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Preface

It is remarkable that the 'humble tuber' made a spectacular journey from Andes to the rest of the world within a short span of about five centuries, and conquered the hearts of billions through its time tested virtues. Such is its impact that potato is now regarded as the millennium crop for food security and sustainability. Potato has made a marvellous growth in India after its introduction in 17th century that have placed India as the second largest potato producing nation and help reach all time high production of approx. 36 million tonne from 1.8 million ha of land in 2009-10. It is a reflection of dedicated and determined efforts of Central Potato Research Institute in all spheres of potato research and development. Nothing can be more satisfying than to be associated as Director of this prestigious institute and present its research achievements for the year 2010-11.

Record potato production during 2009-10 was partly due to favourable weather condition and partly due to sustained and concerted efforts of scientific potato fraternity. However, this achievement has put onus on us to maintain this upwardly trend. Year 2010-11 bears testimony to many remarkable achievements made by the institute. The national gene bank of potato exceeded 3900 accessions/parental lines which are being conserved in field, *in vitro* repository and also as true seeds (TPS). Institute's relentless efforts towards development of improved cultivars carrying adaptability to different agro-climatic conditions of the country and resistance to important diseases and pests resulted in introduction of three advance stage hybrids into AICRP for multi-location testing. Share of tissue culture based production of breeders seed is on the rise reaching 28% during the current year. A commercial scale aeroponic system with 2600 plants capacity along with green house was developed at CPRIC, Modipuram to augment disease-free potato seed production. GIS and crop modeling is being employed for prediction of acreage and production of potato in Punjab, Uttar Pradesh, Bihar and West Bengal in collaboration with ISRO, Ahmedabad. Although results so far have been satisfactory but there is still scope for improvement. Biotechnological tools have increasingly been used for solving intractable problems. Institute has developed late blight resistant transgenic potato and somatic hybrids. Besides, RNAi lines for cold chipping, late blight and virus resistance are at different stages of evaluation. DNA fingerprinting techniques, like AFLP and SSR, were used to monitor the population dynamics of late blight pathogen, *Phytophthora infestans*. Although, the genetic diversity of the pathogen is very high in India, the indigenously developed JHULSACAST model successfully forecasted late blight appearance in north-west Indo-Gangetic plains. Dip-stick assay kits for the detection of potato viruses like PVX, PVY, PVS, PVA and PVM have been developed which will soon be commercialized. The report contains detailed account of not only the aforesaid technologies but also several other such important technologies which are not reflected here for want of space and brevity.

I sincerely appreciate all the CPRI staff members for their devoted work in bringing out a comprehensive report. My candid thanks are due to Joint Director, CPRIC, Modipuram, Project Coordinator, AICRP (Potato) and all the Heads of Divisions for their cooperation and help by timely submission of the reports. The efforts of Drs. VK Dua, Brajesh Singh, Vinay Sagar, Sanjeev Sharma, D Pattanayak and Dhiraj K Singh in the process of editing this document were appreciable. I earnestly thank Drs. Rajesh K Rana and Vinay Bhardwaj for final editing of the report. Finally, I express my gratitude to Director General, ICAR, Deputy Director General (Horticulture) and Members of our Research Advisory Committee for their suggestions in orienting and improving the research programmes of the institute.


(BP Singh)
Director

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Introduction



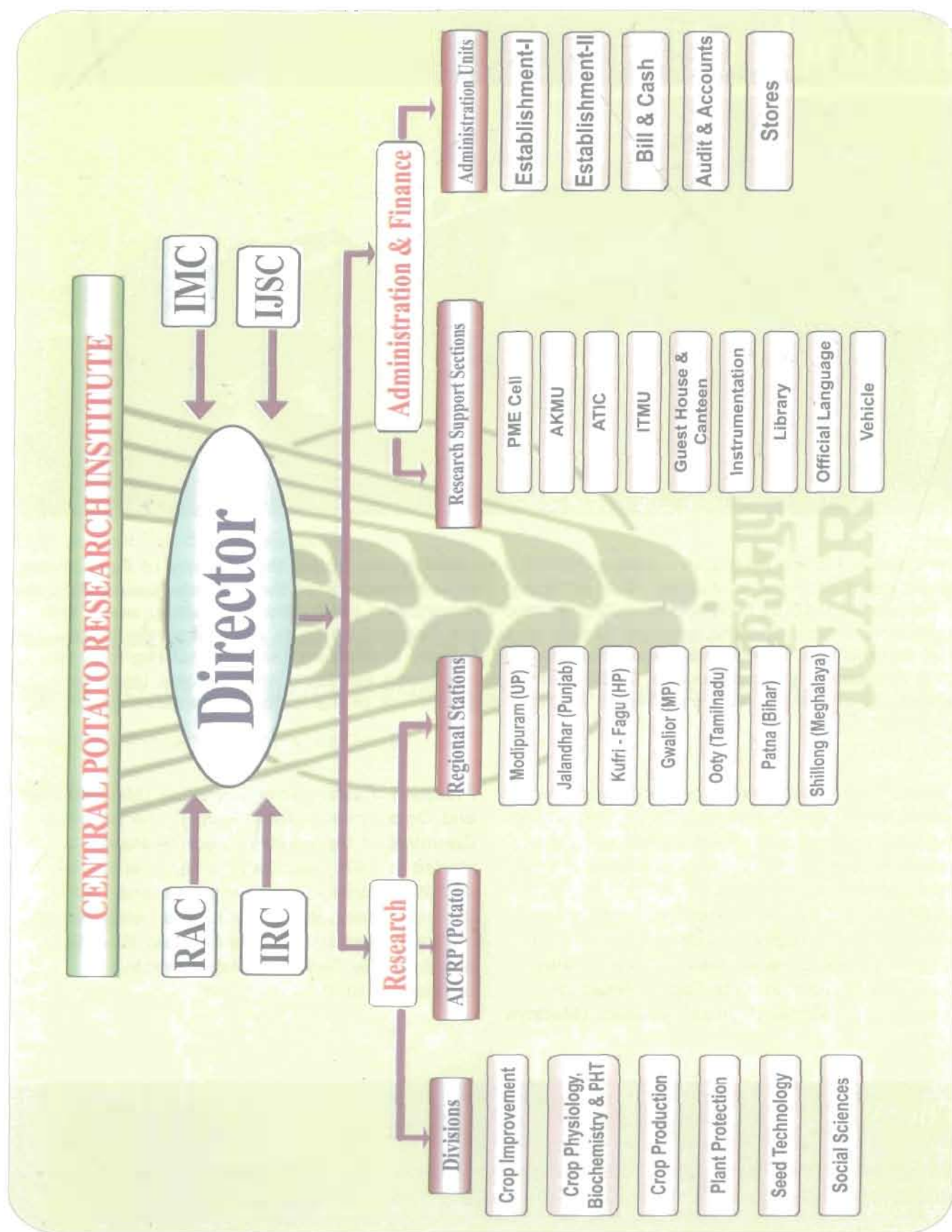
The Central Potato Research Institute (CPRI) was established under the Ministry of Agriculture, Government of India, in August 1949 at Patna. The headquarters of the Institute was shifted to Shimla in 1956 to facilitate breeding of new cultivars and production of healthy seed. The institute is situated in the heart of Shimla city, near Bemloe, which is approximately 4 kms from Shimla Bus Stand and 6 kms from Shimla Railway Station on the National Highway No. 22. It is located 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 institute 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 (Uttar Pradesh) and 6 regional research stations in different potato growing areas of the country. These are located in Kufri-Fagu (Himachal Pradesh), Jalandhar (Punjab), Gwalior (Madhya

Pradesh), 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. Work of the Institute is being carried out by a team of dedicated potato Scientists supported by Technical, Administrative & Supporting Staff.

The Mission

Carry out research, education and extension on potato in collaboration with national and international partners for enhancing productivity and profitability, achieving sustainable food and nutritional security, and alleviating rural poverty.



Mandate

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; Plant Protection; Crop Production; Crop Physiology, Biochemistry & Post Harvest Technology; Seed Technology; and Social Sciences under 17 well defined research programmes. In addition to regular research programme, 22 externally funded research projects sponsored by the ICAR, CIP, ABSP-II (USAID), AP Cess Fund, DBT, NABARD (RIF), & Mini Mission-I are also under operation. Production of Breeders' seed is being done by the Institute under a Revolving Fund Scheme and National Seed Programme.



Achievements of the Institute

- Established a germplasm collection, which presently has about 1300 accessions of *Solanum tuberosum* ssp. *tuberosum*, and 1000 accessions of *Solanum tuberosum* ssp. *andigena* and more than 200 accessions of wild and semi-cultivated species. This collection is being maintained in *in vitro* and *in vivo* form. Potential lines resistant to late blight, potato tuber moth, charcoal rot, common scab, etc, were identified from this collection.
- Developed the "Seed Plot Technique" which made it possible to carry out disease free seed production in the plains and established a national disease-free seed production programme for hills and plains, utilizing the low aphid periods identified in the plains.
- Good quality seed tubers are now available in sufficient quantity as a result of basic seed production programme of CPRI. The availability of disease free seed is a major cause for the significant increase in potato production in the country.
- Identified suitable parental lines for production of botanical seed and developed technology for raising a commercial crop using true potato seed (TPS).
- Developed recommendations for fertilizer application and other cultural practices for potato under diverse agro-climates of the country. These were based on studies on the dosage, placement, form, timing, yield responses, residual effects, and interactions of nitrogen, phosphorus and potassium fertilizers, micronutrients and organic manures, seed size and spacing, minimizing wastage of irrigation water; and the control of weeds.
- Developed efficient methods of testing soils and plant tissues for identifying nutrient deficiencies.
- Identified profitable potato-based cropping systems in different agro-climates, including inter-cropping of the potato with sugarcane and wheat, and worked out optimal schedule for weed management, fertilizer and manure application.
- Developed agricultural implements for mechanizing potato cultivation, including an oscillating tray type potato grader, fertilizer applicator-cum-line marker, soil crust brakers, granular insecticide applicator, two/four row automatic potato planter, culti-ridger and potato digger.
- Identified race-non-specific late blight resistance in Indian cultivars and hybrids and the components of such resistance. Developed a late blight forecasting system 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.
- Demonstrated the association of mycoplasmas with purple top roll, marginal flavescence, and tomato spotted wilt virus (TSWV) with stem necrosis of potato and identified their vectors.
- Conducted periodic surveys of the potato crop in Darjeeling hills, which showed the continued presence of the wart pathogen in spite of saturation of many areas with wart resistant varieties, indicating the need for continued and intensified regional quarantine.
- Conducted aphid surveys that led to the identification of low aphid periods for growing seed potatoes.
- Demonstrated the efficacy of bio-products like *Lantana* leaves, Granulosis virus and pheromones in reducing potato tuber moth damage. Identified a number of predators and parasites that have the potential for biological control of potato tuber moth.
- Identified two cyst nematode species *Globodera rostochiensis* and *G. pallida* in Nilgiri and Kodaiknal hills and developed control measures based on long-term rotation, nematicides and the growing of

resistant varieties.

- Carried out basic studies on photosynthesis and its relationship with tuber yields, which generated new information on inter-genotypic, leaf age dependent, seasonal and diurnal variations in photosynthetic rate and its modification by leaf water deficits and light intensity.
- Developed methods of screening for high thermo-period resistance and used them to select heat resistant 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.
- Established relationship between low reducing sugars content and good chipping quality when grown in the North Indian plains.
- Demonstrated the efficiency of chemical control of sprouting during non-refrigerated storage and the feasibility of on-farm storage of potatoes in the western part of the North Indian plains for 3-4 months in an insulated potato store equipped with passive evaporative cooling.
- Studied morphological, anatomical, and physiological tuber characteristics in relation to keeping quality under refrigerated storage and identified characteristics associated with good keeping quality.
- Standardized tissue culture techniques for micro-propagation, *in vitro* microtuber production and rapid multiplication.
- Identified biocontrol agents for potato tuber moth, bacterial wilt, black scurf and late blight.
- Demonstrated that *Azotobacter* strain can partially supplement the nitrogen requirement of the potato crop in the field.
- Produced transgenic potatoes carrying *cry1Ab* gene for PTM tolerance and *AmA1* gene for better protein quality.
- Created DNA fingerprints of Indian potato cultivars using RAPD and SSR markers.
- Disseminated information and technology through 70 extension and technical bulletins.
- Transferred potato technology under Lab-to-Land, ORP, TAD and other programmes, and used innovative extension techniques like "Potato School on Air" along with impact assessments and constraint analysis of adoption of improved technology.
- Collected and maintained 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 annually on modern methods of potato production and seed certification, apart from Farmers Melas, etc.

Research Highlights during the year

- The National repository of potato germplasm was enriched by adding 20 new accessions and now it has more than 3900 accessions.
- Registered a clone YY6/3 C-11 of cultivated species possessing PVY extreme resistance gene.
- Three advanced hybrids namely MS/5-1543, PS/03-2 and PS/04-5 were introduced in AICRP (Potato) for multilocation testing.
- Among the seven transgenic lines of Kufri Chipsona (with RNAi gene construct) one was selected for cold chipping attributes after 90 days of cold storage.
- Developed decision support system for potato crop scheduling in the Nilgirs.
- Estimated potato acreage and production through remote sensing, GIS and crop modeling in the states of Punjab, UP, Bihar and West Bengal.
- Prepared GEO reference maps of available soil nutrients for potato growing areas of Jalandhar (Punjab).
- Water use efficiency of potato was 177, 170 and 93 kg tubers per ha-mm water with drip, sprinkler and furrow irrigation methods respectively.
- In long term manurial / fertilizer experiment, soil physical properties like *in situ* infiltration rate, saturated hydrolic conductivity and porosity were higher in maize- potato-onion than in rice-potato-wheat system.
- Developed an aeroponic system with the locally available materials.
- A PCR based protocol was validated to detect latent infection of *Phytophthora infestans* in seed potato tubers. This could detect the infection up to 20 mm away from the disease lesion.
- The hybrids LBY-15, LBY-17 and SM/92-338 possessing combined resistance to late blight and PVY were selected for introduction into AICRP (Potato) for multiplication trials.
- PCR and RT-PCR protocols for PALCV, PVX, PLRV, PVY, PVS and PSTVd and real time PCR protocols for PALCV, PLRV and PVY have been standardized.
- PALCV infected samples were collected from different parts of the country and coat protein gene of eighty PALCV isolates were amplified and sequenced.

- Collected and maintained 29 isolates of *Ralstonia solanacearum*, 21 of *Rhizoctonia* and 20 of *Fusarium* spp. Identified 47 isolates of *R. solanacearum* by PCR using specific markers Y2 and OLI1. Determined biovar of 47 *R. solanacearum* isolates collected from different parts of the country.
- Soil solarization together with incorporation of stable bleaching powder @ 3q/ha was found effective for control of russet scab disease of potato.
- Application of thiacloprid (0.3 & 0.4%) along with summer oil (0.06%) gave longer protection against aphids while application of thiacloprid alone was effective against whitefly.
- Monocropping of potato hybrid OS/93-D-204 in potato cyst nematode infested plots in Nilgiris resulted in the lowest PCN population followed by the recommended practice of growing potato + French beans intercropping in the autumn season.
- Improved ventilation in cold storage varandha at Satnam Agri Products, Jalandhar helped in maintaining better quality of potatoes (25000 q of Chipsona – I) for flakes making.
- Blending of potato flour with banana flour (50% + 50%) enhanced nutrients value (free amino acid, soluble protein, total phenols, carotenoids, starch and glucose) in the resultant mix.
- Paclobutrazole, 5ppm spray 20 days after planting improved tuber yield and harvest index by retarding above ground plant growth under heat stress in early crop.
- Use of 1,4 DMN (1,4 -di methylnaphthalene) was found to enhance dormancy of seed tubers.
- CPRI produced 2988.24 t of nucleus and breeder seed during 2010-11 of which 2593.13 t of breeder seed were supplied to various agencies and total revenue of Rs. 3, 70, 83,566 was generated from the sale of breeder seed.
- An average of about 60 mini tubers per plant was produced under areoponic system. The germination of aeroponically produced minitubers varied from 92.3 to 100% and the yield from progeny minituber was recorded from 93.4g plant⁻¹ to 173.2g plant⁻¹.
- A survey conducted revealed that cold storage technology at elevated temperature saved nearly 40% of the power consumption in conventional cold storage.
- A study revealed that domestic seed potato production is saving foreign currency of \$ 102.38 million per year.

Staff & Finance

The Institute has 648 sanctioned staff strength comprising of 109 Scientific, 207 technical, 121 Administrative and 211 supporting staff. The staff position as on 31.03.09 was 549 including 77 Scientific, 188 Technical, 111 Administrative and 173 Supporting staff. The expenditure of the Institute for the year (Plan & Non-Plan & RFS) was Rs 31.82 crores and receipts Rs. 5.19 crores including RFS. The CPRI generated about 16.31 % 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. 353.46 lakhs this year and the scheme has been most successful and widely acclaimed. During the year, one scientist was transferred from CPRI to other institute and eight scientists, six technicians, one administrative and six supporting staff members retired.

Facilities

The Institute created state-of-the-art laboratories for conducting basic and strategic research in the field of biotechnology, genetics and plant breeding, plant protection, soil science and agronomy, plant physiology, biochemistry, and post harvest technology. The CPRI is the first Institute, among plant science research Institutes of India, to introduce ELISA (1984) and ISEM (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 Government of India as 'Accredited Test Laboratory' for testing and certification of tissue culture raised potato microplants and minitubers.

The biotechnology laboratory of the Institute, created in 1992, presently houses all the facilities for transgenic research, DNA fingerprinting, molecular breeding, micropropagation and cryo-conservation. A new laboratory has recently been created for conducting basic research on cell biology and somatic cell genetics. The radio-tracer laboratory of the institute was created in 1996 for carrying out basic research on nutrient dynamics in soil and plant. This laboratory is also helping in molecular diagnosis of plant pathogens and other molecular biology related works. The institute has a well-equipped Fungal Pathology Laboratory that has world-class facility for basic and applied research on late blight pathogen. Besides, the institute also has laboratories for Plant Physiology and Post Harvest Technology works.

The institute has 521 ha farm lands distributed over 15 units for conducting field experiments and undertaking breeders' seed production. CPRI Library is the second largest potato library in the world. Besides, the Institute has well-equipped ARIS cell, ATIC, museum, auditorium, conference hall, committee room at the Hqrs. and similar facilities have been provided at the regional stations. The Institute is fully equipped to organize training programmes with AV aids, hostel, etc. A separate administrative building has been constructed with modern office settings and other facilities. In addition, a new pathology laboratory and two additional rooms for library have been made functional.

Publications

During 2010-11, in addition to Institute annual report, two issues of newsletter, two books and one extension folder were brought out by CPRI. CPRI Scientists published thirty seven research papers in referred journals.

सारांश

फसल सुधार

आलू आनुवंशिक सुधार के लिए तीन अनुसंधान कार्यक्रम चलाए जा रहे हैं। संभाग का मूल कार्य आलू जननद्रव्यों के एकत्रीकरण, संरक्षण, मूल्यांकन व प्रलेखन प्रबन्धन एवं पूर्व-प्रजनन द्वारा इसकी आनुवंशिक वृद्धि करना है। वर्ष के दौरान जनन द्रव्य में 20 नए एक्सेशनों को सम्मिलित किया गया। इस समय सीपीआरआई के राष्ट्रीय भण्डार में 3900 से अधिक एक्सेशन जमा हो चुके हैं। इन्हें फील्ड जीन बैंकों, परखनली पात्रों और सत्य बीज के रूप में संरक्षित किया जा रहा है। इन जननद्रव्यों का मूल्यांकन कई महत्वपूर्ण जैविक एवं अजैविक प्रभावों के लिए किया गया और आशानुकूल एक्सेशनों की पहचान की गई तथा प्राप्त जानकारी को इलेक्ट्रॉनिक डाटाबेस में सम्मिलित कर दिया गया है। जननद्रव्य के एण्डीजीना समूह के एकत्रित सत को संघटित किया गया। एण्डीजीनों पापुलेशन में छोटे आकार के कन्द पैदा होते हैं, ऐसे अवांछित गुणों से निजात पाने के लिए एण्डीजीना पापुलेशन में सुधार लाया गया।

दूसरा कार्यक्रम सुधरी किस्मों के प्रजनन से संबंधित है। इस कार्यक्रम का उद्देश्य आलू की ऐसी किस्में विकसित करना है जो भोज्य के साथ-साथ प्रोसेसिंग में भी प्रयुक्त हो सकें, साथ ही ये किस्में देश के विभिन्न कृषि-जलवायु क्षेत्रों में उगाए जाने के लिए अनुकूलन के साथ-साथ मुख्य रोगों और कीटों की प्रतिरोधक भी हो। कई नए पापुलेशन

पैदा करने के अलावा संघजीवी (colonial) मेटेरीयल का मूल्यांकन अगेती एवं एडवांस्ड जनरेशन में किया गया। वर्षों की सतत निष्पादक क्षमता के आधार पर मोदीपुरम से एमएस/5-1543 नामक एडवांस स्टेज की हाइब्रिड और पटना से पीएस/03-2 एवं पीएस/04-5 हाइब्रिड को अखिल भारतीय समन्वित अनुसंधान परियोजना (आलू) में गुणन परीक्षण हेतु शामिल किया गया।

तीसरा कार्यक्रम जैव-प्रौद्योगिकी द्वारा फसल सुधार करने सम्बन्धित है। वर्ष के दौरान चयन के लिए कुफरी चिप्सोना-1 के सात इन्वर्टेस RNAi वंशावलियों के कुछ फील्ड परीक्षण किए। इनमें से RNAi की एक वंशावली का चयन किया गया। इस वंशावली की पैदावार कन्ट्रोल जंगली किस्म के समकक्ष पाई गई और इसके कन्दों को 90 दिनों तक शीतभण्डार में रखने के बाद तैयार चिप्सों की गुणवत्ता अनुकूल पाई गई। SSR फिंगर प्रिन्टिंग विश्लेषण के आधार पर अन्तःजातीय आलू कायिक के 33 प्रसंकरों (हाइब्रिड) की पहचान की गई। कायिक प्रसंकरों में SSR मार्कर W/α प्रकार के कोशिका - द्रव्य (साइटोप्लाज्म) के प्राबल्य को बताता है। आलू की भारतीय किस्मों के शॉट गन सिक्वेसिंग द्वारा 170 Mbp जीनोम के सिक्वेस डाटा को सम्मिलित करते हुए 550 Mbp सिक्वेस पैदा किए। कुल ~56000 contigs प्राप्त हुए जिनमें से 659 contigs बड़े आकार के थे। सबसे बड़े आकार का contig 17.5 Mbp का था।

फसल उत्पादन

पटना में मक्का+आलू की अन्तः फसल में मक्का को नाइट्रोजन की संस्तुत मात्रा का 50 प्रतिशत और आलू की फसल को 100 प्रतिशत देने से प्रति हेक्टेयर सर्वाधिक आलू समतुल्य पैदावार 45.6 टन और शुद्ध आमद ₹80,000/- प्राप्त हुई। नाइट्रोजन को तीन बराबर मात्राओं (पहली एक तिहाई बीजाई के समय, दूसरी एक तिहाई पौधों के घुटनों तक पहुंचने के समय और शेष तीसरी एक तिहाई मात्रा पौधों पर पुष्प बल्लड़ लगने के समय) में डालना लाभकारी पाया गया। पटना में एक अन्य अध्ययन में पाया गया कि धान के पश्चात् आलू की अधिकतम पैदावार प्राप्त करने के लिए खेत में एक बार मोल्ड बोर्ड+ एक बार हैरो +एक बार हल +एक बार पाटा चलाने की आवश्यकता होती है।

नीलगिरि पहाड़ियों के ऊटी क्षेत्र में ग्रीष्म ऋतु में आलू+फ्रेंचबीन की अन्तः फसल उगाने के पश्चात् पतझड़ ऋतु में बन्दगोभी लगाने से उच्चतम आलू समतुल्य पैदावार प्राप्त हुई और इससे दोनों ऋतुओं में आलू के कवचधारी सूत्रकृमियों की संख्या में भी कमी हुई। ऊटी में एक अन्य अध्ययन में खेत में आलू की अकेली फसल लगाने की बजाए आलू की किस्मों (कुफरी गिरिराज और ओएस/93-डी-204) के साथ ब्रॉडबीन उगाना अधिक लाभदायक पाया गया। आलू के साथ ब्रॉडबीन 1:1 के अनुपात में उगाने से उच्चतम आलू समतुल्य पैदावार प्राप्त हुई।

उत्तर पश्चिमी पहाड़ियों के शिमला क्षेत्र में पाया गया कि बीजाई के पश्चात् फसल बढ़वार के दौरान आलू की पत्तियों में क्लोरोफिल की मात्रा में कमी हुई परन्तु जब फसल में

नाइट्रोजन की दूसरी मात्रा डाली गई तो पहले क्लोरोफिल अंशों में तीव्रता से वृद्धि हुई लेकिन समय के साथ-साथ उसमें कमी दर्ज की गई। बीजाई के 49 दिनों के पश्चात् और नाइट्रोजन की दूसरी मात्रा डालने के एक महीने तक नाइट्रोजन की प्रयुक्त मात्रा और क्लोरोफिल अंशों के बीच घनात्मक सह-सम्बन्ध पाया गया। इससे क्लोरोफिल सान्द्रण सूचक (CCI) की जानकारी अच्छे सूचक के रूप में हुई और इसे आलू की फसल के लिए नाइट्रोजन की अनुपूरक आवश्यक मात्रा ज्ञात करने के लिए इस्तेमाल किया जा सकता है।

निर्णय सहायी प्रणाली की आगामी जांच करने के लिए आलू फसल में नाइट्रोजन प्रबन्धन के लिए विकसित सलाह प्रणाली द्वारा मिट्टी की विभिन्न जैविक सम्पदा स्थिति के अन्तर्गत नाइट्रोजन की आवश्यक मात्रा, लक्षित पैदावार और खुदाई सूचक आदि का आंकलन सटीक रहा। नीलगिरि में आलू फसल अनुसूचिकरण के लिए निर्णय सहायी प्रणाली विकसित की गई। प्रणाली की प्रारम्भिक जांच में इसके यथार्थ परिणाम प्राप्त हुए। आलू सूचना प्रणाली और इससे सम्बन्धित डाटाबेस में काम आने वाले विभिन्न संघटकों की संरचना को मूर्तरूप दिया गया। डाटाबेस में इस्तेमाल करने के लिए जिलेवार दैनिक मौसमी आंकड़े एकत्रित किए गए।

अन्तरिक्ष अनुसंधान केन्द्र (इसरो), अहमदाबाद के सहयोग से पंजाब, उत्तर प्रदेश, बिहार और पश्चिम बंगाल राज्यों की रिमोट सेंसिंग, GIS और क्रॉप मॉडलिंग द्वारा आलू फसल का रक्बा और उत्पादन का आंकलन किया गया। पंजाब, उत्तर प्रदेश, बिहार व पश्चिम बंगाल में आलू की शीतकालीन फसल के अन्तर्गत रक्बा क्रमशः 80.0, 492.2, 162.3

व 329.0 हजार हेक्टेयर था जबकि इन राज्यों में आलू उत्पादन क्रमशः 1523.4, 10244.4, 1594.4 व 8558.1 हजार टन होने का अनुमान लगाया गया।

जालन्धर में किसानों के खेतों से एकत्रित मिट्टी के नमूनों का मूल्यांकन करने पर मध्यम, उच्च और सर्वोच्च फास्फोरस उपलब्ध क्षेत्रों की संख्या क्रमशः 10, 80 और 10 प्रतिशत रही। आलू की फसल के 89 प्रतिशत से भी अधिक क्षेत्रों में पोटैश की उपलब्धता कम (<105 ppm) रही। इस क्षेत्र में मुख्य सूक्ष्म पोषक तत्वों (तांबा व मैंगनीशियम में 11 प्रतिशत तथा जस्ता व लौह तत्व में 14 प्रतिशत) की कमी भी पाई गई।

2876 एफ₁सी, पुंजकों की बीजाई की गई और उनसे उत्पन्न कन्दों के आकार/आकृति, छिलके की रंगत, अंखुओं की गहराई आदि गुणों के आधार पर 752 पुंजकों का नाइट्रोजन उपयोग क्षमता हेतु चयन किया गया।

नाइट्रोजन रहित या नाइट्रोजन युक्त ऐसे 27 संकरों का चयन किया गया जिनकी पैदावार औसत कन्द पैदावार से अधिक थी तथा उन्हें आगामी वर्ष में नाइट्रोजन उपयोग क्षमता की पुनः जांच के लिए रख लिया गया।

कुफरी गौरव (हाइब्रिड जेएक्स 576) में नाइट्रोजन की कमी के प्रति उच्च सहनशीलता पाई गई और पटना में यह नाइट्रोजन प्रभावशीलता के लिए सबसे अधिक सक्षम पाई गई। ऊटी में कन्ट्रोल पैदावार के आधार पर (फास्फोरस के प्रयोग रहित) और उसी खेत में निर्धारित कन्द पैदा करने के लिए फास्फोरस दक्षता का मूल्यांकन करते समय सबसे अधिक फास्फोरस दक्ष प्रसंकर ओएस/93-डी-204 रहा जबकि इसके पश्चात् कुफरी हिमालनी, कुफरी

स्वर्णा, कुफरी गिरधारी, कुफरी गिरिराज व कुफरी ज्योति का स्थान रहा।

न्यूनतम नाइट्रोजन दक्ष किस्म कुफरी ज्योति की अपेक्षा सबसे अधिक नाइट्रोजन दक्ष हाइब्रिड जेएक्स 576 की उच्चतम औसत जड़ लम्बाई (2151 सेंटीमीटर/पौधा), जड़ तल क्षेत्र 418 वर्ग सें.मी./पौधा और जड़ घनत्व (6.55 घन सें. मी./पौधा) पाई गई। कुफरी ज्योति किस्म की औसत जड़ लम्बाई 1539 सें.मी./पौधा, जड़ तल क्षेत्र 299 वर्ग सें.मी./पौधा और जड़ घनत्व 4.70 घन सें.मी. प्रति पौधा रही।

सभी परीक्षित किस्मों में से कुफरी गौरव किस्म की जल उपयोग दक्षता सबसे ज्यादा पाई गई। मोदीपुरम में परीक्षित 175 एडवांस्ड नम्बर में से 88 एडवांस्ड नम्बर की पैदावार सिंचाई के समस्त स्तरों पर कुफरी बहार व कुफरी पुखराज के समकक्ष या उससे अधिक रही। अगले वर्ष प्लाटानुसार जांच करने के लिए इनका चयन किया गया।

कुफरी पुखराज की टपका (ड्रिप), छिड़काव (स्प्रिंकलर) और नालियों में (फरो) सिंचाई विधि के आधार पर जल प्रयोग दक्षता क्रमशः 177, 170 और 93 किलोग्राम कन्द प्रति हेक्टेयर मिलीमीटर पाई गई। शिमला में आलू फसल के पौधों के जमाव और कन्दीकरण की प्रारम्भिक अवस्था में, सिंचाई करने से लगभग 100 मिलीमीटर सिंचाई जल की बचत की जा सकती है।

मोदीपुरम में तीन फसल प्रणालियों पर दीर्घकालीन उर्वरक/खाद परीक्षण किए गए। परीक्षणों में अधिकतम आलू समतुल्य पैदावार मक्का-आलू-प्याज प्रणाली में (55.33 टन/हेक्टेयर), उसके पश्चात् धान-आलू-गोहूँ प्रणाली में (48.75 टन/हेक्टेयर) प्राप्त हुई।

न्यूनतम पैदावार तिल-आलू-मूंग फसल प्रणाली (37.03 टन/हेक्टेयर) की दर्ज की गई। तिलहन आधारित फसल प्रणालियों के अन्तर्गत आलू समतुल्य पैदावार में सुधार लाने हेतु तिल की बजाए मूंगफली उगाना अधिक उपयोगी पाया गया और इसकी प्रति हेक्टेयर पैदावार 5.97 टन तक प्राप्त हुई। जैविक की अपेक्षा अजैविक उपचार से प्रणाली उत्पादकता, कन्द आकार एवं कन्द संख्या अधिक रही। खेत में सूक्ष्म एवं गौण पोषक तत्व डालने से धान, आलू व मक्का की पैदावार में वृद्धि हुई।

पिछले वर्ष की तरह इस वर्ष भी जिस स्थान पर पहले जैविक आलू उगाए थे, उसी स्थान पर उगाए गए जैविक आलू परिपक्व होने तक हरे रहे और उनकी पैदावार परम्परागत तरीके से उगाई गई फसल की पैदावार के समकक्ष ही पाई गई। जैविक खादों का उपयोग करने पर विनिमयशील पोटाश में वृद्धि हुई। मक्का-आलू-प्याज फसल प्रणाली में अन्तःस्यंदन दर, संतृप्त द्रवचालित संचालकता व संरंध्रता उच्चतम जबकि इसके पश्चात् तिल-आलू-मूंग की फसल प्रणाली में पाई गई। तीनों फसल प्रणालियों में पोषण तत्वों के प्रबन्धन के विभिन्न विकल्पों में जैविक पदार्थों या फसल अवशेषों को खेत में डालने से अन्तःस्यंदन दर, संतृप्त द्रवचालित संचालकता और संरंध्रता में वृद्धि और ढेर घनत्वता (बल्क डेंसिटी) में कमी होने के कारण मृदा की भौतिक संरचना में सुधार हुआ।

ईंधन से चलने वाले बहुउद्देशीय 'वीडर' के फ्रेम, वीडिंग व पॉवर ट्रांसमिशन सिस्टम को सुचारु रूप से चलाने के लिए निर्माण किया गया। इसका निर्माण 65 सेंटीमीटर चौड़ी कतारों में चलाने के लिए किया गया लेकिन आवश्यकता पड़ने पर इसमें बदलाव करके 60

