-wise/Grade-wise list of Supporting Staff

Station	Grade-IV	Grade-III	Grade-II	Grade-I	Total
Shimla	05	13	06	13	37+3* canteen staff
Kufri	03	05	03	05	16
Patna	02	04	09	06	21
Jalandhar	01	03	16	08	28
Modipuram	01	05	12	04	22
Shillong	04	06	-	-	10
Muthorai	-	02	-	06	08
Gwalior	01	01	17	18	37
Total	**17**	**39**	**63**	**60**	**179+3*=182**

***3 Posts of Canteen Staff**

Staff position as on 31.3.2008 of CPRI showing number of SCs, STs, OBCs & Women

Category	Sanctioned	Total Filled	SC	ST	OBC	Women
Scientific	109*	90*	11	02	06	06
Administrative	122	113	25	08	06	28
Technical	207	190	44	08	12	11
Supporting	211	172+*3	59	09	10	22
Total	**649**	**570**	**139**	**27**	**36**	**67**

*** Excluding 1 RMP**
***3 posts of Canteen staff**

CENTRAL POTATO RESEARCH INSTITUTE

(Indian Council of Agricultural Research)

SHIMLA - 171 001, HP (India)

Phone : Director : (0177) 2625073, Project Coordinator, AICPIP : (0177) 2624398
Sr. Administrative Officer : (0177) 2627269, Website : htpp://crpi.ernet.in
E-mail : dircpri@sancharnet.in
Gram : POTATOSEARCH, SHIMLA - 171 001

EPABX : 2624830, 2625182, 2625074, 2621480, 2625181, 2624575, 2625692, 2624501, 2624923
Fax No. 0177-2624460

Important Extension Numbers

Director	101	Head, Crop Physiology and Post Harvest Technology	451
Project Coordinator, AICPIP	201	Head, Plant Protection	401
Sr. Administrative Officer	301	Head, Crop Improvement	501
Finance & Accounts Officer	302	Head, Social Sciences	561
PA to Director	102	Head, Crop Production	251
Library	110	Head, Seed Technology	431
Security Post, Main gate	579	Entomology Sec., Lower Lab.	Phone: 2674326

CPRI Campus & Stations

Joint Director, CPRIC, Modipuram - 250 110, Uttar Pradesh	0121-2950297
Head, CPRS, Jalandhar - 144 003, Punjab	0181-2791474
Head, CPRS, Patna - 801 506, Bihar	0612-2224218
Head CPRS, Gwalior - 474 006, Madhya Pradesh	0751-2470302
Head, CPRS, Muthorai - 643 003, Tamil Nadu	0423-2550669
Head, CPRS, Shillong - 793 009, Meghalaya	0364-2560885
Head, CPRS, Kufri - 171 012, Himachal Pradesh	0177-2648234


CPRI