सेंटीमीटर चौड़ी कतारों में चलाने का प्रावधान भी रखा गया है। इस खरपतवार निकालने वाले इस वीडर का प्रारूप घूर्णी या ड्रम जैसा है जिन पर अलग-अलग दूरियों पर 'L' आकार के कटिंग ब्लेड जुड़े होते हैं। तना काटने वाली मशीन का भी डिज़ाइन बनाया गया।

दोहरी चैन से खींचने वाले 'आलू डिगर' से खुदाई और आलुओं को बगल में डालने की उपयुक्तता व सुलभता का अध्ययन किया गया। इस प्रणाली में सुधार किया गया और दोहरी चैन प्रणाली की बजाय इसमें एक अधिक लम्बा छड़ (रॉड) वाहक (conveyor) लगाया गया। बगली वितरण (delivery) प्रणाली का ढांचा बनाया गया और इसका निर्माण इस तरह से किया जा रहा है कि खोदे हुए कन्दों को मशीन के एक तरफ से ले जाकर ट्रॉली में सुगमता से डाला जा सके।

एरोपोनिक प्रणाली द्वारा आलू के मिनी कन्द पैदा करने के उद्देश्य से कुफरी सूर्या किस्म उगाकर विभिन्न प्रकार के नोजलों की दक्षता जांचने के लिए परीक्षण किए गए। परीक्षण द्वारा प्रति इकाई क्षेत्र से अधिकतम कन्द संख्या, खाली शंकु नोजल (0.47L/m) क्षमता में पाए गए। स्थानीय उपलब्ध पदार्थों से एरोपोनिक प्रणाली विकसित की गई। मोदीपुरम में वाणिज्यक पैमाने की एरोपोनिक प्रणाली विकसित की गई। इसमें ग्रीन हाऊस सहित 2600 पौधे उगाए जाने की क्षमता है। इस प्रणाली की जांच छः किस्मों पर की जा रही है। कम श्रमिकों और उपचार प्रक्रिया जल्दी करने के उद्देश्य से खुले बीज आलुओं का फोर्क लिफ्ट द्वारा एकत्रीकरण, रखरखाव और उपचार करने के लिए एक नए पैलेट (pallet) का विकास किया गया।

पौध संरक्षण

वर्ष 2010-11 में उपोष्ण कटिबंधीय मैदानी इलाकों में पिछेता झुलसा का प्रकोप कम रहा जिसके फलस्वरूप बम्पर पैदावार रही। *फाइटोथोरा इन्फेस्टान्स* में रेस स्पेक्टरम व मेटिंग टाइप में किसी प्रकार का बदलाव नहीं देखा गया किन्तु मेटालेक्सिल सहनशीलता में मामूली कमी रही। माइटोकोन्ड्रियल हैप्लोटाइप के विश्लेषण में नए हैप्लोटाइप 1a की बारम्बारता में चढ़ाव आया और यह 63 से 76 प्रतिशत तक पाई गई। आरएपीडी, एएफएलपी व एसएसआर मार्कर द्वारा रोगजनकों की संख्या का भी पता लगाया गया और *फाइटोथोरा इन्फेस्टान्स* की आनुवंशिकी विविधता बहुत अधिक रही। बीज कन्दों में गुप्त प्रकोप का पता लगाने के लिए पीसीआर आधारित प्रोटोकॉल की अभिपुष्टि की गई जिसके माध्यम से रोग विक्षति से 20 मि.मी. बाहर के प्रकोप का पता चला। उत्तर पश्चिम गंगावर्ती मैदानी इलाकों में झूलसाकास्ट मॉडल से पिछेता झुलसा रोग का पूर्वानुमान सफलतापूर्वक किया गया। आवश्यकतानुरूप फफूंदनाशक उपचार के लिए व्यापक फफूंदी सिफारिशों की अपेक्षा डीसीज़न सपोर्ट प्रणाली की अभिपुष्टि की गई। पिछेता झुलसा नियन्त्रण हेतु पांच मॉलीक्यूल्स का परीक्षण किया गया जिनमें से फेनामिडॉन व डायमैथोमॉर्फ आधारित फफूंदनाशक बेहतर पाए गए। पिछेता झुलसा प्रतिरोधिता के लिए कुफरी ख्याति व कुफरी पुखराज किस्मों को RNAi जीन के साथ रूपान्तरित किया गया।

पिछेता झुलसा प्रतिरोधक किस्मों को विकसित करने के उद्देश्य से अगेती पीढ़ी (एफ₁सी₁-एफ₁सी₂) के 549 पुंजकों का मूल्यांकन किया गया तथा 205 पुंजकों को आगामी मूल्यांकन के लिए सुरक्षित रखा गया। एडवान्स पीढ़ी में 10 संकरों का मूल्यांकन

किया गया, इनमें से आठ को आगामी मूल्यांकन के लिए सुरक्षित रखा गया। पिछेता झुलसा व आलू वायरस वाई की संयुक्त प्रतिरोधिता के लिए विकसित सात संकरों में से चार संकरों (एसएम/03-13, एलबीवाई-2, एसएम/03-23 व एसएम/03-45) को आगामी मूल्यांकन के लिए सुरक्षित रखा गया। सर्वश्रेष्ठ कन्ट्रोल कुफरी हिमालनी की अपेक्षा मेओटिक टेट्राप्लाइड (वीएमटी 2-5 एवं वीएमटी 5-1) और एलबीवाई संकर (एलबीवाई-18 व एलबीवाई-24) से अधिक सार्थक उपज प्राप्त हुई। अखिल भारतीय समन्वित अनुसंधान परियोजना (आलू) के गुणन परीक्षणों के लिए पिछेता झुलसा व पीवीवाई की संयुक्त प्रतिरोधिता के एलबीवाई-15, एलबीवाई-17 व एसएम/92-338 संकरों का चयन किया गया। पीवीवाई की सर्वोच्च प्रतिरोधिता के लिए एक ट्रिप्लेक्स पुंजक वाईवाई 6/3 सी-11 को पौध जनन द्रव्य पंजीकरण समिति द्वारा पंजीकृत किया गया। 42 एडवान्स पुंजकों एवं विकसित किस्मों का पांच एसएसआर मार्कर के साथ डीएनए फिंगर प्रिंटिंग की गई। पिछेता झुलसा डिफरेंसियलस में आर जीन के साथ जुड़े हुए मॉलिक्यूलर मार्कर की अभिपुष्टि की गई। पांच पैतृक लाइन्स (एसएम/93-239, एचबी/82-372, एचआर 5-2, एचआर 9-3, सीपी-3776) तथा आलू की तीन किस्मों (कुफरी शेरपा, कुफरी कुबेर व कुफरी अलंकार) में आरएफ जीन की उपस्थित सुनिश्चित रही।

डीएस-एलीज़ा के माध्यम से आलू के विषाणुओं के लिए 158 जननद्रव्यों एक्सेशन के साथ-साथ मेरीक्लोनों का भी परीक्षण किया गया। नाश (NASH) तकनीकी के माध्यम से PSTVd के लिए कुल 177 इन विट्रो नमूनों का परीक्षण किया गया जिनमें से दो नमूने ग्रसित पाए गए।

एनसीएस-टीसीपी के अधीन पीवीएक्स, पीवीवाई, पीएलआरवी, पीवीए, पीवीएस व पीवीएम के लिए डीएस-एलीज़ा द्वारा विभिन्न निजी कम्पनियों के 863 नमूनों का परीक्षण किया गया। संगरोध कांच घर में आलू की 34 किस्में लगाई गई तथा आयातित एलीज़ा किट द्वारा इनमें पीवीटी, पीवाईडीवी, एवीबी, एपीएमओवी, एपीएलवी, टीआरवी, टीआरएसवी की उपस्थिति देखने के लिए जांचा गया। इन सभी में वायरस नहीं पाए गए। आरटीपीसीआर तकनीक द्वारा 125 नमूनों को विषाणु व पीएसटीवीडी के लिए जांचा गया। पीवीएक्स, पीवीवाई, पीवीएस, पीवीए व पीवीएम जैसे आलू विषाणुओं के परीक्षण के लिए डिप स्टिक एस्से किट में सुधार किया गया। पीएलसीवी, पीवीएक्स, पीएलआरवी, पीवीवाई, पीवीएस व पीएसटीवीडी के लिए पीसीआर व आरटी-पीसीआर प्रोटोकॉल तथा पीएलसीवी, पीएलआरवी व पीवीवाई के लिए रीयल टाइम प्रोटोकॉल का मानकीकरण किया गया। पीएसटीवीडी, पीएलआरवी व पीवीएक्स के साथ-साथ पहचान करने के लिए आन्तरिक नियन्त्रण के रूप में एलांगेशन फैक्टर $1-\alpha$ ($ef1\alpha$) सहित एक मल्टीप्लक्स आरटीपीसीआर प्रोटोकॉल का मानकीकरण किया गया। एक्सप्रेसन वेक्टर में पीवीवाई के कोट प्रोटीन का क्लोन किया गया तथा एसपीएस-पीएजीई के माध्यम से इनका ई.कोली में एक्सप्रेसन सुनिश्चित किया गया और ई.कोली के म्यूटेन्ट स्ट्रेन में पीएलआरवी के सीपी प्रोटीन एक्सप्रेसन का प्रयास किया गया। खरगोशों में पीएलसीवी के विशुद्ध कोट प्रोटीन का इंजेक्शन लगाया गया तथा डीएस-एलीज़ा के माध्यम से पोलिक्लोनल एन्टीसिरा का शुद्धिकरण किया गया। शिमला की नियन्त्रित परिस्थितियों में कुफरी ज्योति x एसपी 951

के 23 एफसी, पुंजकों का गुणन किया गया तथा आगामी मूल्यांकन के लिए 5 पुंजकों (के जे-16, के जे-21 के जे-65, के जे-66 व के जे-77) का चयन किया गया। कांचघरों में कुफरी बादशाह की 41 प्यूटेटिव पीएलसीवी ट्रान्सजेनिक लाइन्स व कुफरी पुखराज की 22 लाइन्स और 31 पीवीवाई ट्रान्सजेनिक लाइन्स लगाई गई तथा विषाणु प्रतिरोधिता के लिए इनकी स्क्रीनिंग की गई और रीयल टाइम पीसीआर के माध्यम से विषाणु इनोकूलम की मात्रा देखी गई। अधिकतर ट्रान्सजेनिक लाइन्स में उच्च स्तर की विषाणु प्रतिरोधिता देखी गई। स्टम स्टेब इनोकूलेशन द्वारा *रालस्टोनिया सोलेनेसीरम* के लिए कुफरी ज्योति (14), कुफरी गिरिराज (38) व कुफरी सूर्या (15) की प्यूटेटिव इबीडी ट्रान्सजेनिक लाइन्स की स्क्रीनिंग की गई। कुफरी ज्योति (केजेईबीडी-17) की एक व कुफरी गिरिराज की 8 लाइन्स में जीवाणु गलन सहनशीलता पाई गई तथा इसमें गलन के लक्षण एक माह के बाद देखे गए। पांच पीएसटीवीडी प्रभेदों के फुल लन्थ जेनोमिक आरएनए की क्लोनिंग व अनुक्रमण किया गया। देश के विभिन्न हिस्सों से पीएलसीवी के ग्रसित नमूने एकत्रित किए गए तथा पीएलसीवी प्रभेदों के अस्सी कोट प्रोटीन जीन का प्रवर्धन व अनुक्रमण किया गया। देश के विभिन्न प्रान्तों से 40 *आर.सोलेनेसीरम* प्रभेदों के एजीएल, पीजीएल व एचआरपीबी जीन जैसे वेरुलेन्स जीन का पीसीआर प्रवर्धन व अनुक्रमण किया गया। आईटीएस क्षेत्र के *राइजोक्टोनिआ सोलेनाई* के 40 प्रभेदों का प्रवर्धन व अनुक्रमण किया गया। एएफएलपी तकनीकी द्वारा *आल्टरनेरिया आल्टरनाटा* के 20 प्रभेदों की पहचान की गई। *रालस्टोनिया सोलेनेसीरम* के 29, *राइजोक्टोनिआ* के 21 व *फ्यूजेरियम स्पीशीज* के 20 प्रभेदों को

एकत्रित कर संरक्षित किया गया। वाई 2 व ओएलआई 1 के विशेष मार्कर की सहायता से पीसीआर द्वारा *आर.सोलेनेसीरम* के 47 प्रभेदों की पहचान की गई। देश के विभिन्न भागों से डाइसैक्राइड्स उपयोग व आक्सीडाइज़ हैक्सोस एल्कोहल की सामर्थता के आधार पर बायोवार निर्धारण के लिए 47 *आर.सोलेनेसीरम* के प्रभेद एकत्रित किए गए। इनमें से 78 प्रतिशत आइसोलेट्स बायोवार 2/रेस-3 से संबंधित थे जिन्हें मध्य प्रदेश, पश्चिमी बंगाल व आसाम राज्यों से एकत्रित किया गया था, 10.7 प्रतिशत बायोवार 4/रेस-1 से थे और यह हिमाचल प्रदेश में प्रबल थे, 2.1 प्रतिशत बायोवार 1/रेस-1 से थे और पश्चिमी बंगाल में प्रबल थे, 2.1 प्रतिशत बायोवार 3ए/रेस-1 मध्य प्रदेश तथा शेष 6.4 प्रतिशत कर्नाटक से एकत्रित किए गए और यह उपरोक्त किसी भी श्रेणी के नहीं थे। रोगजनक परीक्षणों से पता चला कि मध्य प्रदेश के 22 में से 20 प्रभेद आलू के रोगजनक, 18 टमाटर के, 15 बैंगन के तथा मिर्च का रोगजनक कोई नहीं था। हिमाचल प्रदेश के सभी 6 प्रभेद आलू, टमाटर, बैंगन के रोगजनक थे जबकि मिर्च का रोगजनक कोई नहीं था।

खुदाई, ग्रेडिंग व ढुलाई के दौरान कन्दों के चोटिल होने का अध्ययन आलू की 5 किस्मों को लेकर किया गया। इस अध्ययन से पता चला कि शीत भण्डार के दौरान 1.0 से 8 प्रतिशत चोटिल कन्दों में गलन हुआ जबकि परिवेश वातावरण में भण्डारित चोटिल कन्दों में गलन 13.6 से 71 प्रतिशत रहा। 3 प्रतिशत बोरिक एसिड या 3 प्रतिशत बोरिक एसिड+ 0.2 प्रतिशत कार्बेनडाजिम से आमतौर पर बीज का उपचार करने पर लगभग एक माह के बाद भी उसके संसाधन पर कोई विशेष प्रभाव नहीं पड़ा। खेतों में कन्द जनित

बीमारियों की रोकथाम के लिए इस्तेमाल किए गए उपलब्ध व्यापारिक उत्पादों की जांच करने पर पाया गया कि काली रूसी के नियन्त्रण के लिए सिफारिश किए गए 3 प्रतिशत बोरिक एसिड का उपचार उतना ही प्रभावी रहा जितना थायोफेनेट मिथाइल 70 प्रतिशत डब्ल्यूपी (डिटो @ 5 मि.ली./ली.) या पेन्सीकूरान 22.9 प्रतिशत (मोनोसर्न @2.5 मि.ली./ली.) का। फिर भी कन्द जनित रोगों के नियन्त्रण में 3 प्रतिशत बोरिक एसिड का छिड़काव सस्ता पड़ता है। रस्सट स्कैब के नियन्त्रण के लिए मृदा आलप के साथ-साथ स्टेबल ब्लीचिंग पाउडर @ 3 क्विंटल/हे. या सरसों की खली @ 16.7 क्विंटल/हे. के साथ-साथ *ऐसबेनिया एकूलेटा* की हरी खाद का उपचार प्रभावशाली रहता है।

मोदीपुरम में दिसम्बर के मध्य में *माइज़स परसिकी* का प्रकोप अपनी चरम सीमा पर था, ग्वालियर में इसे दिसम्बर के दूसरे सप्ताह में रिकार्ड किया गया और जनवरी, 2011 के पहले सप्ताह में इसका प्रकोप अपनी चरम सीमा पर था। जनवरी, 2011 के चौथे सप्ताह में इसकी अधिकतम संख्या (52/100 यौगिक पत्तियां) रिकार्ड की गई। 90 सें.मी. ऊंचे चमकीले पीले चिपकने वाले फंदे में अधिकतम माहूँ फंसे। दक्षिण की ओर मुंह रखकर लगाए गए फंदों में अधिकतम माहूँ फंसे। मौसम में बदलाव के चलते *कोसीनेला* एफिड प्रीडेटर एक पखवाड़ा पहले दिखे। ग्वालियर में कुफरी ज्योति की अगेती फसल में माइट्स व थ्रिप्स से गम्भीर नुकसान देखा गया। इसके विपरीत आलू की अगेती व पिछेती फसलों में सफेद मक्खी व लीफ हॉपर का प्रकोप बहुत कम रहा। सितम्बर, 2010 के चौथे सप्ताह में थ्रिप्स की अधिकतम संख्या (36 थ्रिप्स/पौधा) दर्ज की गई तथा नवम्बर-दिसम्बर में इनकी संख्या में

कमी देखी गई। आलू पर स्पोडोप्टेरा का प्रभाव देखा गया तथा इनसे कन्दों का नुकसान कर्तक कीट के बराबर ही रहा। एफिड से बचने के लिए थायोक्लोप्रिड (0.3 व 0.4 प्रतिशत) का समर ऑयल (0.6 प्रतिशत) के साथ उपचार लम्बे समय तक कारगर रहा जबकि केवल थोयोक्लोप्रिड का उपचार सफेद मक्खी के लिए प्रभावशाली रहा।

कवचधारी सूत्रकृमि प्रतिरोधक आलू की किस्म पैदा करने के उद्देश्य से एक ही पहाड़ी/अवलोकन कतार में 1333 संकरों का मूल्यांकन किया गया तथा अगेती पीढ़ी में 694 संकरों का चयन किया गया। जांच के तौर पर कुफरी गिरधारी व कुफरी स्वर्ण किस्मों के साथ 41 एडवान्स पीढ़ी के संकरों का मूल्यांकन किया गया और इनमें से 27 संकरों का चयन किया गया। छः प्रॉमिसिंग एडवान्स संकरों के मूल्यांकन में से तीन संकर ओएस/94-126, ओएस/01-497 व ओएस/01-516 सर्वश्रेष्ठ नियन्त्रित किस्म कुफरी गिरधारी की तुलना में सर्वश्रेष्ठ रहे। चयनित संकर किस्में आलू के कवचधारी सूत्रकृमि (पीसीएन) की दोनों प्रजातियों के साथ-साथ पिछेता झुलसा के लिए भी प्रतिरोधक पाए गए। नीम की खली+ट्रीकोडर्मा विरीडे के साथ मृदा आलप समाकलन करने पर कुफरी गिरिराज की उपज अधिकतम रही व पीसीएन का गुणन न्यूनतम रहा तथा यह कार्बोफ्यूरोन के साथ आलप उपचार के समान ही रही। पॉलिथीन से ढककर रैडिश की पत्तियों @1 कि.ग्रा./मी² का बायोफ्यूमिगेशन करने पर कुफरी गिरिराज की उपज अधिकतम रही व पीसीएन का गुणन न्यूनतम रहा। आलू की उपज व पीसीएन के गुणन पर कारटैप हाइड्रोक्लोराइड (डारट्रिज़ 4 प्रतिशत जी) रसायन का मूल्यांकन

करने पर देखा गया कि कार्बोफ्यूरोन की 2 कि.ग्रा. वास्तविक मात्रा/हे. का उपचार करने पर अधिकतम उपज प्राप्त हुई और यह उपचार कारटैप हाइड्रोक्लोराइड की 2 कि.ग्रा. वास्तविक मात्रा/हे. के उपचार के बराबर ही प्रभावशाली रहा।

कवचधारी सूत्रकृमि की सक्रियता पर मृदा प्रबन्धन उपायों का मूल्यांकन करने पर पाया गया कि पतझड़ के मौसम में बन्दगोभी के बाद गर्मियों के मौसम में आलू+फ्रेंचबीन की अन्तःफसल लगाने पर आलू की अधिकतम उपज प्राप्त हुई। एडवान्स पीढ़ी के संकर ओएस/93-डी-204 के मामले में अकेले आलू लगाने पर कवचधारी सूत्रकृमि की संख्या न्यूनतम रही तथा यह पतझड़ के मौसम में बन्दगोभी के बाद सिफारिश किए गए आलू + फ्रेंचबीन की अन्तःफसल के समतुल्य रही।

फसल दैहिकी, जीव रसायन और फसलोत्तर प्रौद्योगिकी

ढेर व गड्ढों में आलू भण्डारण गुण का मूल्यांकन करने हेतु आलू की तीन नई किस्मों को 105 दिनों तक भण्डारित करने पर कुफरी हिमसोना किस्म में कम भार ह्रास हुआ और इसकी भण्डारण दक्षता अधिक पाई गई। सी.आई.पी.सी. से उपचारित कुफरी चिप्सोना-1, कुफरी चिप्सोना-3 और कुफरी हिमसोना किस्मों के कन्दों में मध्य जून तक अवकारक शर्करा कम और चिप्स की रंगत स्वीकार्य पाई गई। खुदाई उपरान्त 10 दिनों तक छिलका पकाए व बिना छिलका पकाए कन्दों को CIPC से उपचारित करके ढेरों में भण्डारण किया गया और उनकी भण्डारण क्षमता आंकी गई। कुफरी बहार किस्म के कन्दों को बिना छिलका पकाए

व खुदाई के तुरन्त पश्चात् (तीन दिनों के भीतर) CIPC से उपचारित करके 90 दिनों तक ढेर में भण्डारित करने पर बहुत अधिक सड़न व कुल ह्रास पाया गया। जबकि कुफरी चिप्सोना-1 में छिलका पकाने का कोई विशेष प्रभाव नहीं पड़ा। एक प्रदर्शन के दौरान लावड़ गांव (उत्तर प्रदेश) में कुफरी पुखराज के बड़े ढेर लगाए गए व इनमें 60 दिन के पश्चात् सी.आई.पी.सी. उपचारित कन्दों में केवल 5 प्रतिशत जबकि गैर उपचारित कन्ट्रोल कन्दों में 10 प्रतिशत तक ह्रास पाया गया। सतनाम एग्री प्रॉडक्ट्स लिमिटेड, प्रतापपुरा (जालन्धर) को कुफरी चिप्सोना-1 किस्म के 25000 क्विंटल कन्दों को शीत भण्डार के बरामदे में ढेर लगाकर भण्डारित करने के लिए तकनीकी जानकारी दी गई। इन भण्डारित कन्दों को 20 मई, 2010 तक बढ़िया किस्म के फ्लेक्स (चिवड़े) बनाने के लिए उद्योगों में प्रयोग किया गया। प्रोसेसिंग गुण का मूल्यांकन करने पर चार किस्मों के परिपक्व कन्दों में अवकारक शर्करा के अंश कम और तैयार चिप्सों की रंगत स्वीकार्य स्तर की पाई गई। कुफरी चिप्सोना-1 और कुफरी चिप्सोना-2 के कन्दों को 12⁰ सेल्सियस तापमान पर 90 दिनों तक भण्डारण करने के उपरान्त उनसे तैयार चिप्सों की रंगत स्वीकार्य स्तर की प्राप्त हुई लेकिन 90 अथवा 120 दिनों से अधिक समय तक भण्डारण करने के उपरान्त उन्हें अधिक तापमान पर भण्डारित करने पर भी उनसे तैयार चिप्सों की रंगत में सुधार नहीं हुआ। प्रोसेसिंग के अनुकूल किस्मों के कन्दों में शर्करा अंश एवं चिप्सों की गुणवत्ता में वर्ष दर वर्ष अन्तर पाया गया है। कन्दों को अंकुर रोधी डायफिनाइलेमाइन (750 ppm) रसायन से उपचारित करके 24±2⁰ सेल्सियस तापमान पर भण्डारित करने से अंकुरों के भार में 92.1 प्रतिशत तक कमी पाई

गई। उत्तर-पश्चिमी पहाड़ी इलाकों में विसरित प्रकाश में भण्डारण के अन्तर्गत बीज आलू की सुषुप्तावस्था बढ़ाने के उद्देश्य से 1,4 DMN (1,4 डाई मिथाइल नैपथलीन) द्वारा आलुओं को उपचारित किया गया। खुदाई के 210 दिनों के पश्चात् तक कन्दों के अंकुरण होने, अंकुरों के भार और अंकुरों की लम्बाई आदि के आंकड़ों के आधार पर यह मालूम हुआ, को बीज कन्दों को 1,4 DMN से उपचारित करने पर अंकुरों की लम्बाई को नियन्त्रित किया जा सकता है और किस्मों में सुषुप्तावस्था के कारण बुआई के समय तक जो अन्तर आता है उसे कम किया जा सकता है।

किस्मों में पोषक तत्वों की मात्रा ज्ञात करने के लिए आलू की 44 किस्मों का मूल्यांकन किया गया। 100 ग्राम ताजे आलू में एस्कार्बिक अम्ल की मात्रा 13 से 26 मि.ग्रा., अवकारक शर्करा की मात्रा 22 से 800 मि.ग्रा. और सुक्रोज की मात्रा 111 से 403 मि.ग्रा. के बीच पाई गई। आलू की दस किस्मों के छिलके और गूदे में ग्लायकोएल्कलायड सोलेनिन व चाकोनीन की मात्रा का निर्धारण किया गया। 100 ग्राम ताजे गूदे में अल्फा-सोलेनिन की मात्रा 0.3 से 1.5 मि.ग्रा. के बीच और अल्फा चाकोनीन की मात्रा 0.5 से 2.0 मि.ग्रा. के बीच पाई गई। प्रति 100 ग्राम ताजे भार में कुल ग्लायकोलायड की मात्रा 1 से 3.5 मि.ग्रा. के बीच पाई गई और यह प्रति 100 ग्राम शुद्ध ताजे भार की स्वीकार्य मात्रा 20 मि.ग्रा. से बहुत ही कम थी। 50 प्रतिशत आलू के आटे को और 50 प्रतिशत केले के आटे को मिलाकर आलू-केले के सम्मिश्रण में पोषक तत्वों का मूल्यांकन किया गया। मूल्यांकन से आलू आटे में केले के आटे की तुलना में स्टार्च (मंड), कुल शर्करा, सुक्रोज, एमिनो अम्ल, घुलनशील प्रोटीन, कुल फिनोल,

केरोटिन, लौह और जस्ता (जिंक) तत्व अधिक पाए गए जबकि एस्कार्बिक अम्ल की मात्रा आलू आटे की तुलना में केले के आटे में अधिक पाई गई। परिणामों से यह मालूम हुआ कि केले के आटे को आलू आटे में मिलाकर केले के आटे के पोषण मूल्यों में सुधार किया जा सकता है। फ्रेंच फ्राइज़ को ओवन में 2.30 मिनट तक पका कर तलने से उनमें तेल की मात्रा 2.7 से 4.5 प्रतिशत के बीच जबकि सीधे गहरी तलाई करने पर तेल की मात्रा अधिक (14.6 से 18.9) तक पाई गई।

उष्मा प्रतिरोधकता के लिए 69 सफल संकरों द्वारा 99219 बीज पैदा किए गए। कांचघरों में सत्य बीजों से एफ₁सी₁ अवस्था में पनीरी उगाकर व खेतों में आलू लगाकर 587 लाइनों का चयन किया गया। मोदीपुरम में खेत चयन के दौरान एफ₁सी₃ अवस्था में 39 पुंजकों (क्लोन), एफ₁सी₄ अवस्था में 5 पुंजकों और एफ₁सी₅ अवस्था में 3 पुंजकों का आगामी गुणन हेतु चयन किया गया। उष्मा प्रभावित अवस्था में बीजाई के 28 दिनों के उपरान्त वृद्धि विलम्बित पेक्लोब्युट्राजोल रसायन के 5ppm घोल का छिड़काव करने से कन्द पैदावार एवं खुदाई सूचकांक में सुधार हुआ।

जलाभाव अवस्था में मूल्यांकित 16 प्रसंकरों में से 14 प्रसंकरों की पैदावार कन्ट्रोल किस्मों से अधिक प्राप्त हुई। अत्याधिक जलाभाव के कारण कन्ट्रोल किस्मों की पैदावार में 25 प्रतिशत से अधिक कमी की अपेक्षा 6 प्रसंकरों की पैदावार में 10 प्रतिशत से भी कम कमी हुई। प्रारम्भिक अध्ययनों में कन्दीकरण हेतु कम से कम 8 घण्टे तक रात्रि तापमान 18° सेल्सियस रहने पर ही कन्दीकरण ठीक पाया गया जबकि 12 घण्टे की अवधि तक 18° सेल्सियस तापमान रहने पर कन्दीकरण सबसे

अधिक हुआ। पटना में कुफरी सूर्या की अगेती फसल से अनुकूलतम पैदावार प्राप्त करने के लिए उर्वरकों की सही मात्रा 160 कि.ग्रा. नाइट्रोजन, 25 कि.ग्रा. फास्फोरस और 80 कि.ग्रा. पोटाश आंकी गई।

बीज प्रौद्योगिकी

प्रारम्भिक एवं हाईटैक तकनीक प्रणाली द्वारा नाभकीय एवं प्रजनक बीज उत्पादन (पीआई-2010/16 आई.पी.आर.-एफ-00/210)

मोदीपुरम, जालन्धर, ग्वालियर, पटना, कुफरी व शिमला में वर्ष के दौरान आलू की विभिन्न प्रजातियों की विषाणु प्रभावसीमा जानने के लिए कुल 17,604 कन्दों की इन्डेक्सिंग की गई। मोदीपुरम, जालन्धर, ग्वालियर, पटना व कुफरी में कुल मिलाकर कन्द इन्डेक्सिंग में स्वास्थ्य प्रतिशतता क्रमशः 96.50, 90.0, 97.70, 100.0 व 95.30 रही, जबकि प्रथम चरण में यह प्रतिशतता क्रमशः 95.90, 94.00, 95.90, 99.33 व 98.70 प्रतिशत रही। पारम्परिक एवं हाईटैक बीज उत्पादन प्रणाली के अन्तर्गत 146.81 हेक्टेयर क्षेत्रफल में नाभकीय एवं प्रजनक बीज का कुल उत्पादन 29882.42 क्विंटल हुआ। नाभकीय एवं प्रजनक बीज के अन्तर्गत पारम्परिक प्रणाली में 110.52 हेक्टेयर क्षेत्रफल में बुआई की गई और विभिन्न चरणों में 21,747.97 क्विंटल उत्पादन हुआ जबकि हाईटैक बीज उत्पादन प्रणाली के अन्तर्गत 36.18 हेक्टेयर क्षेत्रफल में बुआई की गई और विभिन्न वंशों में 8,134.45 क्विंटल उत्पादन हुआ। अतः वर्ष के दौरान हाईटैक बीज उत्पादन प्रणाली के अन्तर्गत 24.6 प्रतिशत क्षेत्रफल में बीज लगाकर 27.2 प्रतिशत पैदावार प्राप्त की गई और शेष पैदावार पारम्परिक प्रणाली के अन्तर्गत ली गई। इस प्रकार

22052.14 क्विंटल प्रजनक बीज का उत्पादन (पारम्परिक प्रणाली से 15827.64 व हाईटैक तकनीक प्रणाली से 6224.5 क्विंटल) प्राप्त हुआ। विभिन्न केन्द्रों में सूक्ष्म पौधों, सूक्ष्म कन्दों, ऐरोपौनिक एवं <3 ग्राम मिनी कन्दों के पुनर्चक्रीकरण से कुल 10,55,306 मिनी कन्द पैदा किए गए। ऊटी और शिलांग केन्द्रों पर 14.21 हेक्टेयर क्षेत्रफल में बुआई करके 1444.09 क्विंटल क्वालिटी बीज का उत्पादन प्राप्त हुआ। इसके अतिरिक्त 137.25 हेक्टेयर क्षेत्रफल में चक्रीय फसलों में गेहूं, चना, सरसों, बाजरा, जई और मक्की लगाने पर 2407 क्विंटल उत्पादन हुआ।

ऐरोपौनिक प्रणाली के अन्तर्गत औसतन लगभग 60 मिनी कन्द प्रति पौधा उत्पन्न हुए। ऐरोपौनिक प्रणाली से उत्पन्न मिनी कन्दों के अंकुरण की प्रतिशतता 92.3 से 100 रही तथा वंशज मिनी कन्दों की उपज 93.4 ग्राम से 173.2 ग्राम प्रति पौधा रही। विभिन्न प्रणालियों द्वारा उगाई गई फसलों की तुलना करने पर अंकुरण में कोई महत्वपूर्ण अन्तर नहीं पाया गया। फिर भी मोदीपुरम में चरण-4 की तुलना में वंश-2 में बीज आलू संख्या में अधिक पाए गए जबकि जालन्धर में फसल निर्गमन, वानस्पतिक बढ़वार, विषाणु प्रभाव सीमा और उपज मापदण्डों में कोई महत्वपूर्ण प्रभाव नहीं देखा गया। उत्तर प्रदेश के आगरा व मेरठ मण्डलों में पीवीएक्स, पीवीएस, पीएलआरवी, पीवीवाई और पीएलसीवी जैसे विषाणुओं की उपस्थिति देखी गई। आगरा मण्डल में पीवीवाई की प्रभावसीमा (13.5 प्रतिशत) और पीएलआरवी की (12 प्रतिशत) रही जबकि मेरठ मण्डल में इनकी प्रभावशीलता क्रमशः 3.4 और 6 प्रतिशत मात्र रहीं। ऐपिकल लीफ कर्ल विषाणु की प्रभाव सीमा के आपतन परीक्षणों में जालन्धर, अमृतसर, होशियारपुर व भटिण्डा

में इसका आपतन 0 से 43.7 प्रतिशत रहा, जबकि उग्र मौजेक की विविधता 0 से 11.7 प्रतिशत रही। हाईटैक तकनीक के अन्तर्गत कुफरी बहार किस्म में फिनोटाइपिकली कन्दों की अधिकतम संख्या 44 प्रतिशत आंकी गई। जालन्धर में अगेती बीज फसल की कम उपज के लिए थ्रिप्स और माइट्स मुख्य बाधक रहे। जालन्धर में बिना फसल चक्र के लगाए गए खेतों में आलू की फसल पर रस्सट स्कैब 60.7 प्रतिशत व काली रूसी बीमारी का आपतन 44.8 प्रतिशत की तुलना में द्विवार्षिक फसल चक्र में लगाई गई आलू की किस्मों में रस्सट स्कैब का आपतन 0.8 प्रतिशत और काली रूसी का आपतन 0.07 प्रतिशत अर्थात् बहुत कम रहा। जड़ की उपयुक्त उत्पत्ति के लिए सूक्ष्म पौधों के कटे कोनों को इन्टोल एसिटिक एसिड व इन्टोल ब्यूटेरिक एसिड के 125-250 पीपीएम घोल में डुबोना जड़ की अनुकूलतम उत्पत्ति के लिए उपयुक्त पाया गया। पौधों की बढ़वार पर बिना किसी प्रभाव के सिफोटोक्साइम 100-120 मि.ग्रा./लीटर या कार्बेनिसिलम 50-100 मि.ग्रा./लीटर या पौध परिरक्षित मिश्रण 0.1-0.15 प्रतिशत का उपयोग माइक्रोब्स के नियन्त्रण के लिए किया जा सकता है। जैव रसायन स्वरूप के मामले में गैर इनसूलेटेड बढ़वार कक्ष द्वारा क्लोरोफिल-ए (185.5 प्रतिशत), क्लोरोफिल-बी (118.8 प्रतिशत) कुल क्लोरोफिल (159.8 प्रतिशत), कैरोटिनाइड्स (158.3 प्रतिशत) व फिनोल (41.5 प्रतिशत) की वृद्धि हुई।

सामाजिक विज्ञान

गुजरात के किसानों के बीच जाकर बढ़े हुए तापमान पर चलने वाले शीत भण्डारों के प्रभाव का पता लगाने के उद्देश्य से सर्वेक्षण किया गया। इस सर्वेक्षण से यह पता चला कि किसानों के विचार में परम्परागत शीत

भण्डार की अपेक्षा बढ़े हुए तापमान पर चलने वाले शीत भण्डारों का किराया औसतन 22 प्रतिशत अधिक होता है। बढ़े हुए तापमान पर भण्डारित भोज्य आलू के लिए आम उपभोक्ता 28.43 प्रतिशत अधिक कीमत चुकाता है जबकि बढ़े हुए तापमान पर अपने उत्पाद भण्डारित करने वाले किसानों को मात्र 18-19 प्रतिशत ही अधिक कीमत प्राप्त होती है। इस प्रकार यह देखा गया कि इस तकनीकी के कारण हुई मूल्य वृद्धि में बिचौलियों की हिस्सेदारी अधिक रहती है। वैसे देश में इस तकनीकी का उपयोग करने वाले शीत भण्डार की कुल क्षमता 0.37 मिलियन टन है, जिनमें से 0.12 मिलियन टन क्षमता केवल राष्ट्रीय राजधानी क्षेत्र व उसके आसपास के क्षेत्रों में है। इसका उपयोग करने वाले मुख्य राज्य उत्तर प्रदेश, मध्य प्रदेश, गुजरात व पश्चिमी बंगाल हैं। इस तकनीकी से एक सीज़न में प्रति टन 47 किलोवाट बिजली की बचत होती है, यह परम्परागत शीत भण्डार

बिजली खपत का लगभग 40 प्रतिशत ही है। इस सर्वेक्षण से यह भी पता चला कि इस तकनीकी को अपनाने से 10 प्रतिशत अतिरिक्त रोजगार के अवसर प्राप्त होते हैं।

अखिल भारतीय स्तर पर प्रत्येक वर्ष अनुमानतः 2.9 मिलियन टन बीज आलू की आवश्यकता पड़ती है। घरेलू बीज उत्पादन के फलस्वरूप हर साल 102.38 मिलियन अमरीकी डालर विदेशी मुद्रा की बचत होती है। शिमला में चयनित आलू तकनीकियों का मूल्यांकन करने पर कुफरी ज्योति की कन्ट्रोल किस्म की अपेक्षा कुफरी हिमालनी (32.7 प्रतिशत) व कुफरी गिरधारी (25.7 प्रतिशत) किस्मों की उपज में बढ़ौतरी हुई। कुफरी ज्योति किस्म के कन्ट्रोल प्लॉट में अगेता झुलसा रोग का प्रभाव 35 से 40 प्रतिशत रहा जबकि अन्य तीन प्रदर्शित प्लॉटों में से किसी में भी अगेता झुलसा रोग के लक्षण नहीं देखे गए।

Executive Summary

Crop Improvement

The division of crop improvement has three research programmes aimed at genetic improvement of potato. The management and the enhancement of potato germplasm is the basic programme of the division aimed at collection, conservation, evaluation and documentation of germplasm and its genetic enhancement through pre-breeding. During the year, 20 new accessions were added to the collection and the present collection in the national repository at the CPRI has more than 3900 accessions. These are being conserved in field genebanks, in-vitro repository and also as true seeds. The collection was evaluated for a number of important biotic and abiotic stresses and promising accessions were identified. The information generated has been added to electronic databases. Core collection of *Andigena* group of germplasm was constituted and population improvement of *Andigena* to overcome the undesirable character of smaller tuber size was continued.

The second programme is on breeding improved cultivars, which aims at developing varieties for table as well as processing purposes and carrying adaptability to different agro-climatic regions of the country with emphasis on resistance to important diseases and pests. Besides generating a number of new populations, the clonal material was evaluated in early as well as advanced generations. Based on consistence performance over the years, advance stage hybrids namely MS/5-1543 (from Modipuram), PS/03-2, and PS/04-5 (from Patna) have been introduced in AICRP for multiplication testing.

The third programme is on use of biotechnology for crop improvement. During the year limited field trial of seven invertase RNAi lines Kufri Chipsona-1 were conducted for event selection. One RNAi line, possessing yield potential equal to wild type control and desirable cold-chipping attributes after 90 days of cold storage, was selected. Thirty three interspecific potato somatic hybrids were identified based on SSR

fingerprinting analysis. SSR markers indicated dominance of W/α type cytoplasm in the somatic hybrids. Shot-gun sequencing of Indian potato cultivar generated 550 Mbp sequence data covering 170 Mbp of the genome. A total of ~56000 contigs were generated out of which 650 were large contigs. Size of the largest contig was 17.5 Kbp.

Crop Production

Resource management strategies were developed for major potato growing systems. In maize + potato intercropping at Patna, highest potato equivalent yield (45.6 t/ha) and net returns (Rs. 80,000/ha) were obtained when maize received only 50% of recommended N and potato received 100% N. Split application of N to maize at $\frac{1}{2}+1/4+1/4$ at planting+ knee high stage + tasselling stage was superior over $1/3+1/3+1/3$ or $0+1/2+1/2$ splits. In another study on conservation agriculture at Patna, potato following rice crop required one mould board ploughing + one harrowing + one tilling + one planking to produce highest potato yield.

At Ooty, potato + French beans intercropping in summer season followed by growing of cabbage in the autumn season gave the highest potato equivalent yield and also decreased the PCN population significantly during both the seasons. In another study at Ooty, intercropping potato with Broadbeans in 1:1 ratio gave higher potato equivalent yield.

At Shimla, a positive significant correlation between N application rate and chlorophyll content was observed at 49 days after planting and upto one month of application of 2nd dose of N, indicating that CCI (chlorophyll concentration index) is a good index and can be used to work out supplementary N requirement of potato.

Advisory System for Nitrogen Management in Potato, gave realistic estimates of N requirements under different soil organic carbon status, yield targets and harvest index. A decision support system for Potato Crop

Scheduling in the Nilgiris (CAASPS for Nilgiris) was developed and preliminary testing showed that the outputs were realistic. The structure of an Information System on Potato and the various databases that would form the components of the database were finalized. District-wise daily weather normals were collected for use in the database.

Potato acreage and production were estimated through remote sensing, GIS and crop modeling in the states of Punjab, Uttar Pradesh, Bihar and West Bengal. Winter potato acreage in these four was 1063.5 thousand hectares and total potato production was predicted as 21920.3 thousand tonnes.

Analysis of soil samples collected from different farmers fields of Jalandhar revealed that area under medium, high and very high available P was 10, 80 and 10%, respectively. More than 89% of area under potato was low in available K (<105 ppm) for potato crop. The percent deficient area under individual micronutrient was 11% for Cu and Mn, 14% for Zn and Fe.

Based on tuber characters, such as shape, skin colour and eye depths 752 clones were selected for testing for N use efficiency. The hybrid JX 576 (Kufri Gaurav) possesses high tolerance to nitrogen stress and was the most N efficient at Patna. Based on the control yield (No P applied) and dose of P required to produce fixed tuber yield in the same field, hybrid OS/93-D-204 was most P efficient followed by cvs., Kufri Himalani, Kufri Swarna, Kufri Girdhari, Kufri Giriraj and Kufri Jyoti at Ooty.

Most nitrogen efficient hybrid JX 576 had significantly higher mean root length (2151 cm/plant), root surface area (418 cm²/plant) and root volume (6.55 cm³/plant) than least N efficient cultivar Kufri Jyoti, which had mean root length of 1539 cm/plant, root surface area of 299 cm²/plant and root volume of 4.70 cm³/plant.

The cv. Kufri Gaurav showed significantly higher water use efficiency than all other cultivars tested. The 88 of the advanced numbers out of 175 tested produced equal/higher yield than popular varieties Kufri Bahar and Kufri Pukhraj at all irrigation levels at Modipuram and have been selected for testing under plot wise trials next year. Water use efficiency of cv. Kufri Pukhraj was 177, 170 and 93 kg tubers/ha-mm water with drip, sprinkler and furrow irrigation method,

respectively. About 100 mm of irrigation water could be saved if irrigation water is applied at establishment and tuber initiation stages of potato crop at Shimla.

In long term manurial/fertilizer experiment at Modipuram, system productivity in terms of potato equivalent yields (PEY) was highest in maize – potato – onion (55.33 t/ha) followed by paddy – potato – wheat (48.75 t/ha). The lowest PEY was recorded in sesamum - potato – moong system (37.03 t/ha). To improve PEY of oilseed based cropping system, groundnut, instead of existing sesamum has been found very useful and yielded up to 5.97 t/ha. The system productivity, tuber size and number in inorganic treatments were higher than organic treatments. Application of micro and secondary nutrients increased the yield of paddy, potato and maize.

The organic potato raised on same site remained green till maturity and yielded at par with conventionally raised crop. The treatment receiving nutrients through organic manure showed increase in exchangeable K. The *in situ* infiltration rate, saturated hydraulic conductivity and porosity were highest in maize- potato-onion system, followed by sesamum-potato-moong. Among the nutrient management options, the treatments involving incorporation of organic matter or residue recycling improved the soil physical conditions by increasing *in situ* infiltration rate, saturated hydraulic conductivity, porosity and by decreasing the bulk density.

Fabrication work of the frame, weeding system and power transmission system of the engine operated multipurpose weeder was carried out. The prototype has been fabricated to work at a row width of 65 cm, with provision to change to 60 cm, if required. Weeding attachment of the prototype consists mainly of a rotor or a drum with L-shaped cutting blades of variable lengths. Design work for the fabrication of a haulm cutting attachment was also carried out.

The twin chain trailed type potato digger windrower was studied for its suitability for conveying and side delivery of dug tubers. The system was modified and the twin chain system was replaced with a single extra long rod chain conveyor. The side delivery system was designed and is being fabricated for conveying and delivery of dug tubers on one side of the machine to fill in the trolley.

Highest number of tubers per unit area was observed when hollow cone nozzle (discharge of 0.47 l/m) was used in aeroponic system. An aeroponic system was developed with the locally available materials. A commercial scale aeroponic system with 2600 plants capacity along with green house was designed and developed at Modipuram and is being tested on six varieties. A new pallet was developed for handling and treatment of loose seed potatoes with fork lift to reduce labour requirement and to quicken the handling and treatment process.

Crop Protection

Late blight incidence in the sub-tropical plains was insignificant during 2010-11 resulting in a bumper harvest. No change in race spectrum and mating types was observed in *Phytophthora infestans* but a slight decrease in tolerance to metalaxyl was recorded. Analysis of mitochondrial haplotypes revealed that the frequency of new haplotype Ia is on the rise and it increased from 63% to 76%. The pathogen population was also characterized by RAPD, AFLP and SSR markers which revealed that genetic diversity level of *P. infestans* was very high. PCR based protocol was validated to detect latent infection of *Phytophthora infestans* in seed tubers which could detect infection up to 20 mm away from the disease lesion. JHULSACAST model successfully forecasted late blight appearance in North-west Indo-Gangetic plains. A Decision Support System validated for need based fungicide application proved better over blanket fungicidal recommendation. Five molecules were tested against late blight and Fenamidone and Dimethomorph based fungicides proved better. Transformed two Indian potato cultivars Kufri Khyati and Kufri Pukhraj with RNAi gene construct for late blight resistance.

For development of late blight resistant cultivars, 549 early generation (F_1C_1 - F_1C_4) clones were evaluated and 205 clones were retained for further evaluation. In advanced generation, 10 hybrids were evaluated and eight were retained for further evaluation. Out of seven hybrids developed for combined resistance to late blight and Potato Virus Y, four hybrids (LBY-2, SM/03-13, SM/03-23 & SM/03-45) were retained for further evaluation. The meiotic tetraploids (VMT 2-5 & VMT 5-1) and LBY hybrids (LBY-18 & LBY-24) yielded significantly higher than

the best control Kufri Himalini. The hybrids LBY-15, LBY-17 and SM/92-338 possessing combined resistance to late blight and PVY were selected for introduction into AICRP (Potato) for multiplication trials. A triplex clone 'YY6/ 3 C-11' possessing extreme resistance to PVY has been registered with Plant Germplasm Registration Committee. The DNA fingerprinting of 42 advanced hybrids and released varieties has been completed with five SSR markers. Molecular markers linked to R-genes have been validated in a set of late blight differentials. Five parental lines (SM/93-239, HB/82-372, HR5-2, HR9-3, CP-3776) and three potato varieties (Kufri Sherpa, Kufri Kuber and Kufri Alankar) were confirmed for the presence of R1 gene.

One hundred and fifty eight germplasm accessions including mericlones were tested for potato viruses through DAS-ELISA. A total of 177 in vitro samples were tested for PSTVd through NASH technique and only two samples were found positive. Under NCS-TCP, eight hundred and sixty three samples from different private companies were tested for PVX, PVY, PLRV, PVA, PVS and PVM through DAS-ELISA. Thirty four potato varieties were planted in the quarantine glass house and tested for PVT, PYDV, AVB, APMoV, APLV, TRV, TRSV with imported ELISA kits and all were found negative. One hundred and twenty five samples were tested for potato viruses and PSTVd through RT-PCR analysis. Dip stick assay kits for the detection of potato viruses like PVX, PVY, PVS, PVA and PVM have been improved. PCR and RT-PCR protocols for PALCV, PVX, PLRV, PVY, PVS and PSTVd and real time PCR protocols for PALCV, PLRV and PVY have been standardized. A multiplex RT-PCR protocol has been standardized for the simultaneous detection of PSTVd, PLRV and PVX with elongation factor 1- α (ef1 α) as internal control. The coat protein of PVY was cloned in expression vector and its expression in *E. coli* was confirmed through SDS-PAGE and the CP protein of PLRV was tried to express in mutant strains of *E. coli*. The purified coat protein of PALCV was injected in rabbits and polyclonal antisera was purified and tested through DAS-ELISA. Twenty three F1C4 clones of Kufri Jyoti x SP951 were multiplied under contained condition at Shimla and 5 clones (KJ-16, KJ-21, KJ-65, KJ-66, and KJ-77) have been selected for further evaluation. Forty one putative PALCV transgenic lines of Kufri

Badshah and 22 lines of Kufri Pukhraj and thirty one PVY transgenic lines were planted in the glass house and screened for virus resistance and the virus inoculum was quantified through real time PCR. Most of the transgenic lines showed high level of virus resistance. The putative EBD transgenic lines of Kufri Jyoti (14), Kufri Giriraj (38), and Kufri Surya (15) were screened against *Ralstonia solanacearum* by stem stab inoculation method. One line of Kufri Jyoti (KJEBD-17) and 8 lines of Kufri Giriraj showed tolerance to bacterial wilt and delayed wilt appearance by more than one month. Full length genomic RNA of five PSTVd isolates were cloned and sequenced. PALCV infected samples were collected from different parts of the country and coat protein gene of eighty PALCV isolates were amplified and sequenced. The virulence genes like *egl*, *pgl* and *hrpB* genes of 40 *R. solanacearum* isolates collected from different regions of India were PCR amplified and sequenced. The ITS region of 40 isolates of *Rhizoctonia solani* were amplified and sequenced. Twenty isolates of *Alternaria alternata* were characterized by AFLP technique.

Collected and maintained 29 isolates of *Ralstonia solanacearum*, 21 of *Rhizoctonia* and 20 of *Fusarium* spp. Identified 47 isolates of *R. solanacearum* by PCR using specific markers Y2 and OLI1. Determined biovar of 47 *R. solanacearum* isolates collected from different parts of the country on the basis of their ability to utilize disaccharides and to oxidize hexose alcohols. 78% of those isolates belonged to biovar 2/race 3 and were distributed in MP, WB, UP and Assam; 10.7% isolates were of biovar 4/race 1 and dominant in HP; 2.1% of biovar 1/race 1 present in WB, 2.1% of biovar 3A/race 1 from MP and rest 6.4% collected from Karnataka did not fall in any of the above category. Pathogenicity tests indicated that 20 isolates out of 22 from MP were pathogenic on potato, 18 on tomato, 15 on brinjal and none on chillies. Similarly, 5 of 6 isolates from WB were pathogenic on potato, 6 on tomato and none on chillies. All the 6 isolates from HP and 7 from UP were pathogenic on potato, tomato, brinjal but not on chillies.

Study carried out with tubers injured during harvest, grading and handling in 5 potato varieties revealed that the injured tubers develop 1.0 to 8% rotting under cold storage and 13.6 to 71 % under ambient storage conditions. Seed

treatment with 3% boric acid or 3% boric acid + 0.2% carbendazim carried out as per normal practice after about a month of their curing do not provide adequate protection. Screening of commercially available products for control of tuber diseases in a field trial revealed that thiophanate methyl 70%WP (Ditto @ 5 ml/l), or pencycuron 22.9% (Moncern @2.5 ml/l) were as effective as the recommended 3% boric acid for control of black scurf. However, treatment with 3% boric acid by spray was the cheapest method to manage tuber borne diseases. Soil solarization together with incorporation of stable bleaching power @ 3q/ha or burying of green manure of *Sesbania aculeata* crop together with soil application of mustard cake @16.7q/ha were found effective for control of russet scab.

At Modipuram, *Myzus persicae* crossed the critical level in mid December; in Gwalior, it was recorded in 2nd week of December and crossed the critical level by 1st week of January, 2011. Highest population (52/100 compound leaves) was recorded in 4th week of January, 2011. Maximum aphids were trapped on bright yellow sticky traps at a height of 90 cm. South facing traps captured highest number of aphids. The aphid predator *Coccinella* was appeared about fortnight earlier probably because of change in weather. Incidence of mites and thrips severely damaged early planted crop of Kufri Jyoti at Gwalior. On the contrary, incidence of whitefly and leafhopper was very low on early and late potato crops. Highest population of thrips (36 thrips/plant) was recorded during 4th week of September, 2010 and population declined in the month of November-December. Infestation of *Spodoptera* was observed on potato and which caused tuber damage similar to cutworm. Application of thiacloprid (0.3 & 0.4%) along with summer oil (0.06%) gave longer protection against aphid while application of thiacloprid alone was effective against whitefly.

For breeding cyst nematode resistant potato variety, one thousand three hundred and three hybrids were evaluated in single hill/observational rows and 694 hybrids were selected in early generations. Forty one advance generation hybrids were assessed along with Kufri Girdhari and Kufri Swarna as checks, of which twenty seven hybrids were selected. Among the six promising advance generation hybrids assessed, three hybrids viz. OS/94-126, OS/01-497 and OS/01-516 out yielded the

best control K.Girdhari. The selections were found to be resistant to both species of potato cyst nematodes (PCN) and field resistant to late blight. Integration of soil solarisation with neem cake + *Trichoderma viride* recorded the maximum yield in Kufri Giriraj and minimum PCN multiplication and it was at par with solarisation treatments combined with carbofuran. Biofumigation with incorporation of radish leaves @1 kg/m² with polythene covering, recorded maximum yield of Kufri Giriraj and minimum PCN multiplication. Chemical pesticide Cartap hydrochloride (Dartiz 4%G) was evaluated on potato yield and PCN multiplication and it was observed that maximum yield was recorded in carbofuran application @ 2 kg a.i./ha and was at par with Cartap hydrochloride @ 2 kg a.i./ha.

Evaluation of soil management practices on PCN dynamics revealed that the potato equivalent yields were maximum from the improved practice of potato + French beans intercropping in summer season followed by growing of cabbage in the autumn season. In case of advance generation hybrid OS/93-D-204, monocropping of potato recorded the lowest PCN population and it was closely followed by the recommended practice of growing potato + French beans intercropping followed by cabbage in autumn season. Growing potato with Broad beans and rosemary in 1:1 ratio recorded better potato equivalent yield and lowest PCN multiplication compared to other intercrop combinations in Kufri Giriraj.

Crop Physiology, Biochemistry & Post Harvest Technology

Out of 3 newly released cultivars evaluated under heap and pit storage, Kufri Himsona recorded good storability with reduced losses up to 105 days. Reducing sugar content in CIPC treated tubers of Kufri Chipsona-1, Kufri Chipsona-3 and Kufri Himsona was low and chip colour was highly acceptable up to mid June. Cultivar differences in storability in heaps after treatment with CIPC with/without a curing period of 10 days after harvest were recorded. Total losses and losses due to tuber rots after 90 days of storage were significantly higher in Kufri Bahar treated immediately after harvest (within 3 days) due to bruised skin at the time of CIPC

treatment compared to potatoes treated after a 10 day curing period. Whereas, the differences in storage losses within the treatments were not significant in cv. Kufri Chipsona-1. In a demonstration heap of Kufri Pukhraj laid in Lawad village (U.P), total losses in CIPC treated heap were 5.0% compared to 10% losses in the control after 60 days of storage. Technical guidance was provided to Satnam Agri Products Ltd., Pratapura (Jalandhar) for storage of 25,000 q of Kufri Chipsona-1 in heaps with improved ventilation in the cold storage Varandah. Stored potatoes were used in making good quality flakes in the industry up to 20th of May, 2010. In processing quality evaluation of mature tubers of four cultivars, reducing sugar content was low at the time of storage and chip colour was acceptable. At 12°C storage, chip colour was acceptable up to 90 days in Kufri Chipsona-1 and Kufri Chipsona-2, but could not be improved by reconditioning in any variety after 90 and 120 days. Considerable variation in the sugar content and chipping quality of potatoes were recorded in processing varieties on year to year basis. Tuber treatment with diphenylamine (750 ppm) recorded maximum sprout suppression effect with 92.1% reduction in sprout weight up to 120 days of storage at 24±2°C. In efforts to enhance dormancy of seed potatoes in the North-western hills under diffused light conditions, 1,4 DMN (1,4-dimethylnaphthalene) was evaluated in two potato varieties. Data on sprouting, sprout weight and sprout length by 210 days after harvesting, coinciding with the planting in hills showed that with 1,4 DMN treatment, length of sprouts in seed tubers can be controlled and variations due to differences in the dormancy durations in the varieties can be minimized.

Forty four potato varieties were analyzed for nutrients content. The ascorbic acid content varied from 13 to 26 mg/100 g FW, reducing sugar content varied from 22 to 800 mg/100 g FW and sucrose content varied from 111 to 403 mg/ 100 g FW. Glyco-alkaloids solanine and chaconine were determined in peels and flesh of ten potato varieties. The α -solanine in flesh varied from 0.3 to 1.5 mg/ 100 g FW and the α - chaconine content varied from 0.5 to 2 mg/100 g FW. The total glycoalkaloid content varied from 1 to 3.5 mg/100 g FW and was thus much below the acceptable limit of 20 mg/100 g FW. Nutrients content of potato –banana blend containing 50% each of potato

flour and banana flour, showed that starch, total sugars, sucrose, free amino acids, soluble protein, total phenols, carotenes, iron and zinc content were higher in potato flour as compared to banana flour, whereas ascorbic acid content was higher in banana flour. The results revealed that by blending potato flour with banana flour, the nutritional value of banana flour can be improved. Frozen French fries cooked in microwave oven for 2.30 minutes showed lower oil content (2.7 – 4.5%) as compared to deep fried frozen French fries (14.6 – 18.9%).

Out of 69 successful crosses for heat tolerance, 99219 seeds were extracted. 587 selections were made from the seedlings raised from these seeds in F_1C_1 in the glass house and field. In the field selection at Modipuram, 39 clones at F_1C_3 , 5 clones at F_1C_4 , and 3 clones at F_1C_5 stage were selected for further evaluation. Growth retardant, Paclobutrazole, 5 ppm spray 28 days after planting improved tuber yield and harvest index under heat stress conditions. Out of sixteen hybrids evaluated for water stress, 14 yielded more than controls and 6 showed less than 10% reduction in yield under severe stress compared to more than 25% for controls. Preliminary studies on duration of night temperature on tuberization indicated that a period of more than 8 hrs of night temperature resulted in good tuberization; however 12 hr duration at 18°C resulted in maximum tuberization in cuttings. Fertilizers for optimum yield/ha during early planting of Kufri Surya were worked out at Patna to be 160 kg N, 25 kg P_2O_5 and 80 kg K_2O .

Seed Technology

During the year a total of 17,604 tubers of different potato cultivars were indexed at Modipuram, Jalandhar, Gwalior, Patna, Kufri and Shimla. Over all health status of Modipuram, Jalandhar, Gwalior, Patna and Kufri recorded during tuber indexing was 96.50, 90.0, 97.70, 100.00 and 95.30%, while in stage-I it was 95.90, 94.00, 95.90, 99.33 and 98.70% respectively. A total production of 29882.42 quintal nucleus and breeder seed was achieved in an area of 146.81 hectare under conventional and hi-tech seed production system. Under nucleus and breeder seed a total of 110.52 hectare area was planted under conventional seed production system and a production of

21,747.97 quintal was achieved in different stages whereas, under hi-tech seed production system an area of 36.18 hectare was planted and production of 8,134.45 quintal was achieved in different generations. Therefore during the year, 24.6% area and 27.2% production was covered under hi-tech seed production system and the rest from conventional system. A total of 22,052.14 quintal breeder seed was produced through conventional (15,827.64 quintal) and hi-tech. (6,224.5 quintal) seed production system. In generation-0 a total of 10,55,306 mini/tubers were produced from microplants, microtubers, aeroponic and recycling of <3 g minitubers at different stations. At CPRS, Ooty and Shillong, an area of 14.21 hectare was planted and 1,444.09 quintal quality seed was produced. In addition to this an area of 137.25 hectare was planted under rotational crops viz., wheat, gram, mustard, bajra, oat and maize and a production of 2407 quintal was achieved.

An average of about 60 minitubers per plant was produced under aeroponic system. The germination of aeroponically produced minitubers varied from 92.3 to 100% and the yield from progeny minituber was recorded from 93.4g plant⁻¹ to 173.2g plant⁻¹. During comparison of crops raised with different system revealed that there was no significant difference in germination however significantly higher numbers of seed tubers were recorded in generation-2 crop over stage-4 crop at Modipuram while no significant effect in crop emergence, vegetative growth, virus incidence and yield parameters observed at Jalandhar. Virus profiling in Meerut and Agra divisions of Uttar Pradesh revealed that the viruses like PVX, PVS, PLRV, PVY and PALCV are present in both the divisions. The incidence of PVY (13.5%) and PLRV (12%) was recorded in Agra division, while the infection was only 3.4% and 6% respectively in Meerut division. Apical Leaf Curl Virus incidence ranged from 0-43.7% and severe mosaic varied from 0-11.7% in surveyed districts of Jalandhar, Amritsar, Hoshiyarpur and Bhatinda. Under hi-tech. system maximum number (44%) of phenotypically changed tubers were recorded in Kufri Bahar. Damage due to thrips and mites and the low yield were major constraints for the early seed crop at Jalandhar. Potato cultivar grown in plots with two year crop rotation at Jalandhar revealed a very low incidence of 0.8% russet scab and 0.07% black scurf in the progeny tubers as

compared to non rotational plot which exhibited 60.7% incidence of russet scab and 44.8% black scurf diseases. Dipping of cut end of microplants in IAA and IBA at 125-250 ppm is found suitable for optimum root induction. Cephotoxime 100-200 mg/l or carbenicillin 50-100 mg/l or plant preservative mixture 0.1-0.15% can be used for controlling the microbes without affecting the plant growth characters. The un-insulated growth room accelerated chlorophyll-a (185.5%), Chlorophyll-b (118.8%), total chlorophyll (159.8%), caretenoids (158.3%) and phenol (41.5%) which, resulted vigorous and sturdy growth microplants.

Social Sciences

Survey was conducted at farmers field of Gujarat for assessing impact of cold storage technology at elevated temperature. The survey reveals that from farmers point of view the storage rental of cold stores adopting elevated temperature technology was on an average 22% higher than the conventional cold store. For table purpose the average consumer paid 28-43% higher price for potatoes stored at elevated temperature, however, the farmers received 18-29% higher price for their produce stored at elevated

temperature. This indicates that the middle-men were cornering higher share in the value addition due to this technology. The estimated cold storage capacity using this technology was estimated at 0.37 million tonne out of which 0.12 million tonne was in NCR and its nearby areas. MP, Gujarat and West Bengal were other important states adopting this technology. This technology saved 47 KW per tonne electricity in a season which is nearly 40% of the power consumption in conventional cold storage. The survey also revealed that about 10% additional employment is generated by this technology.

At all India level the requirement of seed potato was estimated 2.9 million tonne every year. Domestic seed potato production is saving foreign currency to the tune of \$102.38 million per year. The assessment of selected potato technologies were assessed at Shimla. The assessment revealed that maximum increase in yield was recorded in Kufri Himalini (32.7%) and Kufri Girdhari (25.7%) as compared to control variety i.e. Kufri Jyoti. The incidence of early blight was observed in control plot of Kufri Jyoti to the extent of 35 to 40% while none of the three varieties of demonstration plot showed any symptom of early blight.

Research Programmes year 2010-11

Research Programmes & Institute Code No.	Programme Leader and Associates
Management and enhancement of potato germplasm P1-2010/1-IPR-F30/0210	Dr. Jai Gopal Associates: Drs. Vinod Kumar, Vinay Bhardwaj, Raj Kumar, Jagesh Kumar Tiwari, SK Luthra, Ratna Preeti Kaur, TA Joseph, E Eradasappa, Sanjeev Sharma, Jeevalatha, AK Somani, Kamlesh Malik, MS Gurjar, R Uma Maheswari, Ashiv Mehta, Name Singh, Bandna, SP Trehan, KR Naik (Dharwad), MS Nagaraj (Hassan) and Anil Gupta (Hissar)
Breeding for improved varieties P1-2010/2-IPR-F30/0210	Dr. SV Singh Associates: Drs. SK Luthra, Raj Kumar, Shambhu Kumar, VK Gupta, Ratna Preeti Kaur, E Eradasappa, Sanjay Rawal, SP Trehan, SK Singh, Mehi Lal, RK Arora, Rahul R Bakade, Ashiv Mehta, Vinay Bhardwaj, Bandana and AK Srivastava
Biotechnology in potato improvement P1-2010/3-IPR-F30/0210	Dr. D Pattanayak Associates: Drs. VU Patil, Jagesh Kumar Tiwari, Shashi Rawat, SK Chakrabarti, Basawaraj, Vinay Bhardwaj, Sanjeev Sharma, Brajesh Singh, Raj Kumar and SK Luthra
Resource management strategies and information technology tools for potato based cropping systems. P1-2010/4-IPR-F27/0210	Dr. SS Lal Associates: Drs. PM Govindakrishnan, VK Dua, Shashi Rawat, K Manorama, SP Singh, Sanjay Rawal, RK Arora, SK Singh, MA Khan, Manoj Kumar, MK Jatav, SK Yadav, Rajesh K Rana, G Ravichandran, Islam Ahmed, Ashwani Kumar and Sushil Kumar
Nutrients and water management P1-2010/5-PR-F25/0210	Dr. SP Trehan Associates: Drs. MC Sood, VK Dua, Manoj Kumar, Name Singh, MK Jatav, Sanjay Rawal, MA Khan and Raj Kumar
Nutrient dynamics studies on long term manurial/fertilizer application and organic farming in potato production P1-2010/6-IPR-F25/0210	Dr. NC Upadhyay Associates: Drs. OP Singh, MC Sood, Sanjay Rawal, MA Khan, Kamlesh Malik, Manoj Kumar and MK Jatav
Farm machines for potato cultivation P1-2010/7-IPR-N20/0210	Er. Manjit Singh Associates: Ers. Sunil Gulati and Sukhwinder Singh
Management of late blight P1-2010/8-IPR-H20/0210	Dr. BP Singh Associates: Drs. SK Kaushik, Vinay Bhardwaj, SK Chakrabarti, Sanjeev Sharma, Mehi Lal, RK Arora, D Pattanayak, MA Khan, AK Srivastava and TA Joseph
Molecular characterization, detection and management of potato pathogens. P1-2010/9-IPR-H20/0210	Dr. SK Chakrabarti Associates: Drs. Sanjeev Sharma, Vinay Sagar, A Jeevalatha, Baswaraj, VU Patil, Jagesh Kumar Tiwari and EP Venkatasalam
Characterization, detection and management of major soil and tuber borne pathogens of potato P1-2010/10-IPR-H20/0210	Dr. RK Arora Associates: Drs. SK Chakrabarti, Vinay Sagar, KK Pandey, AK Somani, Sanjeev Sharma, A Jeevalatha, Malkhan Singh Gurjar and Rahul Bakade

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Research Programmes & Institute Code No.	Programme Leader and Associates
Integrated pest management in potato P1-2010/11-IPR-H20/0210	Dr. (Mrs.) Kamlesh Malik Associates: Drs. SK Chakrabarti, Gulab Ram and Anuj Bhatnagar
Management of potato nematodes P1-2010/12-IPR-H10/0210	Dr. TA Joseph Associates: Drs. R Uma Maheswari and K Manorama
Physiological and genetic approaches in managing heat and water stress under sub-tropical environment in potato P1-2010/13-IPR-F60/0210	Dr. JS Minhas Associates: Drs. Devendra Kumar, VK Gupta, Sanjay Rawal, Kamlesh Malik, Brajesh Singh, Shashi Rawat, and Name Singh
Potato Storage: Efficient and eco-friendly methods for improved quality, P1-2010/14-IPR-F60/0210	Dr. (Mrs.) Ashiv Mehta Associates: Drs. R Ezekiel, Brajesh Singh, Bandana, Pinky and MA Khan
Nutritional value of potato and potato products, P1-2010/15-IPR-Q10/0210	Dr. R Ezekiel Associates: Drs. Ashiv Mehta, Brajesh Singh, Pinky and Bandana
Production of breeder seed of potato through conventional and hi-tech system. P1-2010/16-IPR-F00/0210	Dr. KK Pandey Associates: Drs. BP Singh, SK Chakrabarti, EP Venkatasalam, Vinod Kumar, Ashwani Kumar Sharma, SK Kaushik, Rajpal Singh, Dhruv Kumar, Vinay Singh, JS Minhas, RK Arora, AK Somani, Anuj Bhatnagar, SP Singh, MJ Sadawarty, RP Rai, SK Singh, Rahul Bakade, Er. Sukhwinder Singh, R Muthuraj, G Ravichandran and Ratna Preeti Kaur
Impact of potato technologies developed by the Institute P1-2010/17-IPR-C00/0210	Dr. NK Pandey Associates: Drs. Rajesh K Rana, Dhiraj Kumar Singh, Rambir and SK Yadav

Results-Framework Document (2011-12)

Section 1: Vision, Mission, Objectives and Functions

Vision

Potato for food & nutritional security and sustainable inclusive growth.

Mission

Carry out research, education and extension on potato in collaboration with national and international partners for enhancing productivity and profitability, achieving sustainable food and nutritional security, and alleviating rural poverty.

Objectives

1. Enhancing productivity and quality of potato.
2. Production of quality planting material of potato.
3. Effective and eco-friendly crop protection.
4. Human resource development and technology transfer.

Functions

To plan, coordinate, implement and monitor R&D programmes for sustainable potato production and resource conservation.

Section-2

Inter se priorities among key objectives, success indicators and targets

Objectives	Weight	Action	Success Indicators	Unit	Weight	Target/Criteria Value				
						Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%
Enhancing productivity and quality of potato through varietal improvement.	20	Development and introduction of improved hybrids in AICRP.	Number of hybrids introduced in AICRP for multi-location trial.	Number	15	2	1	-	-	0
		Collection and conservation of genetic resources for sustainable use.	Number of germplasm accessions added to gene bank.	Number	5	20	18	16	14	12
Production of quality planting material of potato.	20	Production of potato nucleus and breeder seed through conventional system.	Quantity of seed produced	Quantity in Quintals	8	22,000	20,000	18,000	17,000	16,000
		Production of potato nucleus and breeder seed through tissue culture.	Quantity of seed produced	Quantity in Quintals	8	13,000	12,000	11,000	10,000	9,000
		Production of minitubers through aeroponics	Number of minituber produced	Number	4	55,000	50,000	45,000	40,000	35,000

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Objectives	Weight	Action	Success Indicators	Unit	Weight	Target/Criteria Value				
						Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%
Resource based planning and crop management.	18	Field trials for evaluation of nutrient and water use efficiency.	Number of varieties/hybrids evaluated.	Number	7	25	20	15	10	5
		Characterization of potato growing environments in <i>kharif</i> season.	Areas for growing <i>kharif</i> potato with potential growing period and yield.	Date	7	31.12.2011	26.01.2012	21.02.2012	20.03.2012	15.4.2012
		Field trials for identifying promising crop sequences/inter-cropping systems for north-eastern plains.	Crop sequences/inter-cropping systems with high yield potential and/or nutrient use efficiency.	Date	4	31.3.2012	30.4.2012	30.5.2012	30.6.2012	30.7.2012
Effective and eco-friendly crop protection.	18	Collection of <i>Phytophthora infestans</i> isolates from different agro-ecological zones and their phenotyping.	Isolates of <i>P. infestans</i> collected, characterized and conserved.	Number	8	150	135	120	105	90
		Study genome variability of potato apical leaf curl virus isolates of sub-tropical areas.	Clustering of PALCV isolates on the basis of genome variability	Date	5	31.12.2011	27.01.2012	24.02.2012	24.03.2012	20.04.2012
		Development of diagnostic kits for potato pathogens.	PCR based diagnostic protocol for <i>Phytophthora infestans</i> .	Date	5	31.12.2011	27.01.2012	24.02.2012	24.03.2012	20.04.2012

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Objectives	Weight	Action	Success Indicators	Unit	Weight	Target/Criteria Value				
						Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%
Improving storage methods and nutritional quality of potato based foods.	12	Screening of environmental friendly sprout inhibitors	Number of compounds screened.	Number	4.0	4	3	2	1	0
		Define pre-harvest biomarkers for improved storability.	Determining the effect of tuber maturity and curing of varieties/hybrids.	Number	3	4	3	2	1	0
		Value added products with improved nutritional quality.	Recipes with improved nutritional quality.	Number	2	2	1	0	0	0
		Analyse seed potato distribution chain.	Respondent covered.	Number	4	270	243	216	189	162
Seed chain analysis, human resource development and technology transfer.	12	Capacity building and training to farmers/ KVK officials and other extension functionaries	Beneficiaries provided training.	Number	3	250	225	200	175	150
		Technology dissemination through mass media and on-farm demonstration.	Technology dissemination activities.	Number	2	50	40	35	30	25
		Analysis of adoption pattern of potato growers.	Farmers to be covered.	Numbers	3	60	54	48	42	36

Section 3

Trend values of the success indicators

Objectives	Action	Success Indicators	Unit	Actual Value for FY 09/10	Actual value for FY 10/11	Target value for FY 11/12	Projected Value for FY 12/13	Projected Value for FY 13/14
Enhancing productivity and quality of potato through varietal improvement.	Development and introduction of improved hybrids in AICRP.	Number of hybrids introduced in AICRP for multi-location trial.	Number	-	-	2	2	2
	Collection and conservation of genetic resources for sustainable use.	Number of germplasm accessions added to gene bank.	Number	-	-	18	20	20
Production of quality planting material of potato.	Production of potato nucleus and breeder seed through conventional system.	Quantity of seed produced	Quintals	24,000	22,000	20,000	18,000	16,000
	Production of potato nucleus and breeder seed through tissue culture.	Quantity of seed produced	Quintals	8,000	10,000	12,000	14,000	16,000
	Production of minitubers through aeroponics.	Number of minituber produced	Number	-	-	50,000	75,000	1,00,000

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Objectives	Action	Success Indicators	Unit	Actual Value for FY 09/10	Actual value for FY 10/11	Target value for FY 11/12	Projected Value for FY 12/13	Projected Value for FY 13/14
Resource based planning and crop management.	Field trials for evaluation of nutrient and water use efficiency.	Number of varieties/hybrids evaluated.	Number	-	-	20	20	20
	Characterization of potato growing environments in kharif season.	Areas for growing kharif potato with potential growing period and yield.	Date			26.01.2012	-	-
	Field trials for identifying promising crop sequences/inter-cropping systems for north-eastern plains.	Crop sequences/inter-cropping systems with high yield potential and/or nutrient use efficiency.	Date	-	-	30.4.2012	-	-
	Collection of Phytophthora infestans isolates from different agro-ecological zones and their phenotyping.	Isolates of P. infestans collected, characterized and conserved.	Number	153	141	135	150	150
Effective and eco-friendly crop protection.	Study genome variability of potato apical leaf curl virus isolates of sub-tropical areas.	Clustering of PALCV isolates on the basis of genome variability	Date	-	-	27.01.2012	-	-
	Development of diagnostic kits for potato pathogens.	PCR based diagnostic protocol for Phytophthora infestans.	Date	-	-	27.01.2012	-	-

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Objectives	Action	Success Indicators	Unit	Actual Value for FY 09/10	Actual value for FY 10/11	Target value for FY 11/12	Projected Value for FY 12/13	Projected Value for FY 13/14
Improving storage methods and nutritional quality of potato based foods.	Screening of environmental friendly sprout inhibitors	Number of compounds screened.	Number	-	-	3	3	3
	Define pre-harvest biomarkers for improved storability.	Determining the effect of tuber maturity and curing of varieties/hybrids.	Number	-	-	3	3	3
	Value added products with improved nutritional quality.	Recipes with improved nutritional quality.	Number	-	-	1	2	3
	Analyse seed potato distribution chain.	Respondent covered.	Number	-	-	243	270	135
Seed chain analysis, human resource development and technology transfer.	Capacity building and training to farmers/ KVK officials and other extension functionaries	Beneficiaries provided training.	Number	127	200	225	250	200
	Technology dissemination through mass media and on-farm demonstration.	Technology dissemination activities.	Number	40	45	40	45	45
	Analysis of adoption pattern of potato growers.	Farmers to be covered.	Numbers	-	-	54	120	160

Section 4: Description and definition of success indicators and proposed measurement methodology

Objective 1

The objective aims at development of improved potato varieties for high yield, processing quality and resistance/tolerance to important biotic and abiotic stresses. This activity will be achieved by collection, conservation, evaluation and utilization of potato germplasm for breeding improved cultivars. Both conventional and non-conventional approaches will be used for germplasm management as well as breeding improved cultivars. The success of the task will be measured in terms of germplasm conserved and utilized and number of advance hybrids introduced in AICRP (Potato) for multi-location trial and subsequent release of improved cultivars.

Objective 2

Production of quality planting material of potato is an important mandate of CPRI. Nucleus and breeder seed of potato is being multiplied through conventional and high-tech systems at five stations located in different parts of the country. The main aim is to meet out the requirement of potato breeder seed of the country. It is supplied to different state government agencies as per the allotment made by DAC, Ministry of Agriculture for further multiplication at State level so that farmers can get good quality potato seed to enhance the production and productivity of potato in the country. Success will be measured in terms of quantity of good quality potato planting materials produced.

Objective 3

The realization of the full potential of a variety requires proper match between the resource requirement and the genotypic behaviour.

Moreover, there is always a constraint of availability of resources. Therefore, characterization of the potato growing environments would enable deployment of varieties according to target environments. Further, there is lot of variability among genotypes with regard to efficiency of utilization of nutrients and water. Identification of efficient genotypes would enable developing package of practices according to resource availability. Potato is a short duration crop requiring high level of inputs. Identification of proper crop sequences/inter-cropping systems would enable harnessing the available natural resources to the maximum as well as efficient use of inputs by exploiting the synergy between crops.

Objective 4

This objective envisages reduction of crop loss due to disease and pest attack. Population dynamics and genotypic variability of pathogens will be studied for working out sensitive pathogen diagnostics and effective management strategies. The success of the task will be measured in terms of number of isolates of different pathogens collected and characterized, availability of specific and sensitive diagnostic tools for different pathogens.

Objective 5

Losses during storage of potatoes particularly under non-refrigerated storage conditions continue to remain high. There is a need for safer and eco-friendly sprout suppressants for use on potatoes during storage at 10-12°C in refrigerated stores and under non-refrigerated storages conditions. Further, in view of the importance of meeting the nutritional requirements of the population, efforts should be made to develop potato based products with improved nutritional quality. The success of this endeavour will be measured in terms of reduction in storage losses, identification of naturally occurring compounds with sprout suppression effect and development of value added products with improved nutritional value.

Objective 6

Potato seed chain analysis envisages to conduct survey of farmers, trading agencies etc. for generation of data and to identify seed movement channel. For effective transfer of potato technologies, it is proposed to organize various extension activities such as demonstrations, kisan mela, awareness camp and live phone-in-programme on AIR and Doordarshan. The success will be measured in terms of number of beneficiaries provided training. Survey will be conducted to find out technology adoption pattern in potato growers in different parts of the country. The success will be measured in terms of number of farmers to be covered and number of extension activities for reducing the adoption gap.

Section 5: Specific performance requirements from other departments

1. MOU are required for germplasm import and evaluation with International Potato Genbanks e.g CIP, Lima-Peru ; SCRI, Scotland; Dundee, UK and NRSP, Potato Introduction Centre, Wisconsin; Sturgeon Bay, USA. Collaborative projects in the field of pre-breeding will help to improve the availability of genetic resources for potato breeding.
2. Capacity building training of manpower would depend upon financial assistance from different departments like Directorate of extension, NHRDF, State departments of Hort./ Agriculture and NHM (DAC).
3. With respect to survey, the assistance from State Agil. Universities, State Agril./Hort. Departments and local bodies would be required.

DIVISION OF CROP IMPROVEMENT



Management and enhancement of potato germplasm

This programme serves the potato breeders and researchers by providing potato germplasm for use as parents and genotypes with diverse characters. The main activities are to import the germplasm, conserve the available collection safely, evaluate the collection for important biotic and abiotic stresses, and document the information in easily retrievable form. The wild species are evaluated for traits not available in the cultivated collection, and the cultivated groups of germplasm i.e. *Tuberosum* and *Andigena* are pre-bred to improve their agronomic performance and disease and pest resistance.

Collection

During the year under report, 14 accessions from USA, 3 from Netherlands, 2 from Denmark and 1 each from UK and Germany were added to cultivated germplasm collection. Two indigenous samples collected from West Bengal were also added to the collection. The present germplasm collection at CPRI consists of more than 3,900 accessions of cultivated and wild species from 30 countries.

Conservation

One thousand three hundred forty-nine *Tuberosum* accessions, 770 *Andigena* accessions and 69 indigenous samples were maintained in fields at Jalandhar. Nearly 1275 *Tuberosum* accessions and 90 indigenous samples were maintained in fields at Kufri. Seven hundred fifty one *Andigena* accessions were maintained in fields at Patna. Ten dihaploids of Indian commercial varieties were maintained in glasshouses at Shimla. With a view to evaluate different wild species, 230 clones were obtained from 25 accessions belonging to 7 species by raising seedlings from TPS. A total of 2458 true seeds of 7 accessions pertaining to 3 wild

species were produced through sib-mating/selfing at Shimla. With the objective of conservation of wild species in DNA form, DNA was extracted from more than 30 accessions and presently 62 accessions of 16 species are in the form of DNA.

Nearly 1750 *Tuberosum* accessions were maintained in *in vitro* form (Fig. 1). Minutubers of 102 accessions from *in-vitro* repository were produced and added to the germplasm collection maintained under field conditions at Kufri. Two thousand two hundred mericlones of 57 virus infected accessions were produced.



Fig. 1. Slow-growth *in-vitro* conserved potato germplasm



Fig 2. Microplant growth after 18 months of conservation on A) MS Medium with 20g^l⁻¹ sucrose and 40g^l⁻¹ sorbitol B) MS Medium with 20g^l⁻¹ sucrose (control)

Out of 57 mericlones of 37 accessions tested, 35 mericlones of 25 accessions were freed of PVX and PVS by meristem tip culture.

A study was conducted to compare the effect of mannitol versus sorbitol for *in-vitro* conservation of potato microplants at low temperature. After 18 months without subculturing, maximum survival (58%) coupled with microplant condition good enough to provide suitable nodes for subculturing was observed with the use of MS medium having 20 g^l⁻¹ sucrose plus 40 g^l⁻¹ sorbitol (Fig. 2)

Evaluation

Adaptability

Temperate long days (Kufri) : Thirty accessions found to be good yielder or resistant to late blight or both during previous years were evaluated in a replicated trial. None out yielded the best control variety Kufri Girdhari (270 g/plant, CD 53 at 5%). In another single row trial, 160 accessions were evaluated along with Kufri Jyoti, Kufri Giriraj, Kufri Himalini and K. Girdhari as controls. Two accessions out-yielded the best control variety Kufri Girdhari (271 g/plant) whereas five accessions out yielded control K. Himalini (251 g/plant). The top five accessions were CP 3775 (300 g), CP 3790 (291 g), CP 3776 (267 g), CP 3762 (266 g) and CP 3780 (258 g). All these accessions were resistant to late blight also.

Sub-tropic short days

Jalandhar : One hundred *Tuberosum* germplasm accessions were evaluated under Spring planting

conditions. The yield of germplasm accessions ranged from 27 to 380 g/plant. Best control variety was Kufri Jyoti (300 g/plant). The promising germplasm accessions were:

CP 3270 (380 g/plant), CP 3276 (347 g/plant), CP 3409 (340 g/plant) and CP 3420 (340 g/plant).

Modipuram : Early planting : One hundred three *Tuberosum* genotypes including eight varieties K. Anand, K. Ashoka, K. Bahar, K. Pukhraj, K. Pushkar, K. Khyati, K. Surya and K. Sutlej as controls were evaluated under heat stress conditions. At 75 DAP, the highest tuber yield was recorded in K. Ashoka (229 g) followed by CP 3188 (226 g), CP 3125 (225 g), CP 3099 (221 g), K. Khyati (216 g), K. Pushkar (210 g), CP 3127 (208 g), CP 3142 (203 g), K. Sutlej (201 g) and CP 3172 (200 g/plant).

Normal planting : Seventy three *Tuberosum* genotypes including five varieties K. Bahar, K. Pukhraj, K. Khyati, K. Sadabahar and K. Surya as controls were evaluated. At 90DAP, the highest tuber yield was recorded in CP 3208 (738 g) followed by K. Pukhraj (677 g), K. Khyati (657 g), CP 3461 (657 g), CP 3464 (647 g), CP 3252 (641 g), K. Sadabahar (616 g), CP 3365 (589 g), CP 3358 (576 g), CP 3427 (576 g), CP 3425 (575 g), CP 3433 (573 g), CP 3205 (570 g) and CP 3795 (564 g/plant).

Late blight : Thirty accessions were evaluated in replicated trial with Kufri Jyoti and Kufri Giriraj, Kufri Himalini and Kufri Girdhari as controls. Area under disease progress curve (AUDPC) indicated that 5 accessions namely CP 1012, CP 1187, CP 2001, CP 2003 and CP 2030 were highly resistant (AUDPC<30), 3 accessions namely CP Nos.1812, 1351 and 2320 were resistant (AUDPC 31-100) and accessions namely CP 1319 and CP 2399 were moderately resistant (101-300). Accessions namely CP Nos. 1012, 1187, 1319, 1812, 2001, 2003 and 2330 were promising during last year also. Remaining 20 accessions namely CP Nos. 1160, 1181, 1207, 1366, 1379, 1415, 1453, 1491, 1817, 1822, 1826, 1890, 1978, 1879, 1961, 1983, 2098, 2269, 2290 and 3184 were susceptible to late blight.

In another set, 180 accessions were evaluated for foliage resistance to late blight. On the basis of AUDPC value, 16 accessions were found to be highly resistant, 21 accessions were resistant

and 18 moderately resistant. Remaining 125 accessions were susceptible to late blight.

At Shillong, out of 40 accessions, 7 accessions namely CP 1722, CP 2000, CP 2018, CP 2132, CP 2163, CP 2379 and CP 2415 were moderately resistant. Accessions CP 1722, CP 2132 and CP 2163 were promising during last year also.

By detached leaf method, 73 germplasm accessions were tested for foliage resistance to late blight. Only one accession (CP 1658) was highly resistant, 9 accessions were resistant and 23 were moderately resistant. Out of 73 accessions tested for tuber resistance by tuber slice method, only one accession (CP 3874) was found to be moderately resistant and remaining 72 accessions were susceptible.

Stem necrosis : A total of 59 germplasm accessions were screened in field at Gwalior for the 4th successive year. Of them 10 accessions were found to be highly resistant, 7 were resistant and 17 were moderately resistant. A total of 66 germplasm accessions were screened for the 3rd successive year. Among these 47 accessions were highly resistant, 3 accessions were resistant and 7 were moderately resistant. Forty-seven germplasm accessions were screened for the 2nd time. Twenty-two accessions were highly resistant and 9 were moderately resistant.

Viruses : Forty-two germplasm accessions were screened for resistance against six viruses namely PVX, PVS, PVY, PVA, PVM and PLRV through DAS-ELISA for the first year resistance. Out of these 6 accessions viz. CP 1339, CP 1551, CP 1906, CP 1910, CP 1918 and CP 3379 were found free from all the six viruses and others were found infected with one or more viruses. In another lot, out of 39 *Tuberosum* lines tested for PVX and PVY by mechanical inoculation and ELISA, 10 accessions namely CP Nos. 1416, 1912, 2023, 2354, 3157, 3355, 3376, 3776, 3778 and 3819 were possessing combined resistance to PVX and PVY. Two hundred two *Tuberosum* accessions were screened for apical leaf curl virus (APLCV) at Modipuram. As many as 55 accessions showed symptoms of APLCV.

Leaf hopper and mites : One hundred and three accessions were evaluated under early planting conditions for hopper burn and mite

damage. Nine accessions namely CP Nos. 3021, 3022, 3036, 3096, 3098, 3106, 3109, 3117 and Kufri Surya were promising to both hopper burn and mite. Twenty-four accessions found to be promising for stem necrosis at Gwalior were screened for hopper burn and mite damage at Modipuram. Five accessions namely CP 3281, CP 3430, CP 3431, CP 3450, and CP 3534 were having less than 5% mite burn and hopper burn damage.

Cyst nematode : A total of 102 *Tuberosum* accessions were screened against both the species of cyst nematodes viz. *Globodera pallida* and *G. rostochiensis* at Ootacamund, by planting 5 tubers of each accession in earthen pots (one tuber/pot) containing soil with about 10, 000 propagules of both the species. The plants were maintained at 21±2 °C in a glasshouse. At 65 and 75 days the plants were depotted and entire root ball was observed for Potato Cyst Nematode (PCN) development. Data on developing females were recorded and accessions grouped as resistant (< 5 females), moderately resistant (6-10 females) and susceptible (> 10 females). The data indicated that only 3 accessions (CP 3850, 3861 and 3872) were resistant to both the species and 8 accessions (CP Nos. 3863, 3866, 3871, 3880, 3883, 3919, 4042 and 4056) were resistant only to *G. rostochiensis* whereas CP 3886, CP 3894, CP 3902, CP 3905 and CP 3907 were resistant only to *G. pallida*.

Keeping quality : Seventy *Tuberosum* accessions with three controls namely Kufri Dewa, Kufri Pukhraj and Kufri Ashoka were evaluated for weight loss, sprouting, tuber rotting and firmness at room temperature (15-39°C, 29-83% RH) for 100 days (March onward) storage at Jalandhar. Nineteen accessions viz., CP 2194, CP 2196, CP 2207, CP 2218, CP 2236, CP 2237, CP 2238, CP 2262, CP 2284, CP 2287, CP 2297, CP 2300, CP 2302, CP 2306, CP 2309, CP 2312, CP 2316, CP 2330 and CP 2333 having total weight losses (8.7 to 15.0%) at par with the best control cv. Kufri Dewa (12.8%) up to 100 days were rated as best keepers. Most of the accessions had either long or medium dormancy period. Twenty accessions were rated as good keepers, where total losses ranged between 15-20% and ten accessions as average keepers (total losses 20-25%), and the remaining were poor keepers (total loss > 25%).

Chipping and physico-chemical constituents

At Jalandhar, 72 *Tuberosum* accessions were evaluated for chip colour, dry matter, reducing sugars, sucrose, total phenols and free amino acids after harvest. Dry matter ranged between 14.10% (CP 2297) to 24.85% (CP 2271), reducing sugars between 13.63 (CP2330) to 1134.54 mg/100 g FW (CP 2297), while sucrose content between 86.15 mg/100 g FW (CP 2202) to 218.46 mg/100 g FW (CP 2309), total phenols between 5.28 mg/100 g FW. (CP 2280) to 89.71 mg/100 g FW (CP 2237) and free amino acids from 386.70 mg N/100 g FW (CP 2194) to 809.60 mg N/100 g FW (CP 2318). Based on chip colour (acceptable score up to 3 on 1-10 scale of increasing dark colour) 18 accessions namely CP Nos. 2202, 2209, 2210, 2218, 2271, 2277, 2280, 2283, 2290, 2294, 2301, 2315, 2321, 2322, 2330, 2331, 2333 and 2341 were found to be suitable for chipping. Seventy five accessions were also evaluated for vitamin C content which varied widely between 9.81 (CP 2235) to 25.27 mg/100 g FW. (CP1319). Five top most accessions were: CP1319 (25.27), CP1317 (25.26), CP 1231 (23.63), CP 1181 (23.27) and CP 1351 (22.72).

Water use efficiency : Seventy five accessions along with K Bahar and K Pukhraj were evaluated at 3 irrigation level i.e. 20, 25 and 30 mm cumulative pan evaporation (CPE) for higher yield. The result showed that 22 accessions produced equal or higher yield than varieties K Bahar and K Pukhraj at all irrigation levels. The accessions viz. CP Nos. 1057, 1123, 1151, 1157 D, 1175, 1181, 1197, 1214, 1218, 1235, 1302, 1304, 1308, 1310, 1314, 1316, 1330, 1333, 1338, 1340, 1343 and 1352 were found promising for high yield and water use efficiency.

Core Collection

In order to develop a core collection of *Andigena* germplasm maintained at CPRI, data recorded on 21 characters for 740 accessions were analyzed using Power Core (v.1.0) developed by NIAB, Korea. The data were also analyzed by the SPSS for cluster analysis. Three sampling

strategies within cluster, that is, selection based on random numbers, maximum principal component sum scores and maximum distance were followed. The selection efficiency of various methods was compared using the coverage rate of the core set with that of the entire collection. The optimum core set comprising of 78 accessions representing total diversity was constituted. The set is being further refined.

Documentation

Computer databases of cultivated as well as wild species were updated by incorporating the evaluation data for various accessions. Data bases of availability of various accessions at different conservation sites were also updated.

Improvement of *Andigena*

Crossing programme and raising of seedlings: Crosses among unrelated improved *andigena* hybrids were attempted at Kufri for further improvement of *andigena* population. Out of the large number of crosses attempted 15539 seeds were obtained from 22 crosses. Seedlings were raised at Jalandhar, and at harvest depending upon the availability 5-60 tubers representing different genotypes were randomly retained from different cross combinations for further use in hybridization.

Evaluation of clonal generation material : In first clonal generation evaluation for population improvement, 12-20 genotypes per cross of four crosses were retained. In second and third clonal generation, clones from *andigena* hybrid x *andigena* hybrids crosses and back-crosses of *andigena* hybrids, were evaluated. In second clonal generation 195 clones were planted in observational row and at the time of harvest based on tuber characters 51 clones were selected for further evaluation. The yield range of selected clones was 550-690 g/plant as compared to control Kufri Pushkar (520g/plant). In third clonal generation, 12 clones were planted in observational rows and at the time of harvest 5 clones were selected for further evaluation. The yield range of selected clones was 525-580 g/plant as compared to control Kufri Pushkar (510 g/plant).

Evaluation of wild species

Screening for late blight resistance under field conditions : In order to diversify the source of resistance to late blight in potato breeding programme, 154 clones of 31 wild species and 70 accessions were screened for late blight resistance under natural epiphytotic conditions. 19 clones were highly resistant (AUDPC <100) or resistant (AUDPC 101-200). The highly resistant clones (SS nos.) are listed below.

<i>S. alandie</i>	1765-21
<i>S. albicans</i>	1763-7, 1763-21
<i>S. arnezii</i>	1769-2
<i>S. berthaultii</i>	1870-12
<i>S. cardiophyllum</i>	1825-10, 1825-18
<i>S. circaeifolium</i>	1827-2
	1730-2, 1836-0, 1844-1
<i>S. demissum</i>	1846-4, 1846-30
<i>S. megistacrolobum</i>	2297-3, 2298-0, 2297-2
<i>S. pegazinii</i>	1725-34, 1725-78
<i>S. ugentii</i>	2073-3

The identified sources, however, will be further confirmed for their resistance.

Screening for late blight resistance under lab conditions: Under lab conditions, 174 accessions of 31 wild species were screened for late blight resistance by detached leaf method (Fig. 3) using complex races of *Phytophthora infestans*. Results depicted that among the 174 clones tested, 39 were highly resistant, 28 were resistant, 32 were moderately resistant



Fig. 3. Screening of wild species for late blight resistance by detach leaf method

and remaining 75 were susceptible. The identified sources shall be further tested for their resistance under field conditions.

Chip characters of wild species clones:

Eighty one wild species clones along with five controls were processed into chips after harvest. Clones SS1732 and SS1848-20 along with control Atlantic and Kufri Chipsona 3 possessed acceptable chip colour (up to 3) and were found suitable for processing (Fig. 4).

Germplasm registration

Clone, YY6/3 C-11, an elite parental line possessing PVY extreme resistance gene *Ryadg* in Triplex (YYYy) condition has been registered with NBPGR (IC No. 0586781 and registration number INGR 10143). It is a clone of cultivated species and has high pollen fertility, thus it can be easily crossed with cultivated potatoes.

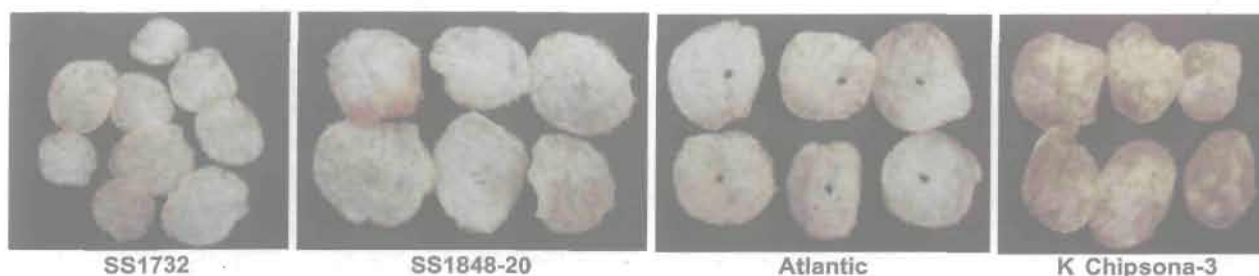


Fig. 4. Chip colour of wild species and controls

Breeding for improved varieties

This programme develops improved cultivars both for table and processing purposes and also families for raising commercial crop from TPS. Besides, the programme also standardize agronomy of the newly developed hybrids/ varieties and also evaluates the genotypes for important diseases and pests and biochemical constituents.

Breeding improved varieties for plains

Hybridization and seedling raising: 7, 77, 487 true potato seeds were obtained from the 287 successful crosses at Jalandhar, Modipuram and Patna. A total of 82, 976 seedlings were raised in field from sowing of 3, 07, 894 true potato seeds. At harvest, 14, 074 promising clones were selected.

Initial clonal generation: 15,649 clones of initial clonal generation (F_1C_1 , F_1C_2 and F_1C_3) were evaluated at 60/75/90 days after planting and 2,144 promising clones were selected.

Early trial at Modipuram: Advance hybrids MS/99-1871 (18 t/ha), MS/4-2261 (18 t/ha), MS/5-1543 (20 t/ha) and MS/6-1947 (18 t/ha) produced significantly high total tuber yield than the heat tolerant variety Kufri Surya (13 t/ha) at 75 days early crop (September planting).

Replicated yield trials: Eighty nine advance stage hybrids were evaluated in 12 yield trials at 60/75/90 DAP at Jalandhar, Modipuram & Patna and 33 promising hybrids were selected. In preliminary yield trials, 22 promising hybrids namely J/5-64, J/5-70, J/5-114, J/5-135, J/5-139, J/5-141, J/5-252, J/5-249, J/5-287 (Jalandhar), MS/7-121, MS/7-645, MS/7-950, MS/7-956, MS/7-2051, MS/7-2191 (Modipuram), PS/06-24, PS/06-27, PS/06-88, PS/06-91, PS/8-63-3, PS-8-97-1 and PS-6-82-2 (Patna) were selected from 64 hybrids evaluated. In confirmatory yield

trials, seven promising hybrids namely J/2-14 (Jalandhar), MS/6-819, MS/6-1895, MS/6-1947 (Modipuram), PS/05-75 PS/05-50, PS/05-73 (Patna) were selected from 19 hybrids evaluated. In final yield trials, four promising hybrids i.e. MS/5-1543 (Modipuram), PS/02-26, PS/03-2, PS/04-5 (Patna) were selected from seven hybrids evaluated.

Introduction of advance stage hybrids in AICRP

Based on consistence performance over the years, advance stage hybrids namely MS/5-1543 (Modipuram), PS/03-2 and PS/04-5 (Patna) are being introduced in AICRP for multi-location trials.

MS/5-1543 (MS/92-1090 x CP 1704): The hybrid produced 48%, 19% and 34% higher marketable tuber yield than K. Bahar, K. Pukhraj and K. Sadabahar, respectively at 80 DAP. The hybrid produces light yellow, oval shape tubers with shallow-medium eyes and white flesh. The hybrid produced 46 t/ha total tuber yield as against controls K. Bahar (31 t/ha), K. Pukhraj (38 t/ha) and K. Sadabahar (34t/ha) at 80 days. MS/5-1543 (20 t/ha) produced significantly high yield than the heat tolerant variety K. Surya (13 t/ha) under early crop (September crop) at 75 days. The hybrid showed tolerance to mite and hopper with comparatively less burn (18% and 8%) as against K. Surya (7 and 12%). The hybrids possess 15% dry matter with good keeping quality and it is resistant to late blight at Modipuram conditions (Fig.5).

PS/03-2 (K. Pukhraj x CP 3192): The hybrid produced 18% higher tuber yield than K. Arun at 75 days. The hybrid produces red round shape tubers with medium deep eyes and creamy flesh. The hybrid produced 26.14 t/ha total tuber yield as against controls K. Arun (22 t/ha) at 75 days. The hybrid possessed 16.44% dry matter,



Fig. 5. MS/5-1543-flowers, tubers and sprout

long dormancy with good keeping quality and it is moderately resistant to late blight at Patna conditions (Fig. 6).

PS/04-5 (85P718 x K. Pukhraj) : The hybrid produced 10% higher tuber yield than K. Pukhraj at 75 days. The hybrid produces white round shape tubers with fleet eyes and light yellow flesh. The hybrid produced 28.57 t/ha total tuber yield as against controls K. Pukhraj (26 t/ha) at 75 days. The hybrid possessed 15.27% dry matter, medium dormancy with good keeping quality and it is moderately resistant to late blight at Patna conditions (Fig.6).

Performance of Indigenous varieties at Modipuram, Patna and Kalyani: The indigenous variety K-22 produced 21.28 t/ha total tuber yield than control K. Khyati (22.73 t/ha) and K. Sadabahar (19.59 t/ha) at 65DAP. At 80 DAP, the total tuber yield of G-4 (27.42 t/ha) and K-22 (27.55 t/ha) was comparable with K Khyati (32.78 t/ha) & K. Sadabahar (30.42 t/ha).

Optimization of fertilizer requirements

Kufri Khyati at Jalandhar: The cv. Kufri Khyati responded significantly to N, P and K both at 60 and 75 days growth period. The response was significant up to 160 kg N/ha, 25 kg P_2O_5 /ha and 80 kg K_2O /ha in a soil testing low in available N and medium in available P and K.

Kufri Sadabahar at Modipuram: The N levels exhibited linearity up to 140 kg ha^{-1} and again a spurt was observed at 350 kg N ha^{-1} for marketable and total tuber yield. No response of phosphorous was recorded in K. Sadabahar at all graded P application over the control. Highest K level 225 kg ha^{-1} recorded maximum and significantly better marketable (39.4 t ha^{-1}) and total tuber yield (41.2 t ha^{-1}) over other treatments and control. Approximately 18 and 16.4% higher productivity for marketable and total tuber yield could be achieved with 225 kg K_2O ha^{-1} over control.



Figure 6. Tubers of P/03-2 and P/04-5

MS/99-1871 at Modipuram: Hybrid MS/99-1871 responded linearly up to 140 kg N ha⁻¹ for graded N levels. At 140 kg ha⁻¹ marketable (48.0 t ha⁻¹) and total tuber yields (52.1 t ha⁻¹) were statistically superior to lower doses and control, while remaining comparable to higher N levels. The P application increased marketable (47.2 t ha⁻¹) and total tuber yields (51.6 t ha⁻¹) significantly at 80 Kg P₂O₅ ha⁻¹ in comparison to control or other levels. Hybrid MS/99-1871 demonstrated linear response markedly with graded K application up to a level of 150 kg K₂O ha⁻¹ and had highest marketable (47.2 t ha⁻¹) and total tuber productivity (51.6 t ha⁻¹) at this level. Marketable and total tuber yields increased by 12.7 and 15.2%, respectively, at 150 kg K₂O ha⁻¹ in comparison to control.

Nitrogen requirement of advance hybrids at Patna: The experiment aimed at standardization of N fertilizer dose of red skin hybrids 2000P55, 2001P55 and varieties K. Arun, K. Lalima at Patna with four graded levels of N (0, 80, 160 and 240 Kg ha⁻¹) at constant dose of Phosphorous (60 Kg P₂O₅ ha⁻¹) and Potassium (100 Kg K₂O ha⁻¹). Application @ 160 kg ha⁻¹ proved to be the optimum level for most of the parameter studied in all the varieties.

Evaluation of advance stage hybrids for late blight resistance

Jalandhar: The late blight did not appear in field and therefore detached leaves obtained from 25 hybrids were artificially inoculated in the laboratory. Preliminary screening revealed that all the hybrids were susceptible.

Modipuram: All the 17 hybrids showed less AUDPC compared to cv K. Bahar (control). Advance hybrid i.e. MS/2-3964, MS/4-2261, MS/5-0284 and MS/5-1543 revealed very less AUDPC than control and their rAUDPC were also less. Based on tuber slice method, five hybrids i.e. MS/99-1871, MS/1-4353, MS/1-4906, MS/4-2261 and MS/6-1523 were moderately resistant and remaining hybrids were susceptible to late blight.

Patna: Late blight did not appear in ten hybrids and eleven varieties (control). Virus incidence was very low and no symptoms were observed in five advance hybrids (P/04-05, P/05-42, P/05-75, P/05-76) and six varieties (Kufri Khyati, Kufri Arun, Kufri Surya, K 22, G4 and JX-576).

Breeding for processing and export quality

Hybridization and seedlings evaluation: A total of 98,354 TPS of 68 crosses were produced at Kufri and 952 clones were selected from the seedlings raised at Modipuram.

Initial clonal generations: A total of 1989 clones of F₁C₁ and F₁C₂ generation were evaluated and 141 clones were retained based on tuber characters and chip colour. In F₁C₃ a total of 13 clones were evaluated and on the basis of chip colour, dry matter and yield only 8 promising clones were selected. In F₁C₄ generation five hybrids namely MP/05-1009, MP/06-26, MP/06-30, MP/06-39 and MP/06-86 were selected out of ten hybrids tested.

Advanced clonal generations: Eight hybrids and varieties Kufri Chipsona-1, Kufri Chipsona-3, Kufri Chipsona-4, Kufri Frysona, Kufri Surya & Atlantic were evaluated and on the basis of total tuber yield, processing grade yield, chip colour & dry matter, three hybrids namely MP/04-578 (French fry), MP/04-816 (chips) & MP/05-180 (high dry matter) were selected (Fig. 7).



Fig. 7. Promising hybrid MP/04-578 for processing into French fries

Performance of advance hybrids at Deesa (Gujarat) and Burdwan (West Bengal): Among the five hybrids along with control varieties evaluated for total yield, processing grade yield,

chip colour, dry matter, glucose and hunter colour, hybrid MP/04-816 was found promising at Deesa, whereas, based on total yield, processing grade yield, solids, UC and TPOD, two hybrids MP/04-578 and MP/04-816 were found promising at Burdwan.

Tuber yield and processing quality of varieties/advanced hybrids at Jalandhar:

Twelve potato varieties/hybrids were evaluated for yield and processing quality at 100 days after planting. Advanced hybrid MP/01-816 had maximum total tuber yield (45.1 t ha^{-1}) followed by MP/03-626 (42.8 t ha^{-1}) and MP/04-32 (42.7 t ha^{-1}) as compared to K. Chipsona-3 (40.6 t ha^{-1}) and K. Chipsona-4 (39.9 t ha^{-1}). Fry grade tuber yield was higher in all hybrids as compared to released varieties. Chip grade tuber yield was maximum in MP/04-32 (20.8 t ha^{-1}) with minimum non-processing grade tubers (8.2 t ha^{-1}), while non-processing grade tuber yield was maximum in K. Himsona (24.3 t ha^{-1}). All the hybrids could make French fries of acceptable colour (score 1.50-2.75) and chip colour of MP/03-626 (2.0), MP/04-816 (2.25) and MP/04-32 (2.0) was highly acceptable at harvest.

Processing quality of varieties/hybrids as affected by tuber maturity: Ten processing

and two non-processing varieties harvested at different maturity periods i.e. 90, 100 days and after a curing period of 20 days were evaluated at Jalandhar for yield and processing attributes. Among the processing varieties maximum total tuber yield (40.3 t ha^{-1}) and fry grade tuber yield (27.7 t ha^{-1}) was recorded in K. Surya, while chip grade tuber yield was maximum in K. Himsona (16.1 t ha^{-1}).

Dry matter content increased with maturity up to 100 DAP and decreased during the curing period (Fig. 8). Dry matter content was more than 20% in all processing varieties at harvest except in K. Surya (19.74%) and Kennebec (19.11%). Maximum dry matter content was recorded in K. Chipsona-3 (23.23%), K. Chipsona-4 (23.64%), K. Frysona (23.32%) and K. Chipsona-2 (23.70%) at harvest. Reducing sugars content (RS) increased with maturity (Fig.9). Among the processing varieties, mean minimum RS contents were recorded in K. Surya (18.79 mg/100 g FW) and Lady Rosetta (28.49 mg/100 g FW). Sucrose contents decreased with maturity (Fig.10) with mean minimum values in Kennebec. Free amino acid contents decreased while phenol contents increased with maturity period. K. Surya recorded maximum phenol and free amino acid contents at all levels of maturity.

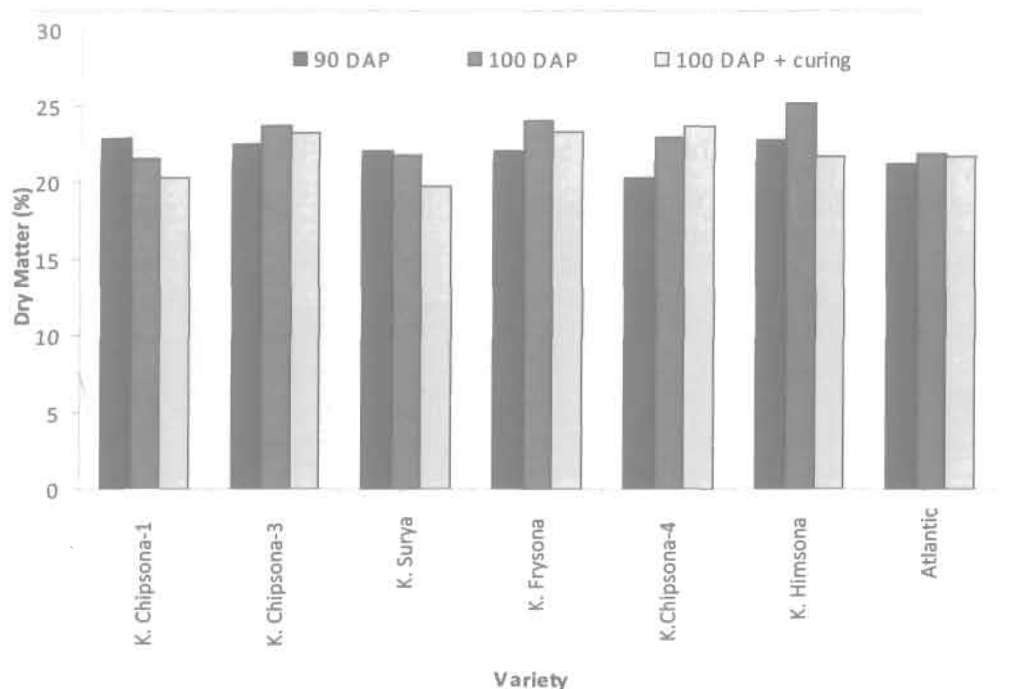


Fig. 8. Tuber dry matter content (%) at different maturity dates in processing varieties at Jalandhar

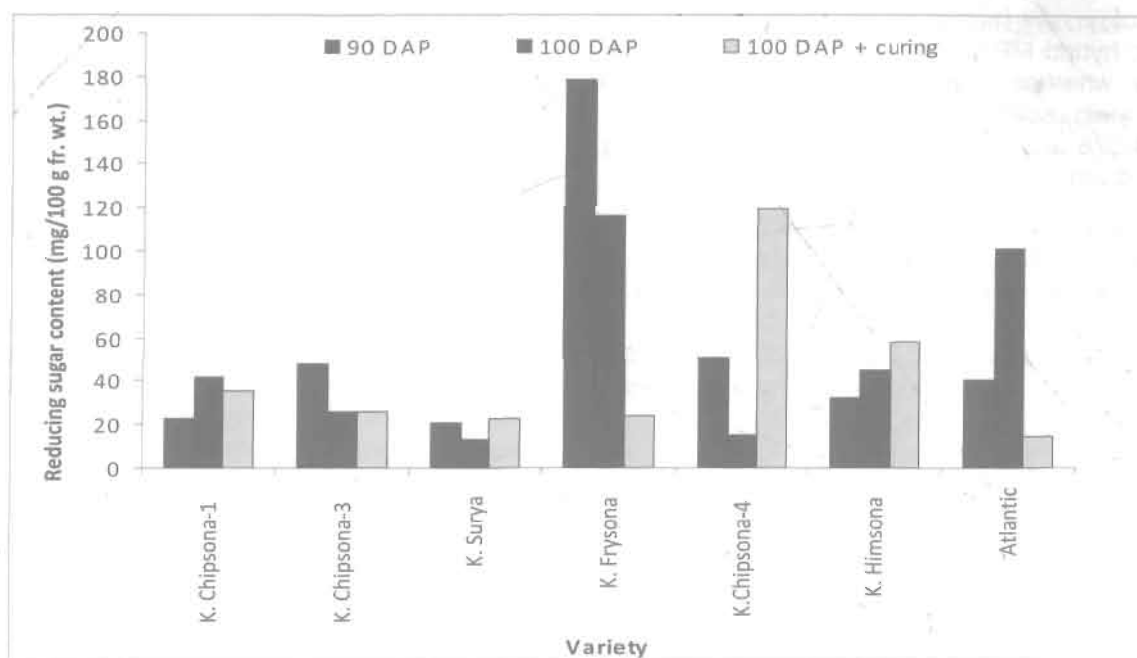


Fig. 9. Reducing sugars content (mg/100g tuber fresh wt.) at different maturity dates in processing varieties at Jalandhar

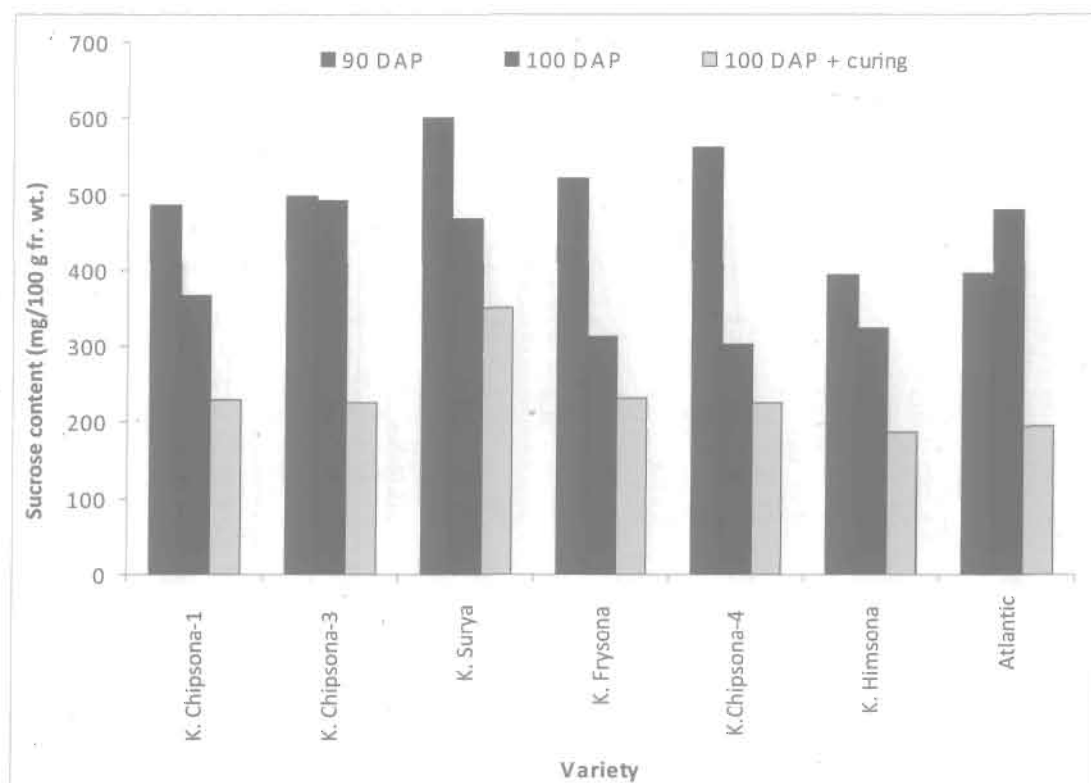


Fig. 10 Sucrose content (mg/100g FW) at different maturity dates in processing varieties at Jalandhar

Chip colour and RS contents were affected by ambient temperatures. Among the processing varieties, chip colour was acceptable at 90 days after planting (DAP) in all varieties except for K. Frysona. At 100 DAP, chip colour deteriorated to unacceptable level in K. Chipsona-3, K. Frysona and Kennebec, while after curing acceptable chips were made in K. Chipsona-1, K. Chipsona-4, K. Surya, Lady Rosetta, K. Himsona and Atlantic.

Processing quality of varieties/advanced hybrids during storage in heaps at Jalandhar:

Nine processing and two non-processing varieties grown during autumn 2009-10 were evaluated during storage in heaps after treatment with CIPC for processing quality. Dry matter content of all processing varieties was high (>20%) except for K. Surya (18.8%) and Kennebec (19.4%). At 0 day of storage among the processing varieties minimum reducing sugars were recorded in K. Himsona (45.1 mg/100 g FW) and maximum in K. Chipsona-4 (144.2 mg/100 g FW) while reducing sugars were unacceptably high in non-processing varieties K. Suttlej (504. mg/100 g FW) and K. Pukhraj (425.5 mg/100 g FW). Reducing sugars decreased during storage in heaps in all the varieties and chip colour improved. Chip colour at 0 day of storage was acceptable in all varieties except in case of Kennebec (5.00). Chip colour of all processing varieties was highly acceptable (chip colour score 1.50-2.75) after storage in heaps for 90 days. Results show that heap stored potatoes of all the nine varieties can meet the short term needs of processing industries.

Optimization of NPK requirement of K. Frysona under micro-irrigation systems (drip and sprinkler)

Nitrogen: Total tuber productivity of K. Frysona was higher by 8.5% under drip (43.2 t ha⁻¹) as compared to sprinkler (39.8 t ha⁻¹); however, French fry grade yield and quality traits viz., specific gravity, tuber dry matter content and fry colour remained comparable in both irrigation systems. The N level of 170 kg ha⁻¹ recorded 30.3 t ha⁻¹ of French fry grade tuber yield which was comparable to all higher N doses. Similarly total tuber yield (44.0 t ha⁻¹) was also

comparable to all treatments except for 320 kg N ha⁻¹. Quality parameters of K. Frysona (specific gravity, tuber dry matter content and fry colour) were not influenced by various nitrogen levels.

Phosphorous: The French fry and total tuber yield significantly improved in drip irrigation by 28.8 and 20.5%, respectively over sprinkler irrigation. But quality traits remained uninfluenced in both mode of irrigation. Total tuber yield increased significantly at 25 kg P₂O₅ ha⁻¹ (44.9 t ha⁻¹) over control (41.5 t ha⁻¹); French fry grade yield also improved but differences were non significant. Higher P doses did not affect productivity distinctly. Specific gravity, tuber dry matter content and fry colour improved significantly at 25 kg P₂O₅ ha⁻¹ in comparison to control.

Potassium: The French fry and total tuber yield improved markedly in drip irrigation system by 51.9 and 30.2%, respectively over sprinkler system. Specific gravity and tuber dry matter content remained more or less same, but fry colour tended to improve in drip irrigation system. French fry grade (24.4 t ha⁻¹) and total tuber yield (41.5 t ha⁻¹) increased significantly at 50 kg K₂O ha⁻¹ in comparison to control (21.0 & 36.9 t ha⁻¹). Higher K levels did not improve productivity at all. Specific gravity was at par with control; tuber dry matter content declined significantly beyond 100 kg K₂O ha⁻¹, while fry colour improved significantly at 150 kg K₂O ha⁻¹ (2.65) in comparison to control (3.25).

Development of TPS population

Production of TPS: Produced about 1.31 kg TPS of 43 crosses under natural photoperiod condition at Patna. Pollinations at different blooming flushes in TPS population 92PT-27 under extended photoperiod resulted into production of 1.9, 1.4 and 1.05 kg of TPS in first, second and third flush, respectively.

Production of TPS

For development of parental lines: 131.5 g TPS of 34 crosses were produced for selection of early bulking parents for further use in hybridization.

For development of TPS Populations: 1337 g TPS of 43 populations (23 red x red and 20

white x white) was produced for selection of early bulking and high yielding populations.

Selection of clones for recurrent breeding:

Two hundred ninety six early bulking clones were selected from 48 populations for recurrent breeding.

Evaluation of TPS populations

Transplanted crop

Patna: Sixty TPS populations including 23 white x white crosses, 40 red x red populations along with TPS/D-150 (OP) and control 92PT-27 were evaluated in five trials as transplanted crop at 90DAP. Out of 40 red x red populations, 11 populations (PT/10-01, PT/10-02, PT/10-04, PT/10-05, PT/10-08, PT/10-12, PT/10-17, PT/10-19, PT/10-48, PT/10-50, PT/10-56) yielded significantly higher than the control (92PT-27); while out of twenty white x white crosses; seven populations (PT/10-26, PT/10-25, PT/10-27, PT/10-35, PT/10-43, PWW 907, PWW 935) gave significantly higher yield than the control 92PT-

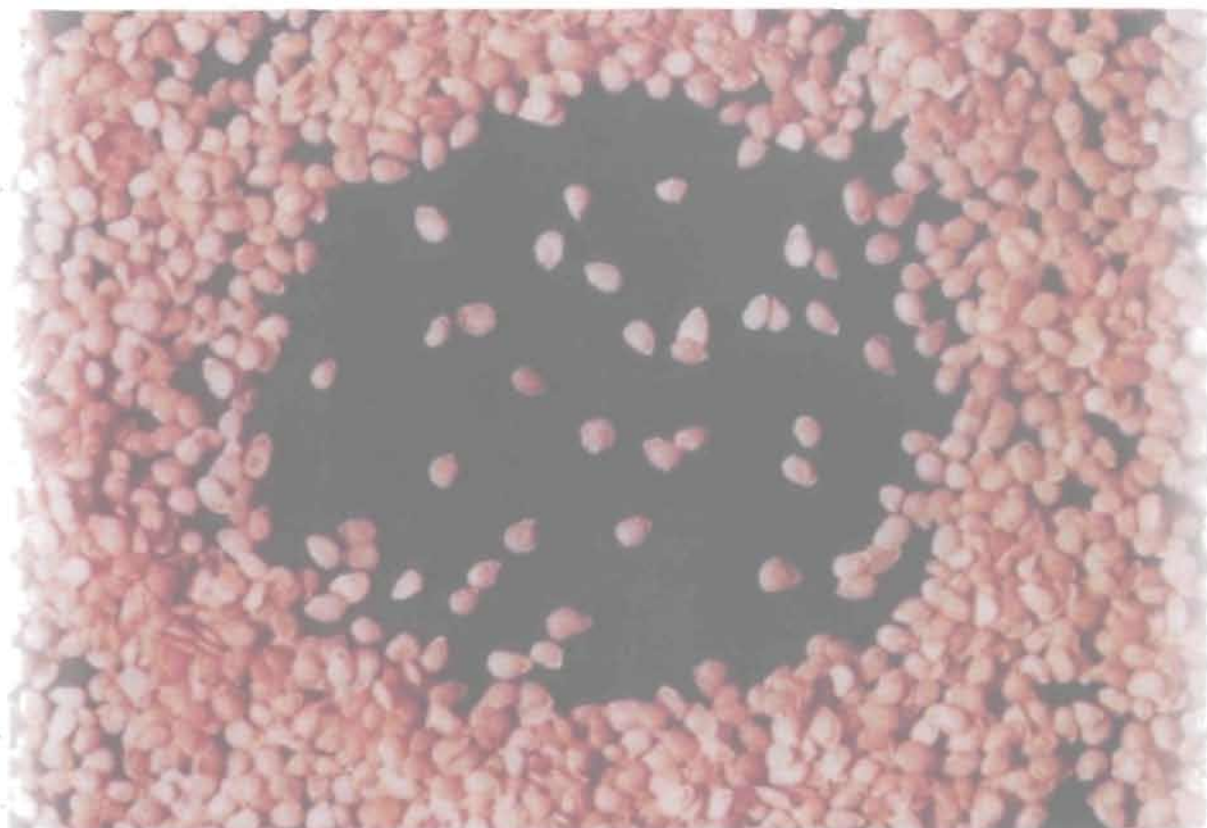
27. The population PT/10-9 gave highest red tubers (77%).

Shillong: Evaluation of 14 Nos. TPS populations during summer and 34 Nos. in autumn seasons during 2010 showed no significant differences between populations for total tuber yield, tuber uniformity and dry matter.

Seedling tubers (F_1C_1) at Patna

Red skinned: Seedling tubers of 7 red skinned populations along with two controls K. Arun & K. Kanchan were evaluated at 75 DAP. Population PRR 902 and PRR 906 yielded significantly higher than the control K. Kanchan.

White skinned: Seedling tubers of 20 white skinned populations along with control 92PT-27 were evaluated at 75 DAP. 11 populations viz 2009KPT-15, 2009KPT-19, 2009KPT-2, 2009KPT-24, 2009KPT-26, 2009KPT-29, 2009KPT-9, PWW 903, PWW 912, PWW 942, PWW 944, PRR 906, and PRR 902 gave significantly higher total tuber yield than the control 92PT-27.



Biotechnology in potato improvement

The main aims of this programme are to conduct strategic research on gene silencing for improvement of potato cold chipping attributes and development of potato somatic hybrids using wild species for late blight resistance; and basic research on genome sequencing of potato and pathogens, and functional genomics on potato tuberization and late blight resistance.

Development of potato transgenics for improvement of cold-chipping attributes

Limited field trial of seven vacuolar acid invertase RNAi lines along with non-transgenic wild type control, Kufri Chipsona-1, was conducted at CPRS, Jalandhar for event selection. There had been no variation in plant morphology in all the seven invertase RNAi lines. Although, there were no variation in eye depth, skin and flesh colour, striking variations in tuber shape and size were observed in two transgenic events, K.ChipInvRNAi-2213 and 2015, which produced very small oblong-shaped tubers. Yield performance of two events, K.ChipInvRNAi-2214 and 2123, in terms of tuber number per plot, processing grade yield, marketable yield and total yield was similar to the non-transgenic control. Yield of other five transgenic events was significantly lower than control. There was not much variation in dry matter content of the transgenic events, and it ranged from 21.16% in K.ChipInvRNAi-2213 to 23.25% in K.ChipInvRNAi-2213 compared to 22.10% in wild-type control Kufri Chipsona-1. Due to very small size and oblong shaped tubers, which are highly undesirable for chip making, and the lowest yield, two transgenic events, K.ChipInvRNAi-2213 and 2015, were not included for evaluation of processing attributes.

Harvested tubers were cold stored at 2 °C, and cold chipping performance was evaluated after 45 days intervals for three months. As reconditioning of cold stored tubers at 20 °C for 21 days is a common practice of processing industry, chipping performance of cold stored tubers of RNAi lines was also evaluated after 21 days of reconditioning at 20 °C. Although, only one invertase RNAi event (K.ChipINV RNAi-2214) produced acceptable chip colour (Fig. 11) after 45 days of cold storage when evaluated directly after cold storage, all the five RNAi events (K.ChipINV RNAi 2214, 2013, 2311, 2123, 2262) produced acceptable chip colour after 21 days of reconditioning as evidenced by visible colour score (3 is acceptable in a scale of 1-10) (Fig. 11). Similar pattern in chip colour was obtained after 90 days of cold storage. K.ChipINV RNAi-2214 produced acceptable chip colour directly after cold storage for 90 days, and three RNAi events (K.ChipINV RNAi 2214, 2013 and 2262) produced acceptable chip colour after 21 days of reconditioning (Fig. 11). Highest level of reduction of reducing sugars (glucose + fructose) with concomitant increase in sucrose level was observed in K.ChipInvRNAi-2214 at all the stages of cold storage. Reducing sugars level in K.ChipInvRNAi-2214 was either below or equal to the acceptable limit, which is 100 mg/100gFW. Reduction of reducing sugars level in K.ChipInvRNAi-2214 directly after three months of cold storage was 91%, while after 21 days of reconditioning it was 82% compared to wild type control. Acceptable limit of reducing sugars level, although, was not obtained in other RNAi lines during different stages of storage, reducing sugars level decreased substantially from that of wild-type control. Based on yield performance from confined field trial for event selection and cold-chipping performance the RNAi event, K.ChipInvRNAi-2214, was selected for further evaluation.

Production of potato somatic hybrids using wild species

SSR analysis

Interspecific potato somatic hybrids of *S. tuberosum* dihaploid C-13 (+) *S. etuberosum* and C-13 (+) *S. pinnatisectum* (Fig. 12) was characterized by DNA fingerprinting using simple sequence repeats (SSR) markers. Somatic hybrids were identified based on the combination of the presence of DNA fragments of both the parents. Seven SSR markers, STI0001, STI0012, STM0019, STM1104, POTM 1-2, STWING12G and STWAX-1, detected 12 somatic hybrids of C-13 (+) *S. pinnatisectum* possessing species-specific diagnostic bands of their corresponding parents (Fig. 13). Four SSRs, STG0016, SSR 136, SSR 188 and SSR 350, confirmed 21 somatic hybrids of C-13 (+) *S. etuberosum* through species-specific diagnostic bands of their corresponding parents (Fig. 14).

Cytoplasm (chloroplast and mitochondria) type of the somatic hybrids was analyzed from the genomic DNA using mitochondrial specific primers pairs ALMT_1/ALMT_3, ALM_4/ALM_5 and ALM_6/ALM_7, and chloroplast specific primer ALCP_1/ALCP_3. Cytoplasm type of the somatic hybrids C-13 (+) *S. pinnatisectum* and C-13 (+) *S. etuberosum* was analyzed using mitochondrial specific primer pairs ALM_4/ALM_5, and ALM_6/ALM_7, respectively. SSR markers indicated dominance of W/α type cytoplasm in the somatic hybrids.

PVY resistance of the somatic hybrids

Hybrid plants and their parents were planted in the glass-house for PVY resistance test of the somatic hybrids of C-13 (+) *S. etuberosum* at CPRI, Shimla. *In vitro* raised plants were mechanically inoculated using PVY^o isolate. Somatic hybrids showed vigor as they derived from a PVY resistant wild parent *S. etuberosum*,



Fig. 11. Cold-chipping performance of invertase RNAi lines after 90 days of cold-storage.



Fig. 12. Development of potato somatic hybrids by protoplast fusion



Fig. 13. SSR marker profile of C-13 (+) *S. pinnatisectum* generated by primer ST10001, M = 50 bp ladder, P1 = C-13, P2 = *S. pinnatisectum*, P1+P2 = Pooled parental DNA, Conformed somatic hybrids (Nos. 1 to 10, 12 and 13)



Fig. 14. SSR marker profile of C-13 (+) *S. etuberosum* generated by primer STG0016, M = 50 bp ladder, P1 = C-13, P2 = *S. etuberosum*, P1+P2 = Pooled parental DNA

and the effects of virus infection of these lines was investigated. Parent C-13, displayed sensitivity to the virus with clear symptoms of progressive leaf discoloration and decrease in plant growth and symptom appearance. Hybrids

displayed resistance to PVY consisting of the absence of virus symptoms compared to parent C-13. Twenty-one somatic hybrids showed resistance to PVY by das-ELISA. In all the somatic hybrids, the das-ELISA value was lower than the threshold value of healthy control (0.03).

Structural and functional genomics of potato

Shot-gun whole genome sequencing of a tetraploid Indian potato cultivar was carried out using GS FLX Titanium next generation sequencer. The raw sequence data of 550 Mbp was processed with various set of softwares like GS Analyser and GS Assembler, and the sequence reads were finally assembled in contigs. Shot-gun sequencing of Indian potato cultivar generated 550 Mbp sequence data. A total of ~56000 contigs covering 170 Mbp of the genome were generated out of which 650 were large contigs. Size of the largest contig was 17.5 Kbp.

Three dimensional homology model of potato vacuolar acid invertase (valNV) was developed by *in silico* approach. Active site analysis and docking of substrate, sucrose, were done to study possible interactions into

the hydrophobic cavity of the enzyme. The stereochemistry of the models was gauged by Ramachandran plot. In this model, 86.1% of the amino acid residues were in the favourable regions of the plot for the whole enzyme, whereas 12.1% of the residues were in the additionally allowed region (total of 99.7%), 0.7% in the generously allowed region and 1.0% residue in the disallowed region. Altogether, 99% of the residues was in favoured and allowed regions. The overall structure of valNV was composed of two individual modules, namely a five-bladed Beta -propeller (residues 1–295) catalytic module linked to a C-terminal Beta-sandwich module (residues 306 to 432) by a 10-residue linker (Fig. 15). The active site of valNV was positioned at one end of the cavity at the centre of the beta-propeller catalytic domain which has a funnel-like opening toward the molecular surface. The propeller had a 5-fold repeat of blades, each consisting of four antiparallel β -strands with the classical 'W'

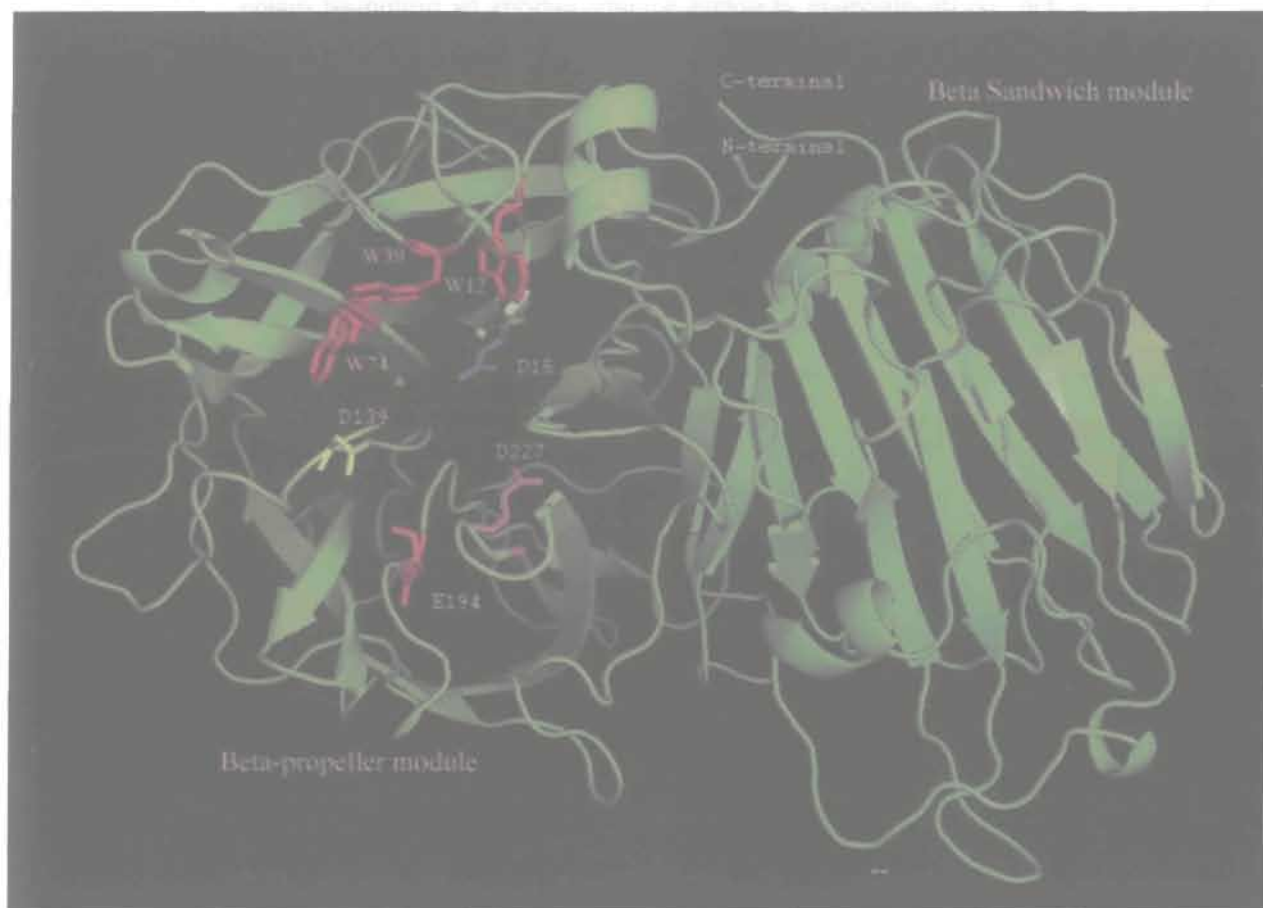


Fig. 15. Predicted model of potato vacuolar acid invertase. The conserved residues are shown by D15, D139, E194 and D227 are shown in blue, yellow orange and magenta respectively. The additionally conserved surrounding residues W12, W39, W74 are shown in red colour.

topology around the central axis generating a high negative charge cavity in the active site. (Fig. 15). The conserved motifs in the active site showed three conserved residues of the WMNDPNG (sucrose binding box), EC and RDP motifs. These three highly conserved residues, (two aspartates and one glutamate) are referred as 'the catalytic triad', which are necessary for binding and catalysis. Aspartate in WMNDPNG acts as a nucleophile, whereas aspartate in RDP motif acts as a transition-state stabilizer, and glutamate in EC acts as acid base/catalyst. However, the aspartate (RDP-motif) seems not to be directly involved in the catalytic mechanism and most probably acts

as a transition-state stabilizer. The conserved residues along with the surrounding residues play crucial function in sucrose binding and catalysis. The fructose ring in sucrose was stabilized by the valNV active site residues Asp 15 (NDPNG), Asp139 (RDP) and Glu194 (EC) which performed as nucleophile, transition state stabilizer, and acid/base catalyst, respectively. However the other residues W12, W39 and W74 form a hydrophobic zone and the residues N22, R138, and D227 were necessary to create the ideal sucrose-binding pocket. The presence of this hydrophobic zone seems to be important for optimal and substrate binding of sucrose.



DIVISION OF CROP PRODUCTION



Resource management and information technology in potato based cropping systems

Mounting pressure on cultivable land in India due to burgeoning population and diversion of agriculture land to non-agricultural uses warrants increasing productivity per unit available land. This demands finding the ways and means for efficient utilization of existing resources. The programme aims to develop resource management strategies in major potato based cropping systems of India. It also endeavors to use IT for developing precise recommendations as well as its dissemination by the use of DSS and other IT tools like GIS and remote sensing.

Spatial intensification of potato through intercropping systems in eastern Indo- Gangetic plains of Bihar

Intercropping of potato and maize is popular and economically more viable in potato growing areas of north Bihar districts as compared to sole cropping of either of the crop. A field experiment was conducted at Patna on sandy clay loam soil under irrigated condition to work out nitrogen management strategies for maize + potato (1:1) intercropping system.

There was significant effect of nitrogen dose on maize grain yield. Although maize grain yield increased with increasing N dose up to the highest level of 100% recommended dose (RD), there was no significant difference in maize grain yield between 75% N and 50% N application to maize crop. Application of 50% N of RD to maize recorded the highest total PEY (45.65 t/ha) as compared to 100% N of RD (43.88 t/ha). This was mainly because of highest potato yield under the treatment, the major contributor

to the total potato equivalent yield (PEY) of the intercropping system.

Method of nitrogen application to maize did influence significantly the yield of maize. Application of nitrogen in three splits as $\frac{1}{2}$ N at the time of planting and $\frac{1}{4}$ N at knee high stage + $\frac{1}{4}$ at tasselling stage, produced higher (8.22 t/ha) grain yield of maize as compared to $\frac{1}{3}$ N at planting + $\frac{1}{3}$ N at knee high stage + $\frac{1}{3}$ at tasselling stage or in two splits ($\frac{1}{2}$ N at knee high stage + $\frac{1}{2}$ N at tasselling). This treatment also produced higher PEY as compared to other treatments due to combined higher yield of potato and maize. The net return of Rs. 82,000/ha was also the highest under this treatment.

Development of agro-techniques for potato + sugarcane intercropping system

In a field experiment in north western plains at Modipuram N, P and K levels of 50, 100 and 100% recommended dose to sugarcane, respectively gave highest potato equivalent yield due to better potato productivity (37.1 t/ha) in potato + sugarcane intercropping system.

Yield stability in potato under varying soil management strategies

Management practices that improve soil quality can enhance potato yield stability by reducing the impact of adverse growing conditions. There are so many technologies available for successful production of potato and among them some are being practiced by farmers

and some are not due to various reasons. In order to evaluate some of our most important technologies in comparison with the farmers' practice, a study was initiated with two varieties of potato viz., Kufri Giriraj and an advanced stage hybrid OS/93-D-204 at southern hills of Ooty. The treatments consisted of growing potato as monocrop, potato-cabbage rotation (Farmers' practice), potato-cabbage rotation by applying FYM @ 20 t/ha to potato crop and potato + French beans (Intercropping)-cabbage rotation (Recommended practice). The potato equivalent yields of the system indicated that the yields were maximum from the improved practice recommended by Ooty station i.e., potato + French beans intercropping in summer season followed by growing of cabbage in the autumn season. The lowest yields of system were recorded in monocropping of potato. Growing of potato cv. Kufri Giriraj as monocrop resulted in significant increase in Potato Cyst Nematode (PCN) population both after summer as well as autumn season crops while monocropping of advanced stage potato hybrid OS/93-D-204 recorded the lowest PCN population.

Introducing new crops in potato as intercrops in the Nilgiri hills

Intercropping of potato with broadbeans was found advantageous in comparison to that of sole potato crop under both the varieties of potato (Table 1). The yields obtained with the advance stage hybrid OS/93-D-204 were higher in comparison with that of Kufri Giriraj both under sole and intercrop stands. Growing potato with broadbeans in 1:1 ratio recorded the highest potato equivalent yield in comparison with other treatments.

To introduce medicinal or aromatic plants as intercrops in potato, two separate trials were initiated at Ooty by planting rosemary and thyme as intercrops in potato under five different treatments. Growing of rosemary as intercrop in potato variety Kufri Giriraj, susceptible to nematodes, was found beneficial. The results indicated that potato + rosemary intercropping in 1:1 row proportions recorded better potato equivalent yield as well as the lowest nematode population. In case of resistant potato hybrid OS/93-D-204, growing of sole potato was more advantageous both; in terms of potato

equivalent yield as well as nematode population. Intercropping of potato with thyme was not much beneficial in both susceptible as well as resistant varieties.

Chlorophyll content and its relationship with stage and N application rate in potato

To study the chlorophyll content and its relationship with stage and N application rate in potato, an experiment was initiated at Shimla. The treatment consisted of 5 N application rates (0, 50, 100, 150 and 200 kg/ha). For the measurement of chlorophyll content in the leaves, chlorophyll concentration index (CCI) was measured at different growth stages of potato using hand held chlorophyll content meter, model CCM-200 of Optiscience make. The results showed that chlorophyll content in the leaves declined with advancement of growth. However, when 2nd dose of N was applied, there was a sharp increase in chlorophyll content and it declined thereafter (Fig. 16). There was a positive significant correlation between N application rate and chlorophyll content at 49 days after planting, which disappeared thereafter till the application of 2nd dose of N. However, where 2nd dose of N was applied, the significant positive correlation again appeared and was observed upto one month after application of 2nd dose of N. Similar correlations were also observed between chlorophyll content and tuber yield. It may be concluded that CCI is a good index and can be used to work out supplementary N requirement of potato.

Predicting N recommendations based on soil nitrate content

Excess nitrogen can result in environmental degradation. If a correlation can be established between soil nitrate content and yield response, it will be very convenient to formulate fertilizer recommendations based on it. Precise matching of application rates with the crop needs could reduce residual soil $\text{NO}_3\text{-N}$ available for leaching. With this objective a trial was initiated at Ooty with four levels of nitrogen (60, 90, 120 and 150 kg/ha) in three different varieties (Kufri Girdhari and two advance hybrids viz., OS/94-D-204

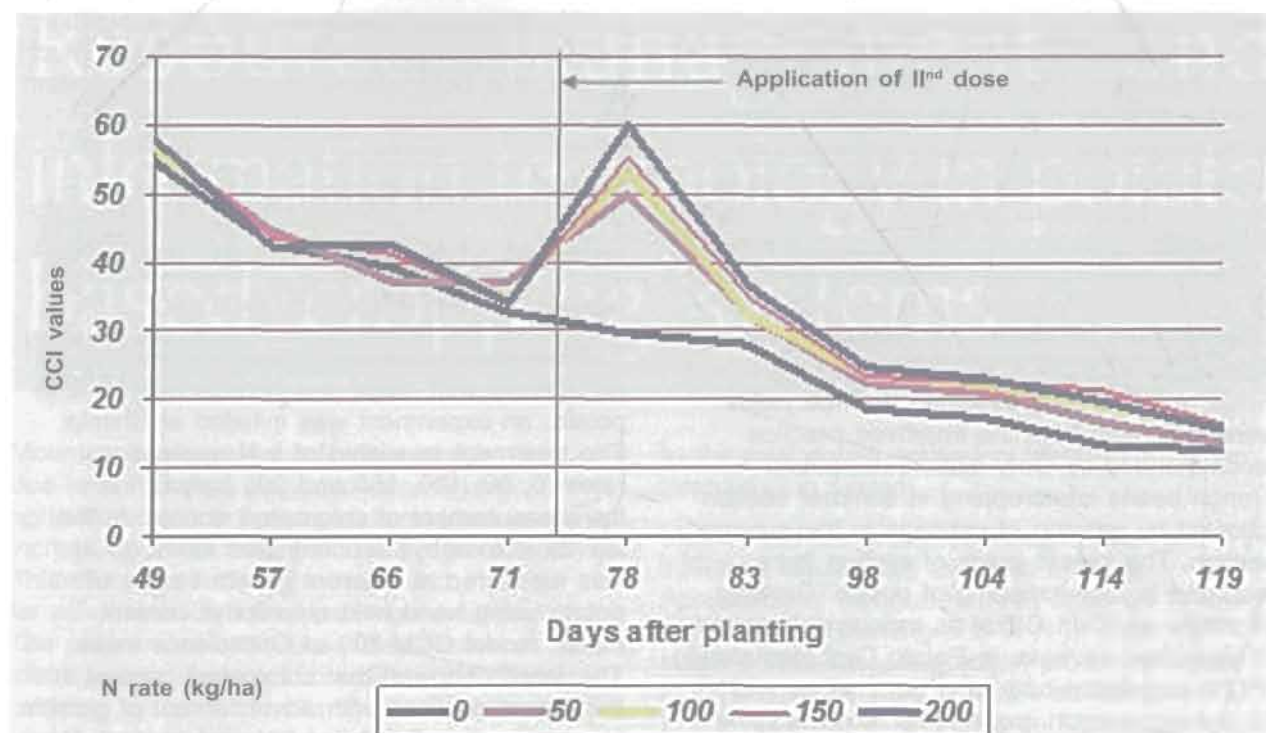


Fig. 16. Relationship between N application rate and chlorophyll content

and OS/93-L-956) during the summer season of 2010. Results showed that there existed a perfect correlation between the nitrate nitrogen at 0 to 30 cm depth and 0 to 90 cm depth, more quantity being accumulated at deeper levels.

Varietal differences also existed in accumulation of nitrate nitrogen at different levels of nitrogen applications. Hence regression equations were calculated for each variety separately and the nitrate nitrogen levels were estimated at optimal levels of nitrogen doses.

Nutritional management in seed potato crop

In order to standardize the varietal specific fertilizer requirement for producing seed crop of potato in Nilgiris, a field experiment was conducted at Ooty. There were differences in fertilizer requirement of varieties especially with respect to seed sized tuber production. In case of Kufri Giriraj, more number of seed sized tubers was recorded (25-75 g) when NPK were applied at 75, 135 and 75 kg/ha. Similarly in case of Kufri Swarna, this requirement was

only 75, 112.5 and 75 kg/ha. In case of Kufri Himalini 60, 135 and 60 kg NPK/ha produced more number of seed sized tubers. Kufri Jyoti produced more number of seed sized tubers at 60, 112.5 and 60 kg NPK/ha. Kufri Girdhari recorded higher number of seed sized tubers at 60, 90 and 90 kg NPK/ha. This indicates that seed crop is to be fertilized at little lower rates than that of ware crop and among the varieties Kufri Girdhari required least quantities of fertilizers. Among the varieties the performance of Kufri Swarna was better in terms of total yield in comparison to other varieties.

Development of weed management strategies for potato crop

At Modipuram, post emergence application of propaquizafop herbicide (0.625 kg/ha) in potato crop under flood irrigation was evaluated in cv. Kufri Sadabahar. Weeds reduced total tuber yield by 40.6% in weedy check. Spray of propaquizafop gave comparable productivity as conventional weeding and earthing up, however,

it was not effective in controlling weeds in later stage of crop growth (80 days). Post emergence herbicide propaquizafop in potato crop cv. Kufri Chipsona- 3 also decreased weed growth at 80 days under sprinkler irrigation and gave comparable productivity as conventional weeding and earthing up.

Effect of tillage and nitrogen on potato production

A field trial was conducted during the winter season of 2010-11 at Patna to study the effect of tillage and N levels on potato production in the rice fallow. Results revealed that tillage significantly influenced potato emergence and potato tuber yield. Minimum total tuber yield (12.7 t/ha) was recorded in no tillage treatment, while highest total yield (28.4 t/ha) was recorded in treatment having one mould board ploughing + one harrowing + one tilling + one planking. This treatment also recorded significantly higher tuber yield of large, medium and total tubers over all other treatments. Application of N @ 150 kg/ha produced higher total tuber yield as compared to 120 kg N/ha.

Development and use of decision support system /tools

Testing of the decision support system (DSS) for deriving situation specific nitrogen recommendations (Advisory System for Nitrogen Management in Potato) was carried out. The DSS was found to give realistic estimates of N requirements under different soil organic carbon status, yield targets and harvest index.

A tentative structure for a DSS for irrigation management has been finalized. During the year under report the structure was critically reviewed and suitable changes made for making it into a generic web based DSS for use by the farmers. Literature for developing the algorithms for use in the DSS was collected.

A decision support system for Potato Crop Scheduling in the Nilgiris (CAASPS for Nilgiris) was developed. A database of meteorological data for different taluks in the Nilgiris was developed using a weather generator and

INFOCROP- POTATO model was run for different dates and different seasons and a database of yield under different scenarios was also created. A graphical user interface was developed for accessing and querying this database. Further testing of this DSS is being carried out.

Develop database and web enabling of decision support systems/tools

The structure of an Information System was finalized and the various databases that would form the components of the database were also finalized. Some data have been collected and further building up of the database is in progress. District wise daily weather normals were collected for use in the database.

Integrated resource management and land use analysis in *kharif* potato and southern hills

The plan for the regional level study was finalized. TechnoGIN software was selected for the study after exhaustive literature search. The data as per input requirements for TechnoGIN are being collected.

GIS based delineation of sites suitable for *kharif* potato cultivation in India

Studies to identify the plateau areas in the Central and Southern parts of the country and then delineate areas suitable for growing potato during the *kharif* season in these plateau areas were continued. The weather database of locations in the areas demarcated as suitable for growing potato in *Kharif* were collected and the available growing period, potential biomass yield mean night temperature of the tuber growing period etc. were estimated using algorithms and further characterization of the region is in progress.

Assessing prospects of potato in India using remote sensing and GIS

The ground truth data were collected from Punjab, Uttar Pradesh and Bihar during December, 2010 - January, 2011. The analysis for winter potato acreage estimation for 2010-11 was done using IRS-P6 AWiFS data in collaboration with Space Applications Centre (ISRO), Ahmedabad. Image analysis was done on TM tiles of $2^\circ \times 2^\circ$. For potato crop acreage estimation, GVI (Green vegetation index), NDVI (normalised difference vegetation index) and LSWI (land surface water index) values were used in algorithms. Multidate images were used and were subjected to isodata multivariate

unsupervised classification. The isodata unsupervised classification was repeated till the pure potato classes were obtained. These potato classes (pixels) were used in stratified random sampling for obtaining potato acreage. Weather data from Jalandhar, Modipuram, Agra, Varanasi and Patna were collected and used for running the INFOCROP POTATO model and yield estimates of Punjab, UP and Bihar were derived. These data were used for production forecast of winter potato for 2010-11.

The acreage forecast under winter potato during 2010-11 in Punjab, Uttar Pradesh, Bihar and West Bengal is 80.0, 492.2, 162.3 and 329.0 thousand hectares, respectively, while the total production was predicted as 1523.4, 10244.4, 1594.4 and 8558.1 thousand tons, respectively.



Advisory System for Nitrogen Management in Potato

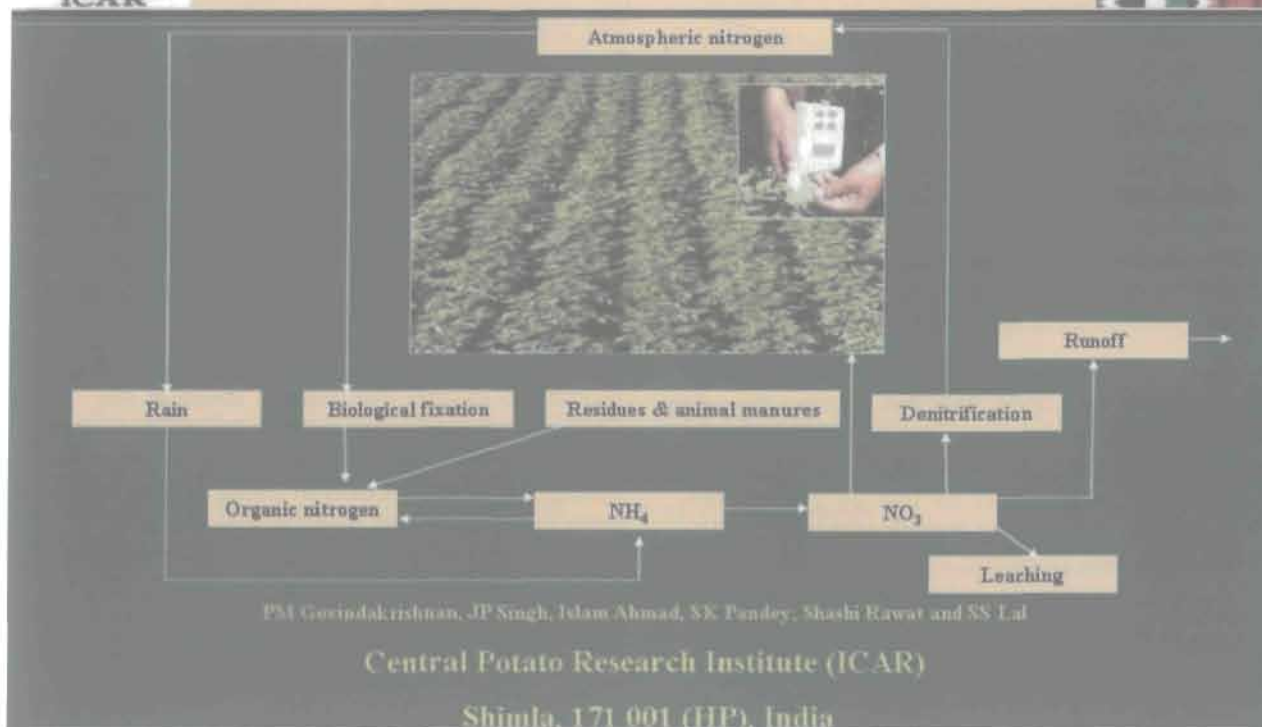


Table 1. Potato equivalent yield (PEY) of potato + broadbeans intercropping at Ooty

Treatment	PEY (t/ha)		
	Kufri Giriraj	OS/93-D-204	Mean
Potato+Broadbeans 1:1	22.6	24.1	23.3
Potato+Broadbeans 2:1	15.9	21.9	18.9
Potato+Broadbeans 3:1	12.5	17.8	15.1
Broadbeans	21.2	22.6	21.9
Potato	11.0	15.5	13.3
Mean	17.0	20.6	
CD 5%			
Varieties	1.8		
Treatments	2.9		
VXT	NS		



Potato + Rabi maize intercropping

Nutrient and water management in potato

Potato is a crop of high input requirement and poor input use-efficiency causing concern about environment. Mostly cultivated in light textured soils, high rates of N and P fertilization pose threat to degradation of surface and ground water quality. This has raised concern worldwide and attempts have been made to develop best management practices which are economically sound and environmentally safe. Therefore, aim of this programme is to improve efficiency of two key inputs viz. nutrients and water. Two pronged approach followed include characterization of soil resources and development of site specific nutrient management strategies on the one hand and development of nutrient and water efficient cultivars on the other.

Geo referenced mapping of available nutrients and development of site-specific nutrient management techniques

Distribution of different forms of P & K in potato growing soils of Jalandhar district of Punjab: Analysis of soil samples collected from different farmers fields of Jalandhar, revealed that area under medium, high and very high available P was 10, 80 and 10%, respectively (Fig. 17). More than 89% of area under potato was low in available K (<105 ppm) for this crop. The per cent deficient area under individual micronutrient was 11% for Cu and Mn, 14% for Zn and Fe (Fig. 18).

Water-soluble K varied from 12.80 to 81.20 mg kg⁻¹ with a mean value of 31.31. Exchangeable K, which represents the fraction of K, which is adsorbed on external and accessible internal surface ranged from 9.44 to 186.90 mg kg⁻¹. The available K content ranged from 34.0 to 226.5 mg kg⁻¹ with a mean value of 74.4 mg kg⁻¹.

Non-exchangeable K, considered to be slowly available to the plants under stress conditions ranged from 285.0 to 3380.5 mg kg⁻¹ with a mean value of 1619.91 mg kg⁻¹. 1N HNO₃-K varied from 332.5 to 3440.0 mg kg⁻¹ with a mean value of 1694.31 mg kg⁻¹.

Site specific nutrient management (SSNM): SSNM tested with omission plot technique and over fertilized reference (OFR) in potato cultivars, viz, Kufri Pukhraj and Kufri Bahar behaved quite differently on farmer's field at Modipuram. The highest tuber yield in Kufri Pukhraj and Kufri Bahar was reduced by 15.3 and 9.9 t ha⁻¹ in N omission plot as compared to OFR plot. In Kufri Pukhraj, after N omission plot, the greatest effect was recorded in K omission plot (8.8 t ha⁻¹) followed by P (5.8 t ha⁻¹), while in Kufri Bahar the order of reduction was K (6.6 t ha⁻¹), P (6.4 t ha⁻¹). At Modipuram farm, the highest tuber yield in Kufri Pukhraj was reduced by 19.1 t ha⁻¹ in N omission plot as compared to OFR plot. After N omission plot, the greatest effect was recorded in K omission plot (5.2 t ha⁻¹) followed by P (2.9 t ha⁻¹) and S (2.3 t ha⁻¹) in omission plots.

Develop/identify nutrient and water efficient potato cultivars/hybrids and characterize nutrient use efficient cultivars

Breeding for water and nutrient use efficiency

Hybridization: A total of 56,648 seeds of 25 crosses were obtained at Kufri.

Raising of seedlings: A total of 20,887 F₁ seedlings obtained from germination of 68,948 seeds, were transplanted in field with no additional nutrient supplied and 6603 selections were made on the basis of tuber characters such as color, shape and eye depth.

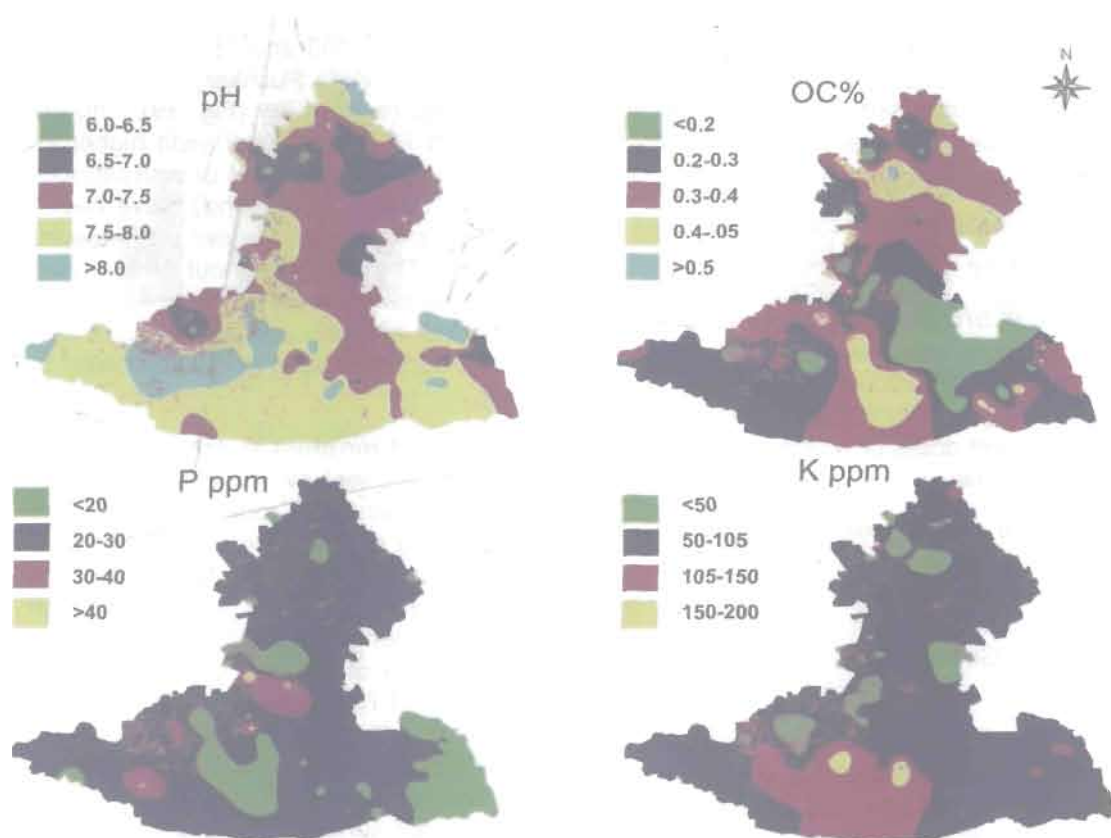


Fig. 17. Spatial distribution of soil pH, organic carbon (OC%), available P and available K in potato growing pockets of Jalandhar district of Punjab (Pink pixels represent potato area)

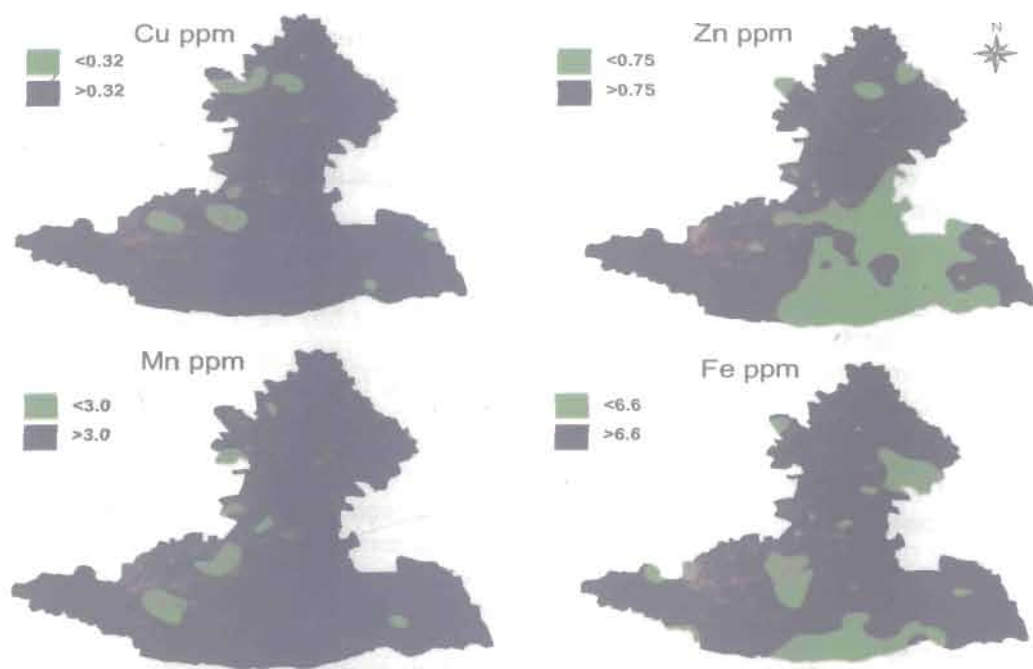


Fig. 18. Spatial distribution of DTPA extractable Cu, Zn, Mn and Fe in potato growing pockets of Jalandhar district of Punjab (pink pixels represent potato area)

Evaluation in first clonal generation: A total of 2,876 F_1C_1 clones were planted. Based on tuber characters, such as shape, skin colour and eye depths; 752 clones were selected.

Screening of hybrids/ cultivars for Water and N use efficiency

Patna: The hybrid JX 576 (Kufri Gaurav) possessed high tolerance to nitrogen stress and was the most N efficient. The hybrid JX 576 produced yield similar to other cultivars including best control Kufri Pukhraj and Kufri Pushkar with lower doses of N under similar agro-ecological conditions.

Ooty: Based on the control yield (No P applied) and dose of P required to produce fixed tuber yield in the same field, hybrid OS/93-D-204 was most P efficient followed by cvs., Kufri Himalani, Kufri Swarna, Kufri Girdhari, Kufri Giriraj and Kufri Jyoti.

Modipuram: A total of 88 of the advanced numbers out of 175 tested produced equal/higher yield than popular varieties Kufri Bahar and Kufri Pukhraj at all irrigation levels and have been selected for testing under plot wise trials for next year.

Jalandhar: Mean water use efficiency of Kufri Gaurav was 129 kg tubers/ha-mm water in

comparison to 117, 103 and 75 kg tubers/ha-mm water of cvs. Kufri Pushkar, Kufri Badshah and Kufri Jyoti, respectively (Fig. 19). The 28 hybrids out of 75 having tuber yield higher than both mean tuber yield without or with nitrogen application (160 or 240 kg N/ha), have been selected for further testing under plot wise trials for next year. The 27 hybrids out of 46, having tuber yield higher than either mean tuber yield without or with nitrogen application, have been selected for further testing under replicated trial next year.

Root studies of different potato cultivars:

Most nitrogen efficient cv. Kufri Gaurav had significantly higher mean root length (2151 cm/plant), mean root surface area (418 cm²/plant) and mean root volume (6.55 cm³/plant) than least N efficient cultivar Kufri Jyoti which had mean root length of 1539 cm/plant, mean root surface area of 299 cm²/plant and mean root volume of 4.70 cm³/plant at 55 days after planting. This cultivar had significantly higher root length, surface area and volume at all N level as compared to Kufri Jyoti (Fig. 20). Mean root length, root surface area and root volume per plant of most N efficient Kufri Gaurav were statistically at par with the highest obtained in any cultivars/hybrid tested.

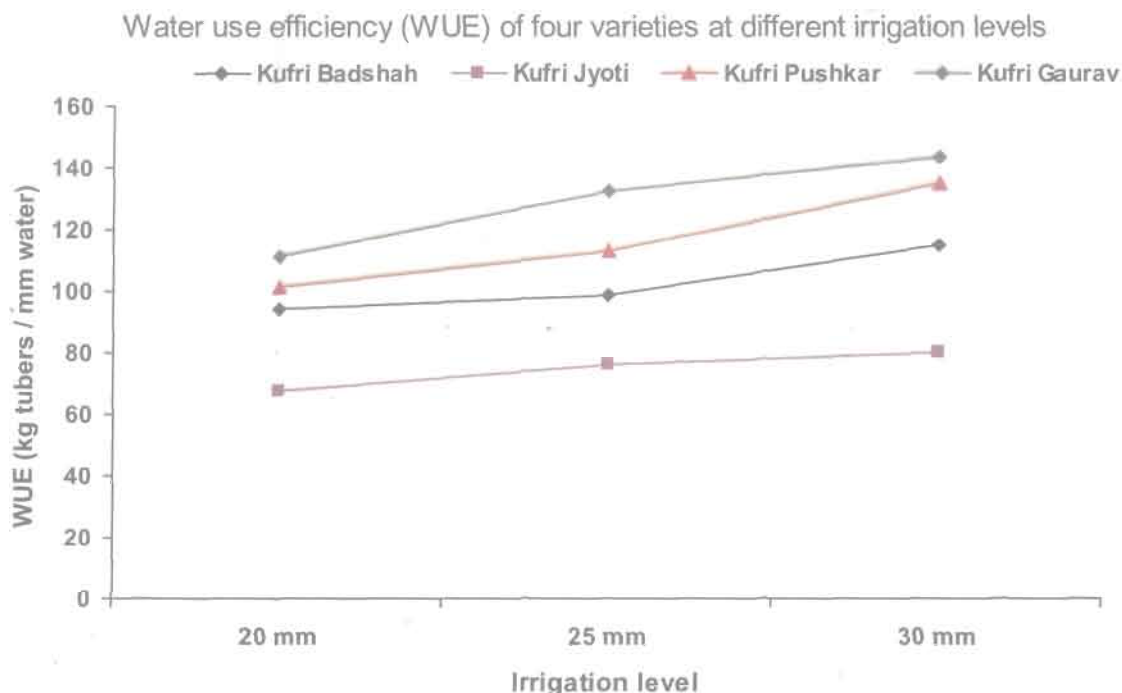


Fig. 19. Water use efficiency of potato cultivars as influenced by different irrigation levels

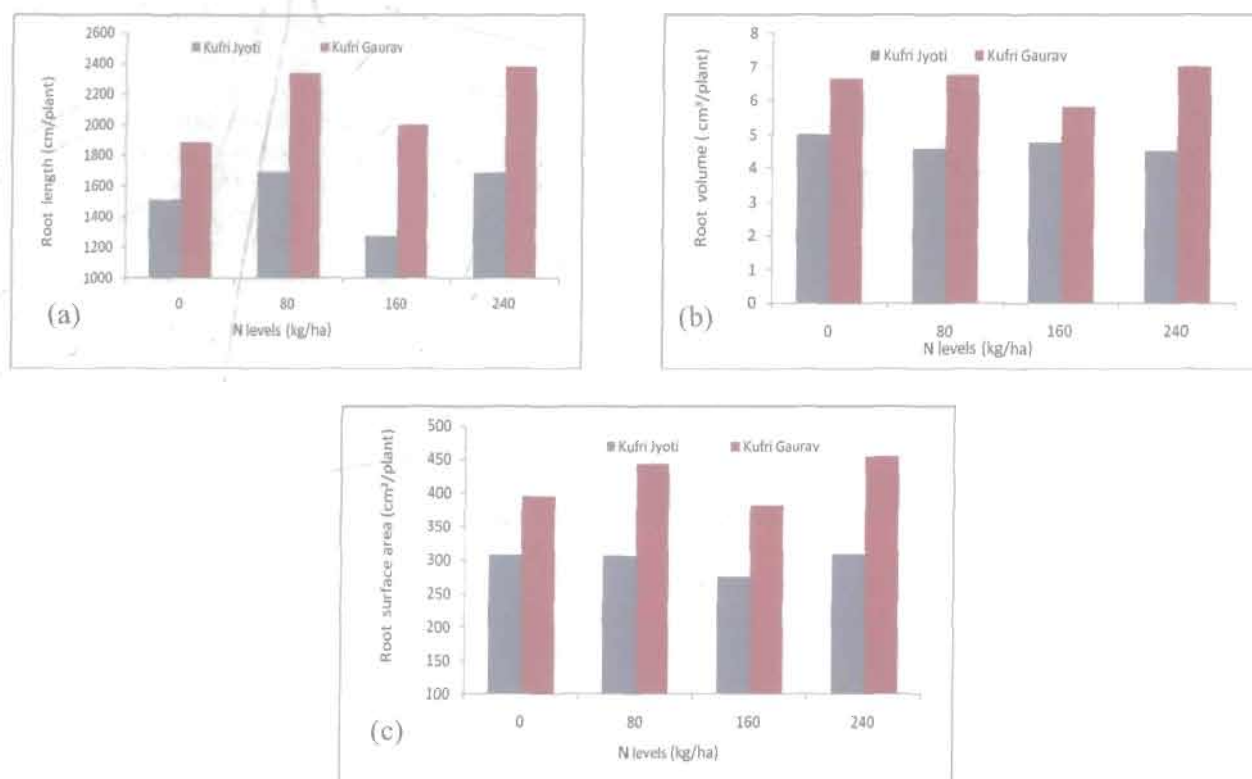


Fig. 20. Root length, volume and surface area of Kufri Jyoti and Kufri Gaurav as influenced by N levels (a) root length, (b) root volume and (c) root surface area

Improving water use efficiency through micro-irrigation in the plains

Water use efficiency: Water use efficiency of cv. Kufri Pukhraj was 177, 170 and 93 kg tubers/ha-mm water with drip, sprinkler and furrow irrigation method, respectively.

Phasic water need: The plant dry matter production (tubers+haulms) increased with increasing water levels from 100 to 150% cumulative pan evaporation (CPE) under drip and sprinkler irrigation method at tuber initiation, early tuber enlargement and late tuber enlargement stages (35, 50 and 65 days after planting, respectively) at Modipuram. The data indicated that the crop requires irrigation at 150% CPE water level at these three stages under modern methods of irrigation. However, the dry matter production at stolon formation stage (25 days after planting) did not differ significantly with varying water levels under modern irrigation methods. The similar trend was also noticed in case of furrow irrigation.

Evaluation of different types of drip laterals/drippers on potato production

The drippers with 2 litres per hour (lph) water discharges placed at 20 cm distance produced significantly higher yield in comparison to other treatments. The yields of all potato cultivars were significantly higher, when potato crop raised under turbo head medium volume mini-sprinkler (THMVS) with water discharge of 170-350 lph, placed at 8 x 8 m distance in comparison to turbo head low volume mini-sprinkler (THLVS), water discharge of 100-250 lph, placed at 5x5 m distance.

While the irrigation system, Metal Impact /Impact Plastic sprinkler, (water discharge 360-720 lph, placed at 10 x 10 m or 10 x 12 m distance), produced higher yield as compared to other mini-sprinkler systems tried. But statistically, it was at par with the produce of mini-sprinkler (THMVS), water discharge of 170-350 lph, placed at 8 x 8 m distance.

Effect of variations in soil moisture content created through irrigation on potato production in the hills

Seeding irrigation (irrigation given at planting time) at Shimla increased soil moisture content in the soil profile which helped in quick seed tuber emergence and growth. Plant emergence was completed 40 days after planting in treatment where seeding irrigation was given, whereas, no emergence was recorded under rainfed condition as no rainfall was received during this period. Seeding irrigation enhanced plant height, number of leaves/plants and leaf area significantly as compared to rainfed condition.

Irrigation water applied at seeding irrigation + 75% available soil moisture (asm) increased potato yield by 45.5% over rainfed condition. Under limited water condition, two irrigations i.e. one at planting and other at tuber initiation stage increased potato yield by 36 % over rainfed and it was significantly at par with the irrigation at seeding irrigation + 75% asm. The results indicated that 100 mm of irrigation water could be saved if irrigation is applied at establishment and tuber initiation stages of potato crop.



Nutrient dynamics studies on long term manurial/fertilizer application and organic farming in potato production

Sustainable crop production on long term basis is most important to feed the increasing population of our country. The programme aims to study the effect of application of organic manure, crop residue, inorganic fertilizers on crop productivity and quality as well as on soil health on long term basis in promising potato based cropping systems. It also aims to develop agro techniques for organic potato production.

Long term manurial and fertilizer experiment on potato based cropping systems

The results of three promising cropping systems viz C₁; Potato – Wheat – Paddy, C₂; Potato – Onion – Maize and C₃; Potato – Moong – Sesamum being raised since 2006 -07, on same site, revealed that among the seven treatments (T1= Absolute control, T2 = 100% NPK through inorganic, T3 = 100% NPK through organic, T4 = 50% Inorganic + 50% organic, T5 = 100% NPK + Secondary nutrients, T6 = 100% NPK + Crop residue and T7 = 100% Organic + Crop residue incorporation) the yield of wheat, potato, onion and maize crops were highest, where 100 % recommended NPK was applied through inorganic fertilizers. But in case of paddy, *moong* and sesamum, yields were at par in organic and inorganic treatments in 2009-10. Application of secondary nutrients along with 100% NPK to potato crop increased the yield of paddy, potato, maize and there was no effect of secondary nutrients on yields of wheat, onion, *moong* and sesamum. The system productivity of inorganic

treatments was 34% higher than organic treatments. Among the three systems, the mean highest potato equivalent yield (62.51 t/ha) was recorded in maize-potato-onion cropping system followed by paddy-potato-wheat (52.62 t/ha) and 37.72 t/ha in sesamum - potato - *moong* crop sequence (Fig. 21).⁵

Under organic treatments, the tuber size remained smaller compared to treatments, receiving NPK through inorganic fertilizers in all the cropping systems. The marketable tuber number and weight were significantly higher in inorganically raised crop of potato. In organic crop, the small size tuber number was 50% higher than conventionally grown potato.

To improve PEY of oilseed based cropping system (potato-*moong*-sesamum), trials were conducted to know the scope of raising groundnut at Modipuram. Among the seven varieties tried, the pod yields varied from 2.28-5.21 t/ha when grown during summer after potato. Except one variety (CSMG- 2014), all varieties yielded more, when sown during *Kharif* before potato.

Impact of long term use of organic and inorganic sources of nutrients on soil properties, pest complex and quality of produce

The dry matter content was highest in treatment receiving 100% organic fertilizer through

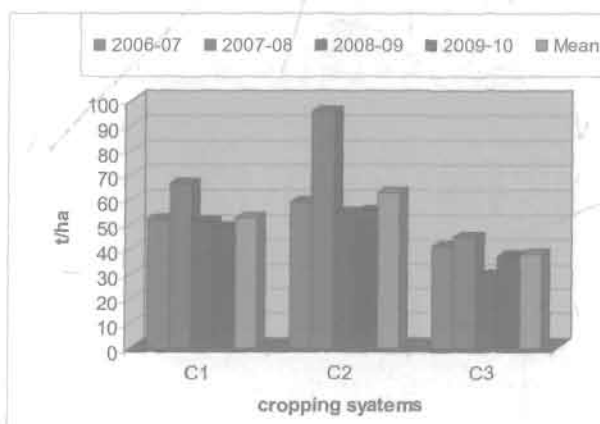


Fig. 21. Potato equivalent yield in different crop sequences (C₁ = Potato - Wheat - Paddy, C₂ = Potato - Onion - Maize and C₃ = Potato - Moong - Sesamum)

vermicompost, which was at par with treatment receiving 50% organic + 50% inorganic and 100% NPK + micro and secondary nutrients. The grain/bulbs nitrogen content was higher in treatment receiving 100% NPK through inorganic sources.

The soil analysis after potato harvest revealed that incorporation of crop residue as well as use of organic manure, with or without fertilizers, improved the organic carbon content of soil as well as microbial biomass carbon. The Subbaiya's mineral N Content was at par in all the three cropping systems, but there were difference among organic and inorganic treatments.

The treatment-wise analysis after potato, onion and maize harvest in potato-onion-maize cropping system, which have highest PEY, revealed that different nutrients options had no appreciable effect on pH, E.C., available N and DTPA extractable Zn, Cu and Fe. The application of nutrients through organic manure increased the soil organic carbon, available P and K significantly.

The treatment-wise microbiological analysis of rhizosphere of all the three cropping systems, after harvest of *kharif* crops, revealed that maximum population of bacteria was found when all NPK were applied through organic manure and minimum in control where no nutrient was applied.

For nutrient dynamic studies in potassium, the exchangeable soil K status before and after

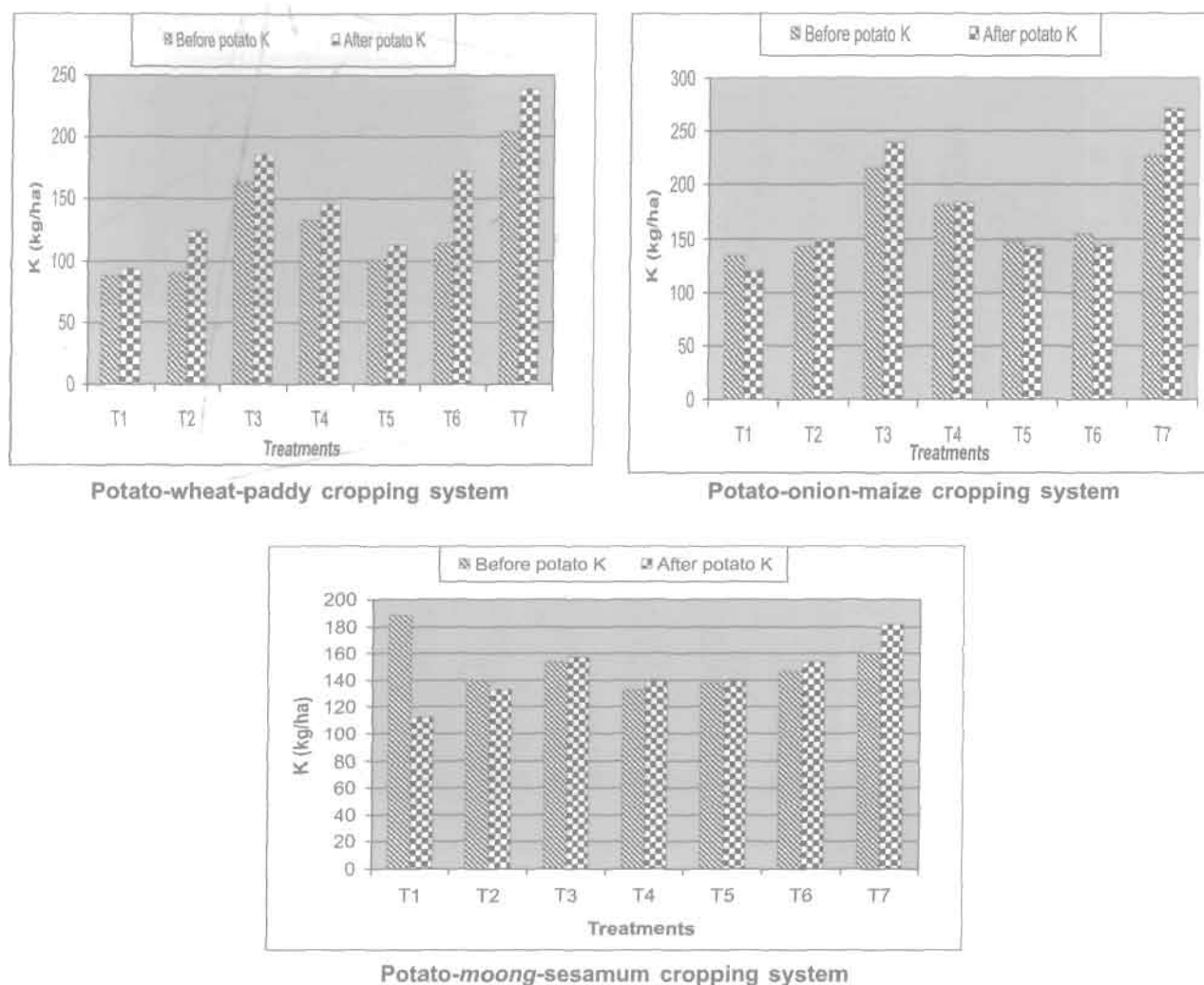
potato in different cropping systems reveal that in C₁ cropping system, irrespective of treatment, there was increase of exchangeable K after potato harvest (Fig. 22). In C₂ and C₃ cropping systems, treatment receiving nutrients through organic manure, showed increase in exchangeable K. Like K, in case of P, the Olsen (NaHCO₃ extracted) and NH₄Cl extracted were also studied to know P dynamics in soil (Fig. 23). The two forms varied with treatment and cropping systems.

The grain /bulbs nitrogen content was higher in treatment receiving 100% NPK through inorganic sources. The nitrogen uptake was higher in inorganic fertilized crop in comparison to organic crop (Fig. 24). The highest nitrogen uptake in potato tubers was in C3 (sesamum -potato-moong) cropping system (average 51.93 Kg/ha), while it was 49.10 and 47.68 Kg/ha in rice -potato -wheat and maize-potato-onion system.

Analysis of soil physical parameters after potato harvest in three cropping systems during 2010 (*viz.* after completion of four cycles of each cropping system) revealed that the *in situ* infiltration rate, saturated hydraulic conductivity and porosity were highest in maize- potato-onion system, followed by sesamum-potato-moong. Among the nutrient management treatments, the treatments involving incorporation of organic matter or residue recycling, improved the soil physical conditions by increasing *in situ* infiltration rate, saturated hydraulic conductivity, porosity and by decreasing the bulk density, in all the three cropping systems. In general, the soil texture, determined on the basis of particle size distribution, was loamy sand in all cropping systems/treatments and aggregate size distribution did not show any trend.

Organic farming for potato production

In permanent organic trial, continuing since 2002-2003, response to different nutrient options varied with cultivars. The highest organic tuber yield (47.23 t/ha) from vermicompost was recorded in Kufri Pukhraj followed by Kufri Chipsona-3 (46.16 t/ha), Kufri Bahar (37.88 t/ha), Kufri Chipsona-1 (31.79 t/ha) and Kufri Surya (25.96 t/ha). In case of FYM, the corresponding yields were 40.40, 38.33, 35.95, 35.35 and 24.67 t/ha, respectively.



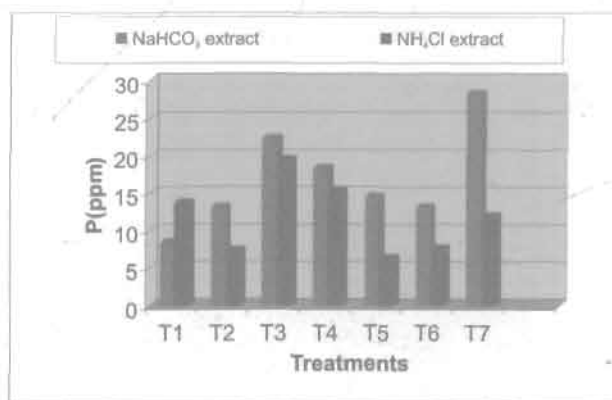
Where, T1= Absolute control, T2= 100% NPK through inorganic, T3= 100% NPK through organic, T4= 50% inorganic + 50% organic, T5= 100% NPK + Secondary nutrients, T6= 100% NPK + Crop residue and T7= 100% Organic + Crop residue incorporation.

Fig. 22. Exchangeable soil K status before and after potato in different treatments and cropping systems

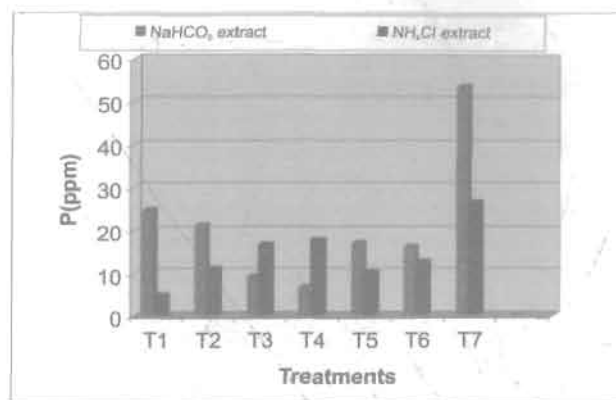
Quality parameters like dry matter, specific gravity, chip colour and surface shinning were better, when raised organically. The organic carbon, microbial biomass carbon, dehydrogenase activity, water holding capacity and soil aggregation increased, soil tilth improved, while bulk density decreased, where organic manure was applied continuously for the last seven years. Among the two organic sources, vermicompost was found superior to FYM. Tuber yields improved over the years due to cumulative effect of organic manure and are stabilized after seven years.

Organic manuring significantly increased the soil organic carbon, available NPK in soil

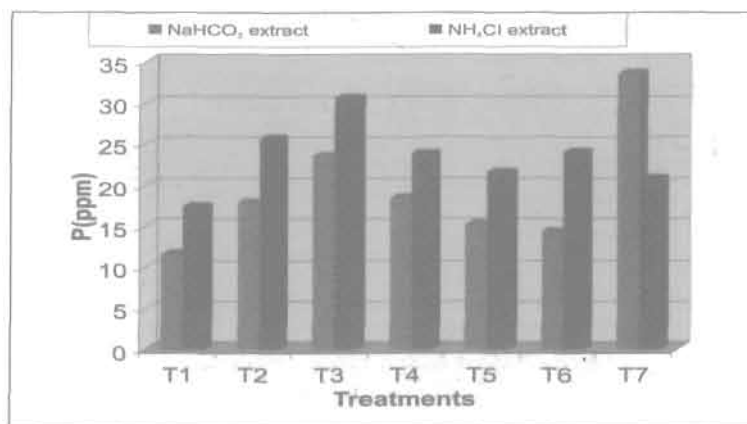
and resulted in reduction of soil bulk density. Organic treatments enhanced the tuber quality parameters viz. dry matter content, specific gravity and chip color. The tuber yields were reduced, when B_5 bioformulation was applied with fertilizers. In contrast, B_5 increased the tuber yield by 1.57, 1.47 and 1.53 t/ha in Kufri Surya, Kufri Pukhraj and Kufri Bahar, respectively, when applied with vermicompost. Statistically, the differences in yields due to B_5 application were non significant in all the three commercial cultivars. Among the three cultivars, Kufri Surya developed early yellowing/senescence than Kufri Pukhraj and Kufri Bahar, resulting in 38 and 28% lower yield, respectively. The soil analysis



Potato-Onion-Maize



Potato-Wheat-Paddy

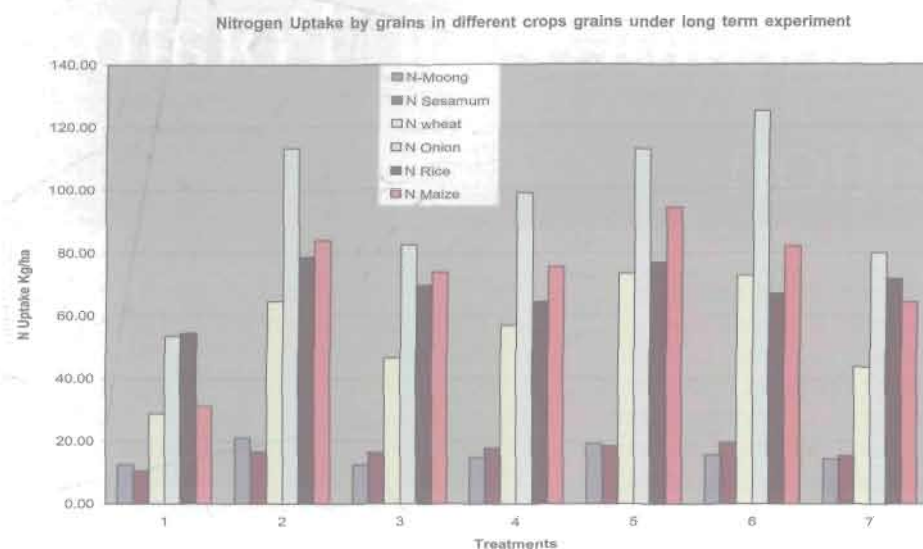


Potato-Moong-Sesamum

Where, T1= Absolute control, T2= 100% NPK through inorganic, T3= 100% NPK through organic, T4= 50% Inorganic + 50% organic, T5= 100% NPK + Secondary nutrients, T6= 100% NPK + Crop residue and T7= 100% Organic + Crop residue incorporation.

Fig. 23. Olsen extractable and ammonium chloride extractable P

revealed that organic manuring increased the electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium and DTPA extractable Zn, Cu and Fe, while the pH decreased slightly.



Where, T1= Absolute control, T2= 100% NPK through inorganic, T3= 100% NPK through organic, T4= 50% inorganic + 50% organic, T5= 100% NPK + Secondary nutrients, T6= 100% NPK + Crop residue and T7= 100% Organic + Crop residue incorporation.

Fig. 24. Nitrogen uptake by grains/bulbs in different crops



Component crops in long term manurial/fertilizers experiments

Farm Machines for Potato Cultivation

The objectives of the research programme are to develop implements and machines for experimental plots and for small farmers including the power tiller operated implements and machines. It also aims to develop potato grader and harvesting and collection system for combine harvester. Aeroponic system for high tech seed production and the potato handling and high capacity seed treatment system shall be developed.

Development of implements and machines for small farmers

Design and development of machines for potato experimental plots and for small farmers

Fabrication work of the frame, weeding system and power transmission system of the engine operated multipurpose weeder, was carried out. Frame of the engine operated multipurpose weeder is made out of 38x38x5 mm angle iron. These angle irons have been welded together in the form of a square so that the frame renders more strength to the whole unit. The prototype multipurpose weeder has been provided with two numbers of aluminium wheels of 450 mm diameter each fitted at the rear of the frame. Two numbers of plastic wheels of diameter 305 mm each have also been fitted in the front, in order to have proper balance of the prototype during operation. Both the aluminium wheels have been got rubber lined in order to have the smooth movement of the prototype in the field. Provision has been made in the system to adjust the height of both sets of the wheels, if required. Whereas both the aluminium wheels have been fitted with the help of two numbers each of ball bearings of internal diameter 25.4 mm (No. 6205), the plastic wheels have been fitted with the help of brass bushes of similar diameter. The prototype has been fabricated to work at a row

width of 65 cm, however, it can be changed to 60 cm upon requirement. Left and right set of the wheels move in the adjacent rows and can cover the ridge profile for weeding and haulm cutting operations etc. Gear box (size 150 mm square) fabricated mainly out of MS sheet of size 4 mm thickness, and provided with a set of bevel gears, in the power transmission system, can be moved up and down, upon requirement. A telescopic pipe frame has been provided for this purpose. A 3 HP engine fitted at the top of the frame shall give power to the attachments. A belt and pulley system and a set of sprockets are also being provided in the power transmission system in order to give required number of rpm (revolutions per minute) to the attachments. Two numbers of sprockets having 47 teeth each, have also been fitted on the shafts connecting the aluminium wheels to the frame, for this purpose. Weeding attachment of the prototype consists mainly of a rotor or weeding drum.

This rotor or weeding drum contains L-shaped cutting blades (made out of 32 X5 mm size flat) of variable lengths, so that it properly covers the whole ridge profile. These blades have been bent at ends in order to have better weeding operation.

Design work for the fabrication of a haulm cutting attachment was also carried out. It shall consist of a cutter bar having 75 mm wide serrated triangular cutting knives and two-tined guards. Clamp holders which are essential to hold the knife sections close against the shearing edge of the guards, shall also be provided. Further fabrication of the prototype and its attachments, is under progress.

Design and development of power tiller operated implements and machines for small farmers

A survey was conducted to find out the mechanization requirements of potato farmers in West Bengal. The farm power source available with the farmers is power tiller, mostly of 12 HP and a specific make and is used in potato,

only for land preparation (Fig. 25) and all other operations are carried out manually.



Fig. 25. Power tiller used for field preparation in potato cultivation

It was found that the power tiller as such cannot be made to work in the potato field for various crop operations due to its small and almost fixed track width and secondly due to its low ground clearance. To mechanize the potato crop in power tiller operated farms, there is a need to make changes in power tiller design and make provisions for adjustments in track width and increase in ground clearance. There is a need to increase the utility of power tiller in potato crop by developing suitable equipment for almost all the operations in potato crop viz. potato inter-cultivator, ridger, digger and planting aid as attachment to power tiller. Based on the observations made, the specifications of the power tiller as required to be suitable for potato crop were identified. The design of a potato digger as attachment to the power tiller was prepared. The selection of raw material for fabrication was carried out and the cost estimate was prepared.

Design and development of potato combine harvesting & grading systems and machines

Design and development of potato harvesting and collection systems of potato combine harvester

The designs of potato harvester combine as used in advanced countries were studied. The

combine harvesters in use were generally 2- row tractor operated with potato lifting, separation, clod crushing or separating, vines removing, size separating, bunker and telescopic conveyor systems for filling in trolley.

The design of a 2-row low cost potato combine system, an improvement over the design of trailed type digger windrower, was prepared and selected for the development of potato digging and conveying systems for the combine harvester. The twin chain trailed type potato digger windrower developed in the past was studied for its suitability and was considered for modification for conveying and side delivery of dug tubers. The chain conveyor system was modified. The twin chain system was replaced with a single extra long rod chain conveyor. The side delivery system was fabricated and provided for collection of tubers on one side of the machine. Both, the rear and side collection were considered. The side delivery was preferred for use for further development of harvester as it can facilitate to fill the trolley simultaneously during harvesting. The fabrication work was carried out. The prototype fabricated so far consisted of :

Digging system: It consisted of 2- passive lifter shares having floating dicone Diablo rollers over and in front of lifter shares. Diablo rollers were provided to reduce the formation of clods during harvesting in heavy soils, to help for better separation and to avoid the injury to the tubers from soil clods. A disc on each side of the lifter share and a set of discs in the centre were provided. The lifter shares are provided with the stone deflectors. Each share or lifter is 400 mm wide and is made triangular in the front for easy penetration and lifting action. The blades are held with the help of a MS flat attached to the main frame.

Elevator Conveyor: A rod chain conveyor 2400 mm long and 1200 mm wide with clear gap of 25 mm between the adjacent rods was fabricated using 12 mm dia MS rods. It was provided in the main frame of the prototype and was supported with set of rollers in the front and the sprocket sets at the rear end of the chain. Two sets of agitators, one of bigger size was provided for more agitation in front and another of small size for less agitation at the rear side of the chain conveyor, for better soil separation and to check the roll back of tubers being conveyed to the cross conveyor for loading in the trolley.

Provisions for side delivery of dug tubers:

A 600 mm wide cross chain made of 72 rods of dia 12 mm and with gap in rods of 25 mm has been provided at the rear of the digger i.e. main conveyor which shall receive the dug material and carry it to the left side of the frame to drop on the second chain conveyor, which is made inclined to carry and drop the material in a trolley. The system is so designed that the material mainly the tubers shall be dropped in the trolley from a height of 1600 mm from ground level. The trolley shall move along with prototype machine on the right side to receive the material continuously. The fabrication of side delivery system is in progress.

Development and evaluation of an improved square wire mesh type potato grader for pre-cold stored potatoes

Design work for the fabrication of an improved square wire mesh type of potato grader capable of grading potatoes in four grades was carried out. Grader shall consist of the mainframe, grading, conveyor belt and power transmission systems. Grading unit shall consist mainly of three numbers of grading sieves having square openings made out of MS wire. These wires shall be locked together to look like a square wire mesh. All the wires shall be so bent that, when held together with the help of GI sheet clamps, they get the shape of squares at regular intervals throughout the width of the grading belt. Both ends of the wire belt shall also be clamped together with the help of GI sheet clamps so that it turns into an endless screen. For getting different grades of tubers, square wire mesh of different sizes shall be provided.

Development of farm machines and systems for seed potato cultivation

Design and development of Aeroponic prototype for mini potato tuber production

Testing of misting nozzles in aeroponic system for potato mini tubers production: An

experiment was conducted with nozzles (N-1, N-2 and N-3) as treatments to find out the most suitable misting cap for aeroponic system for potato mini tuber production. Prototype of this experimental set up consisted of three growth boxes, nutrient solution tank, high pressure pump, filter, electrical and electronic components and other accessories. Nozzles were fitted on 25 mm diameter PVC pipes with the help of hinged clamps (Fig. 26) having threaded cap. Each box was fitted with a different set of nozzles as indicated in table 2. Tissue culture plantlets of variety Kufri Surya were planted on 3 November, 2010 in all grow boxes, after hardening for 15 days in hardening chamber. In all three boxes nutrient supply was maintained from the same solution tank. Spray on and off time was same from common pump for all the sections. Survival rate in box with nozzles N-1 was found 27.7% while it was 83.3% and 80.5% in N-2 and N-3 boxes, respectively. First picking of mini tubers was done 45 days after planting (DAP) and final picking was done 110 DAP. Average number of tubers per plant was highest in N-1 while there was not much difference in N-2 and N-3. Mini tubers per sq meter were highest (1637) in case of N-2.

Development and testing of an aeroponic system from locally available material:

Availability of materials for fabricating different components of aeroponic system has always been an issue. Particularly, materials for grow boxes and right kind of nozzles are not easily available. Imported materials escalate cost of system. Therefore, some locally available materials for fabrication of growth chambers and nutrient supply system were identified. With these materials a prototype for 66 plants was developed. System was first tested for ten days in dummy conditions. After incorporating necessary modifications, prototype was tested in actual conditions by planting micro plants of cultivar Kufri Chipsona-3. Performance of this new system is shown in table 3.

Design and development of commercial scale aeroponic unit: After initial success of aeroponics in small scale prototypes, upgradation was done by designing a commercial scale unit. Whole system consists of mainly two components. One is green house and second is aeroponic system.

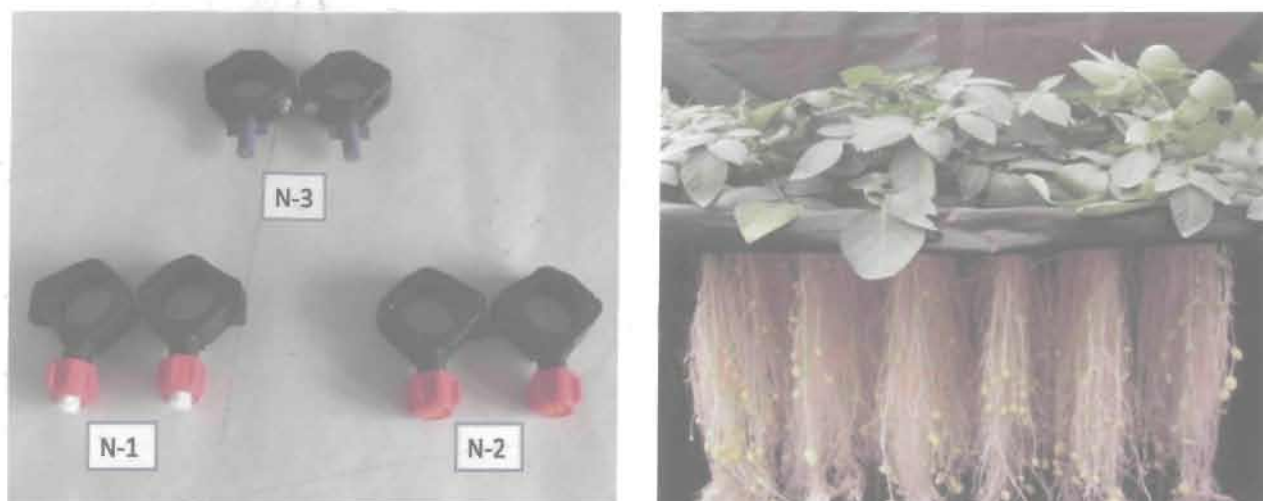


Fig. 26. Different type of nozzles and potato crop in aeroponic system

Table. 2. Comparison of different nozzles in aeroponic system for mini tuber production

Parameter	Growth box with nozzle		
	N-1	N-2	N-3
Type of nozzle	Hollow cone	Hollow cone	Solid cone
Discharge angle	80	80	100
Discharge l/min	0.24	0.46	0.73
Survival of plants %	27.7	83.3	80.5
Root length at 45 DAP (cm)	45.6	64.5	63.8
Plant height at 45 DAP (cm)	22.4	30.2	31.1
First harvest (DAP)	45	54	54
Average number of tubers/plant	54.2	49.1	49.8
Average MT weight/plant (g)	156	142.2	139.3
Avg. number of MT/m ²	602	1637	1605
Average weight/MT (g)	2.89	2.90	2.95

DAP: Days after planting; MT: Mini tuber

Green house was designed in such a way that it can be used as enclosed structure for running cooling system. Same can also be used as naturally ventilated system when environmental conditions are favorable for potato crop. Green house was provided with heating, cooling, misting, UV ray blocking, long wavelength radiation arresting and high pressure washing systems for maintaining favorable inside environment for raising potato crop. Aeroponic system consists of all basic sub systems required for growing crops without soil or solid

media. This include tunnels for growing plants, ten channel auto operated nutrient application mechanism, nutrient supply and return channels, electrical valves and other accessories.

Pre crop dummy testing of system was done for one week. First crop was planted on 27 January, 2011. Six varieties viz. K. Bahar, K. Frysona, K. Chipsona-3, K. Chipsona-4, K. Khyati and K. Pukhraj were planted in new unit. Sequential picking of tubers was started in third week of March, 2011.

Table. 3. Performance of new low cost aeroponic system at Modipuram

Parameter	Description
Variety	Kufri Chipsona-3
Duration of crop	03 -11- 2010 to 14-03- 2011
Survival of micro plants	90.0 %
Root initiation	4 DAP
Stolon initiation	37 DAP
Plant height 50 DAP	28.6 cm
Root length 50 DAP	60.5 cm
Date of first harvest	72 DAP
Total number of pickings	07
Average no. of MT/plant	70.7
No. of MT/m ²	2828
Average weight/MT	2.08 g
Average weight of MT/plant	147.2 g

DAP: Days after planting; MT: Micro tubers

Design, development and testing of handling and high capacity seed treatment systems

For the last couple of years efforts are being made to develop new systems for handling and treatment of seed potatoes so that dependence on farm workers can be reduced. For this, new pallets were designed and tested with fork lift. In these methods potatoes were first filled in 25 kg plastic crates and then transported, washed and treated by placing these crates in pallets of capacity 800-1200 kg. This reduced labour requirement to a great extent. To

further, reduce manpower requirement a new design of pallet was developed at CPRIC, Modipuram for loose handling of tubers (Table 4). As shown in Fig. 27, new pallet is provided with a cushioning material at the floor and tubers are filled manually. Filled pallet was moved with fork lift for washing and treatment in specially developed high volume washing-treatment tanks. Treated tubers were spread on drying floor with new pallet and fork lift. Problems were observed in unlocking mechanism and there was non-uniform opening of flaps, hence irregular spreading of tubers. Pallet will be modified and retested.





Fig. 27. (1) New pallet, (2) Pallet filled with potatoes, (3) dipping of tubers for washing and (4) spreading of treated tubers on ground surface

Table 3. Specifications of modified pallet for loose handling

Parameter	Specifications
Length x width	1250 x 1000, mm
Height	1060 mm
Capacity	450 kg
Side opening slots	20 mm
Side flat size	30 x 5 mm
Frame pipe	36 x 36 x 2 mm
Bottom opening	17 cm
Locking system	Self locking mechanism
Floor padding	10 mm soft padding on floor for tuber damage reduction

DIVISION OF PLANT PROTECTION



Management of late blight

Late blight of potato caused by *Phytophthora infestans* continues to be a major problem both in hills and plains of India. Although, disease appeared late this season in hills but its build up was very fast and it attained a severity level of 50-90% in a short time. The crop grown in sub-tropical plains escaped any major disease attack as the disease was noticed only at the end of the season. As far as plateau regions are concerned, the disease continues to create havoc resulting in heavy crop losses (up to 80%). The Institute is trying to manage the disease by understanding the pathogen population structure and dynamics as well as by developing durable management strategies in the form of development and deployment of host resistance and need based application of fungicides through development and use of Decision Support System (DSS).

Pathogen population structure

As in the previous year, pathogen population consisted of complex races of 9-11 genes. A_1 mating type was dominant in sub-tropical plains

whereas population in temperate highlands consisted of mainly A_2 type. During the report period a slight decrease in the tolerance to metalaxyl was recorded. This change in tolerance to metalaxyl could be due to reduced use of metalaxyl based fungicides during the last few years.

Analysis for mitochondrial haplotypes revealed that the frequency of new haplotype Ia is on the rise. Its frequency increased from 63% to 76 % during last year (Fig. 28 & 29).

A subset of population collected from Punjab (Jalandhar), Himachal Pradesh, Rajasthan (Kota) and West Bengal (Kalyani) was genotyped for RAPD, AFLP and SSR. Grouping of isolates was dependent on type of marker used. When RAPDs was used for diversity analysis, 17 isolates could be categorized into two major groups (Fig. 30). One group consisted of isolates from Punjab (Pi1, Pi2) and HP (Pi3, Pi17, Pi4) while the other group consisted of isolates from HP (Pi5, Pi13, Pi14, Pi15, Pi16), Rajasthan (Pi7, Pi8, Pi6), Punjab (Pi10, Pi9) and West Bengal (Pi11, Pi12).

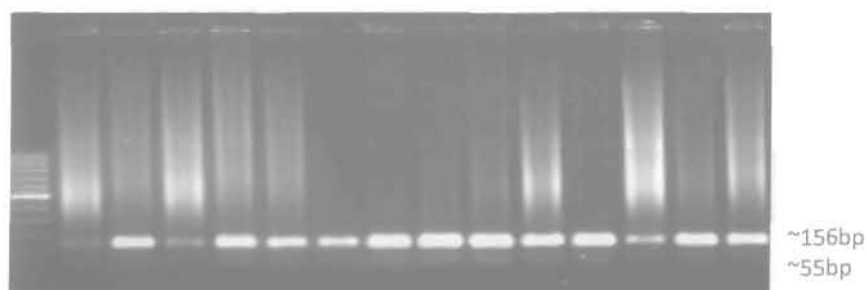


Fig. 28. Mt haplotyping with Primer P3F1 & P3R1+ digested with Eco-RI: lane1= 100bp Molecular Marker, lane2-15= *P. infestans* isolates



Fig. 29. Mt. haplotyping with primer P2F4 and P2R4 + digested with MspI; lane1=100bp marker, Lane2-15 *P. infestans* isolates

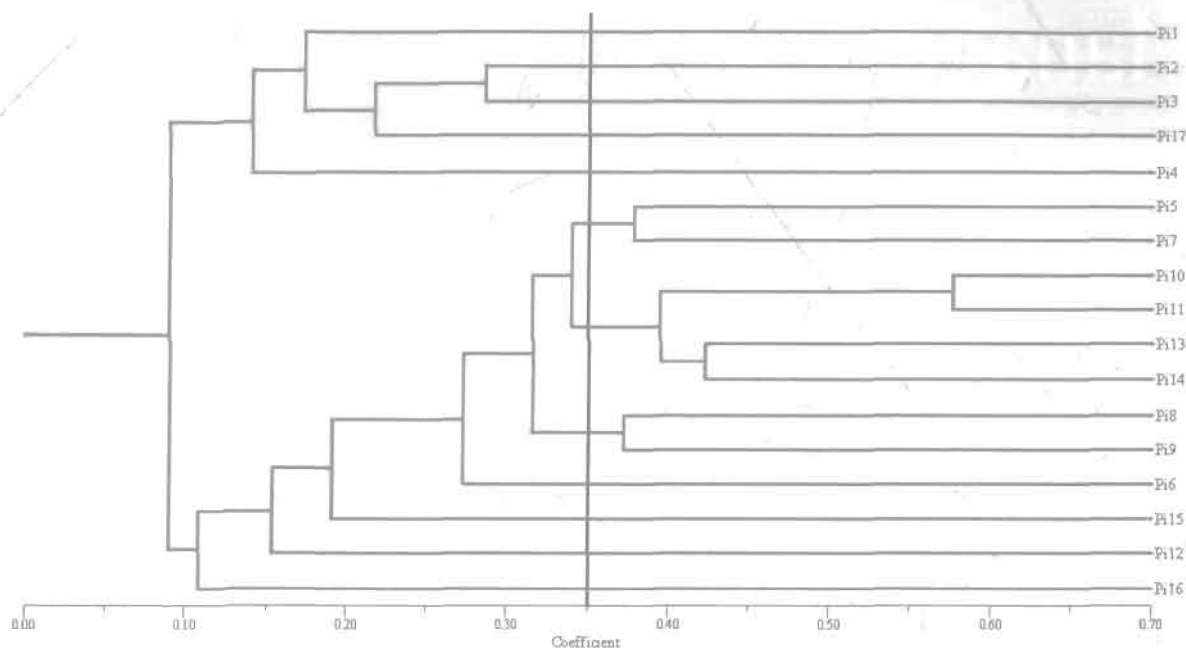


Fig. 30. Dendrogram of *P. infestans* using RAPD

When the same set of population was analysed for AFLP, 17 isolates could be grouped into three major clusters (Fig. 31). First group consisted of thirteen isolates collected from HP (Pi3, Pi5, Pi4, Pi14, Pi17, Pi15, Pi16), Punjab (Pi1, Pi9, Pi10) and West Bengal (Pi2, Pi11). Second group contained three isolates, one from West Bengal (Pi12) and two from Rajasthan (Pi6, Pi7). Third group was made up of only one isolate (Pi13) collected from HP.

Diversity analysis based on SSR markers revealed that 17 isolates under study could be grouped into two major clusters. Eight isolates collected from Punjab (Pi1, Pi2, Pi10), HP (Pi3, Pi13, Pi14) and West Bengal (Pi11, Pi12) constituted one major cluster while nine isolates collected from HP (Pi4, Pi5, Pi15, Pi16, Pi17), Rajasthan (Pi6, Pi7, Pi8) and Punjab (Pi9) formed the other cluster (Fig. 32).

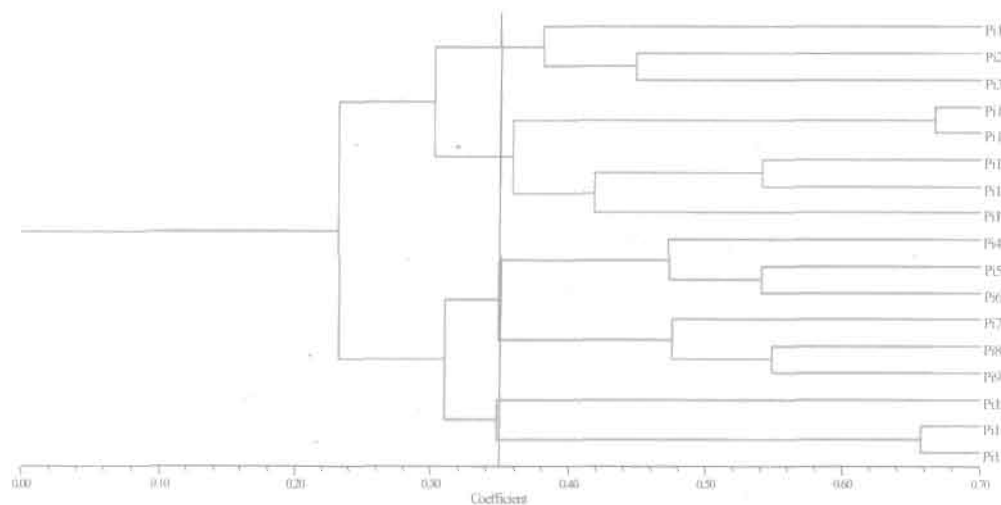


Fig. 31. Dendrogram of *P. infestans* using AFLP

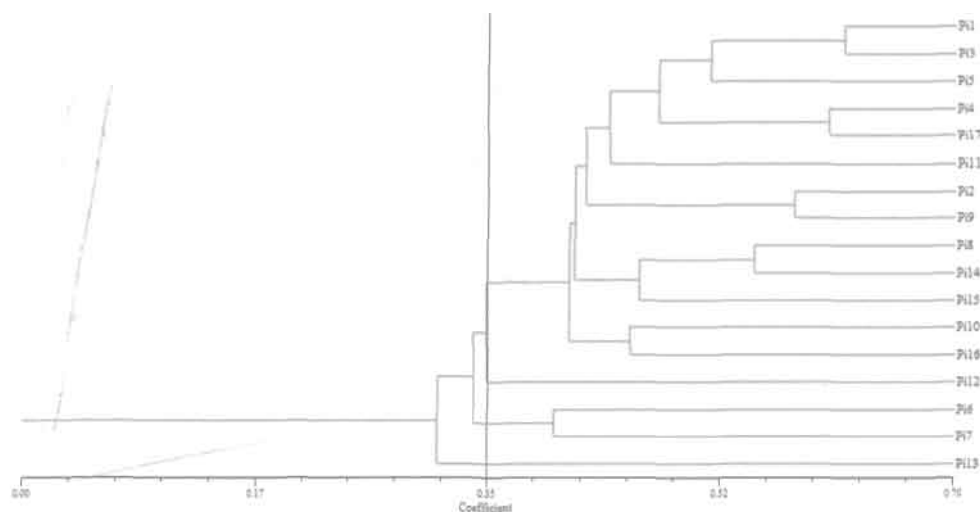


Fig. 32. Dendrogram of *P. infestans* using SSR

Detection and quantification of *P. infestans* in host tissues

Potato seed tubers are the major source of late blight disease and therefore, need was felt to develop more robust diagnostic test that gives a rapid and sensitive estimate of seed contamination. PCR based protocol published earlier was validated in infected potato tubers, seed tubers (storage), infected potato leaf, pure culture of *P. infestans* (Fig. 33).

The protocol could demonstrate that PCR with INF FW2 & INF REV primer set could amplify DNA with a sensitivity limit of 10 fg (Fig. 34).

P. infestans could be detected before the occurrence of visible symptoms. As shown in Fig. 8, PCR with specific primer set (INF FW2 and INF REV) generated amplified products with samples collected from tuber lesion (lane 2), positive control (lane 6) and symptomless samples collected 5, 10 & 20 mm away from the disease lesion (lanes 3-5) Fig. 35.



Fig. 33. 1=Ladder, 2=+ve control (artificial inoculated tuber), 3-9 = seed tubers (storage), 10=+ve control (infected potato leaf, very faint band), 11= -ve control (without template DNA), 12= +ve control (DNA of *P. infestans*)

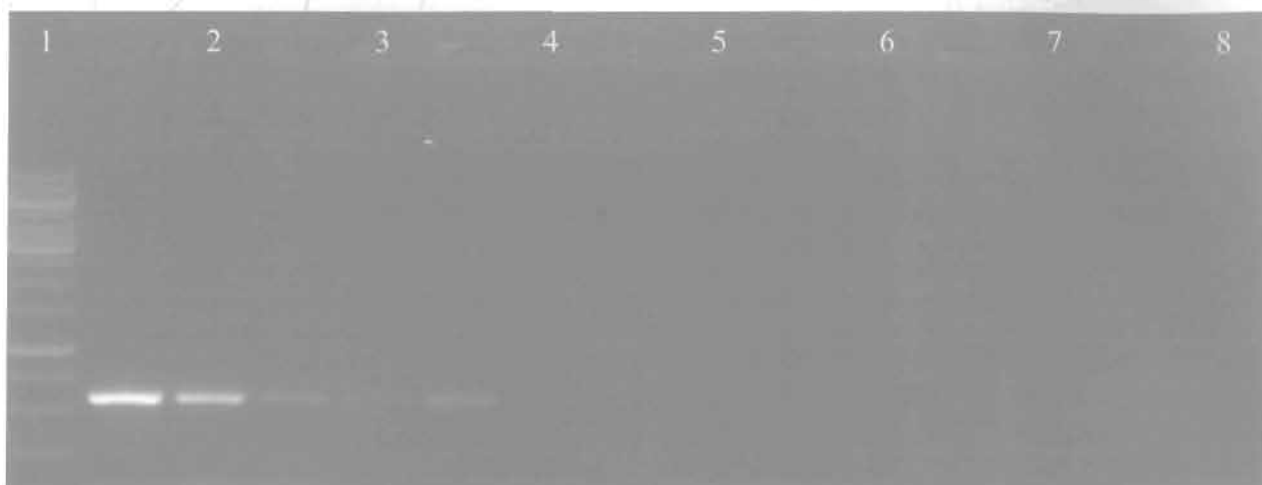


Fig. 34. 1=Ladder, 2= 1ng/ul, 3= 100pg/ul, 4= 10pg/ul 5= 1pg/ul, 6= 100fg/ul, 7= 10fg/ul (very faint band)

Disease epidemiology

JHULSACAST model was once again validated during December 2010-Janauary 2011. The model forecasted late blight appearance during 25- 28 December, 2010 and actual appearance of the disease coincided with this period (27th December, 2010). A Decision Support System developed earlier was validated for need based application of fungicides. Results revealed that the DSS-based fungicide application proved better over CPRI recommendation.

Disease management

Over the years resistance against metalaxyl based fungicides has been developed in *P. infestans* which necessitated the development and use of new molecules for the management of late blight. In this direction, five molecules were tested against late blight and the results revealed that Fénomidone and Dimethomorph based fungicides were better alternative to metalaxyl.

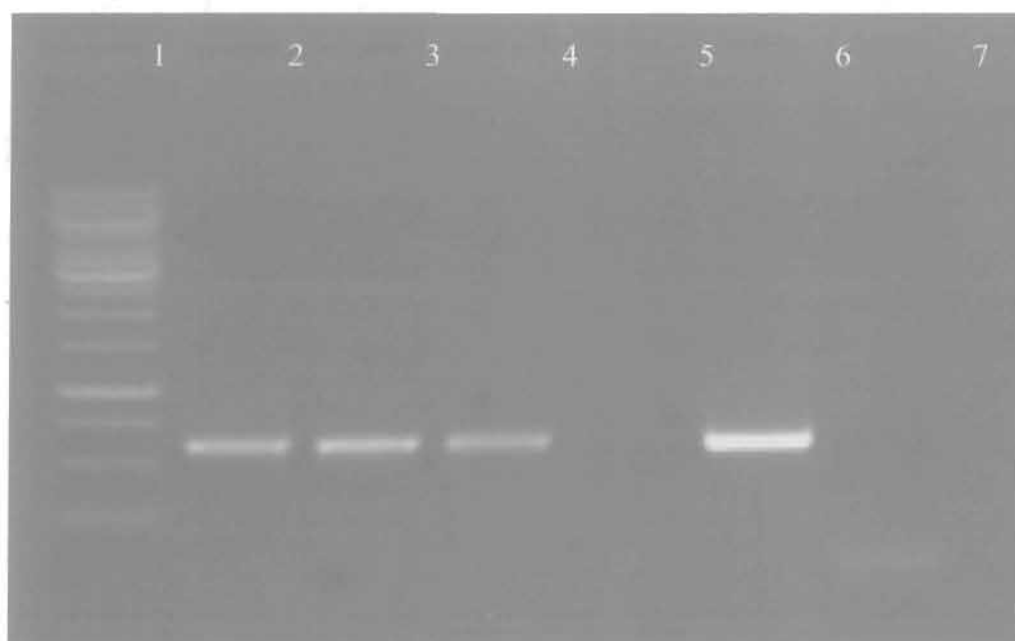


Fig. 35: 1=Ladder, 2= Symptomatic tissue, Healthy tissue (3= 5 mm away, 4= 10 mm away, 5= 20mm away), 6= DNA of *P. infestans*, 7= Control (un-inoculated tuber)

RNAi-Mediated silencing of *Phytophthora infestans* Avr3a gene for imparting late blight resistance

The *Phytophthora infestans* genome sequence web site, http://www.broad.mit.edu/annotation/genome/phytophthora_infestans/Home.html, was mined for the presence of genes carrying RXLR motif. A total of 40 annotated genes sequences were obtained. These 40 genes were aligned for sequence similarity using CLUSTAL X programme. All the 40 genes showed high sequence divergence as they belong to different gene families. Therefore, one important *P. infestans* gene carrying RXLR motif was targeted employing host-delivered silencing strategy. As gene silencing, mediated by siRNA (small interfering RNA) and amiRNA (artificial microRNA) is now the preferred gene knock-out tool for functional genomics, disease resistance and qualitative crop improvement for robustness and efficacy, two strategies have been employed for imparting late blight resistance by silencing of *Phytophthora infestans* gene carrying RXLR motif. The basic premise is that upon invasion *P. infestans*, being hemibiotrophic, will draw these siRNAs and miRNAs, generated in the transgenic host, during nutrition uptake, which will lead to silencing of targeted genes causing pathogen death and/or loss of virulence.

Intron containing inverted repeat gene construct (iIR) driven by constitutive CaMV 35S promoter was

introduced into two late blight susceptible Indian potato cultivars, Kufri Pukhraj and Kufri Khyati, by *Agrobacterium* –mediated genetic transformation of internodal stem explants. About 300 adventitious shoot buds were obtained so far, which are being regenerated for differentiation into shoots (Fig. 36).

Five amiRNAs, having complementarity against five different regions of the target mRNA and without any off-targets, were selected for amiRNA construct development. *Arabidopsis* pre-microRNA (pre-miRNA) 164b stem-loop backbone of 153 nucleotides was chosen for expression of amiRNAs in transgenic background. Appropriate primers were designed replacing *Arabidopsis* miRNA164b sequence and incorporating individual amiRNA into the pre-miRNA backbone. Two Indian potato cultivars, Kufri Pukhraj and Kufri Khyati, were transformed with individual amiRNA construct (Fig. 37). The co-cultivated explants were placed on regeneration media for initiation of adventitious shoot buds.

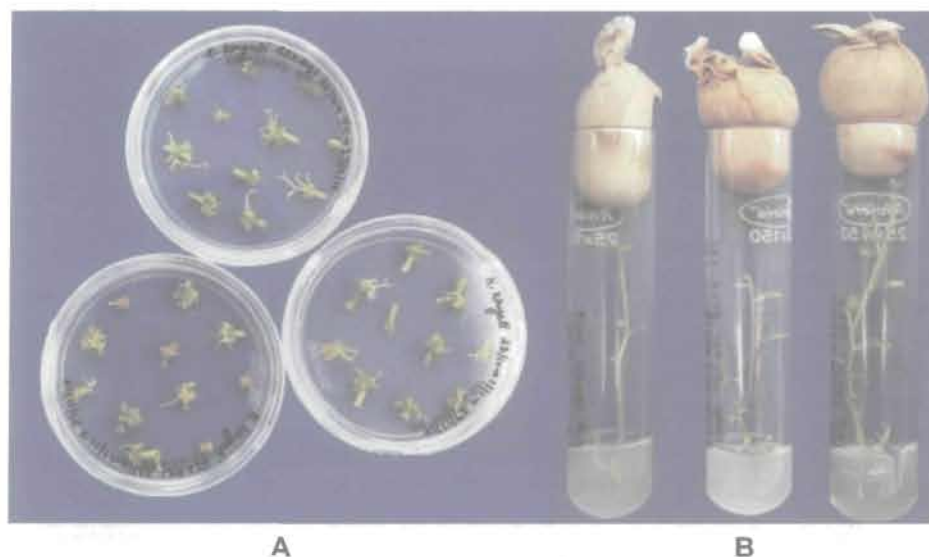


Fig. 36. Potato transformation with inverted repeat gene construct. A: Regeneration of adventitious shoot buds from transformed explants. B: Differentiation of adventitious shoot buds into shoots

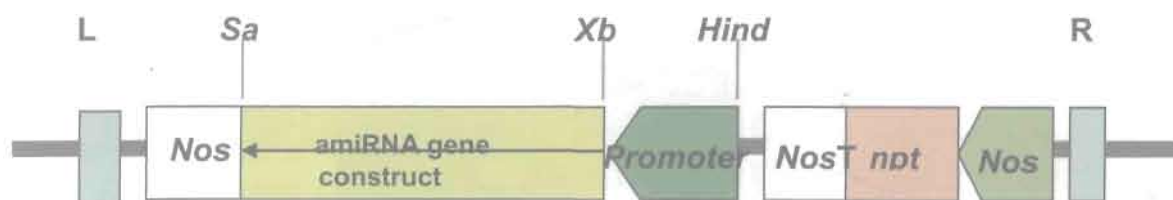


Fig. 37. Map of T-DNA region of amiRNA binary vector cassette

Breeding cultivars for multiple disease resistances for indian hills and plateau regions

Management of late blight through host resistance will remain the most environmentally and economically preferred option globally despite the fact that none of the variety could sustain the blight onslaught for more than 5-7 years. Indian blight resistance breeding programme was not indifferent and a number of resistant varieties bred and deployed beginning 1958 (Kufri Kumar) to 2003 (Kufri Shailja) lost their resistances to matching virulences in *P. infestans*. The experience so far clearly demonstrated that none of the resistance i.e. major genes (Kufri Jyoti) or minor genes (Kufri Giriraj and Kufri Shailja) alone was durable. Therefore, the strategy being followed at CPRI is to combine resistances from diverse sources even from wild species (through MTs) with the idea to provide durable resistance.

Accordingly, during the current year about 77,500 hybrid TPS were produced from 73 successful crosses between selected late blight resistant parental lines. Over 11,000 seedlings from sixteen crosses were screened and 764 resistant ones were selected for further evaluation under field conditions. The highest number of resistant seedlings (%) were obtained in the cross CP-2379 x SM/94-44 (10.4%) followed by CP-

2011 x HR-9-5 (9.8%), CP-2379 x HR 9-5 (9.5%) and CP-2370 x Kufri Himalini (9.0%). At harvest 241 clones were obtained. Further, at Shillong, 185 clones have been selected from 12 crosses based on tuber characteristics and resistance to late blight.

Seven hybrids having combined resistance to late blight and Potato Virus Y were developed and evaluated in a replicated trial at Kufri and four hybrids viz. SM/03-13, LBY-2, SM/03-23 and SM/03-45 were retained for further evaluations. In another trial involving three MTs and four LBY hybrids, VMT 2-5 and VMT 5-1 (MTs) and LBY-18 and LBY-24 (hybrids) produced significantly higher yield than the best control Kufri Himalini. The hybrid SM/92-338 was evaluated in a replicated trial at Modipuram for adaptability along with three controls. The hybrid produced significantly higher yield than the best control Kufri Bahar. Besides, two LBY hybrids (LBY-15 and LBY-17) with combined resistance to late blight and PVY yielded higher than the best control. Based on their consistent performance

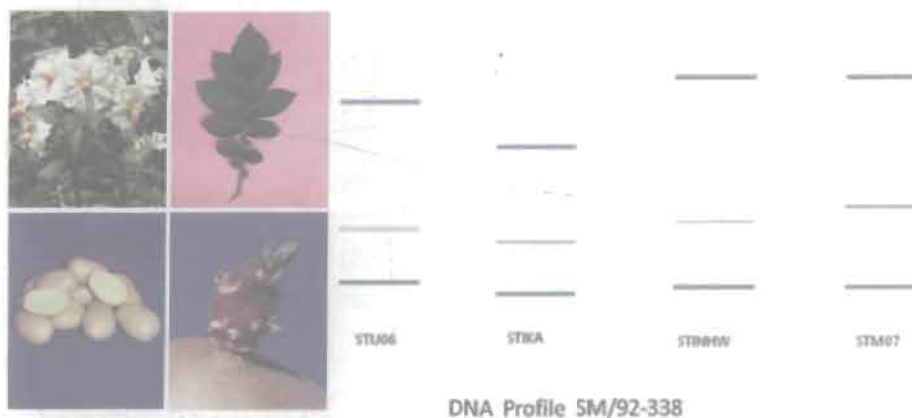


Fig. 38. Leaf, flower, sprout, tuber and DNA fingerprint of advanced potato hybrid, SM/92-338



Fig. 39. Tubers of advanced potato hybrids, LBY-15 and LBY-17

over the years, the IRC 2011 has approved the introduction of three hybrids i.e. LBY-15, LBY-17 and SM/92-338 (Fig. 38 & 39) into AICRP (P) for multi-location trials.

At Kufri, in preliminary generations (F_1C_1 - F_1C_4), 549 genotypes were evaluated and 205 clones

were retained for further evaluations at Kufri. In advanced generations, 10 hybrids were evaluated and eight hybrids were retained for further evaluations. At Ootacamund, six hybrids were evaluated with Kufri Girdhari and Kufri Jyoti as checks. Among them, one hybrid viz. SM/02-07 out-yielded (50.2 t/ha) the check Kufri Girdhari (31.4 t/ha), whereas, all the entries performed better than (18.1-32.1 t/ha) Kufri Jyoti (12.3 t/ha). On the basis of agronomic traits and field resistance to late blight, 7 hybrids were retained to confirm the results. At Shillong, two hybrids viz., SS/05-1-4 and SS/05-6-9 from CPRS, Shillong and 9 hybrids from CPRI Shimla along with 3 checks were tested for late blight resistance and tuber yield. None of the hybrids exhibited higher yield than check Kufri Girdhari. Only one line SS/05-6-9 showed late blight resistance comparable to resistant check Kufri Girdhari. All the hybrids have been retained for final yield evaluation in the next generation.

Development and registration of elite potato parental line

Triplex clone, 'YY6/3 C-11' is an elite parental line possessing Potato virus Y (PVY) extreme resistance gene R_{yadg} in triplex (YYYy) condition (Fig. 40). When used as progenitor in hybridization, it is expected to produce 96% progeny carrying at least one allele of the gene

thus ensuring extreme resistance to PVY and eliminating the need of cumbersome challenge inoculation and ELISA testing. It is a clone of cultivated species with high pollen fertility, thus it can be easily crossed with cultivated potatoes. Besides, it possesses good tuber characters.

NBPGR has registered this hybrid with national identity, IC No. 0586781 and registration number INGR 10143.

Molecular breeding

One hundred and twenty six clones of the mapping population (SC) developed upon crossing diploid wild species *S. spegazinii* (SS 1725-87) x *Solanum chacoense* (SS 1671-1) were maintained in the glass house at Kufri. This mapping population has also been conserved *in vitro*. The work on DNA fingerprinting was initiated on 42 advanced hybrids and released varieties using SSR markers. The DNA fingerprinting has been completed using five SSR markers i.e. Stu 6, Stika, STM007, STINHW, STM0037 (Fig. 41).

Validation of molecular markers linked to R-Genes

In an effort to expedite the resistance breeding strategy, an attempt is being made to pyramid 'R' genes through MAS. The specific markers linked to R genes (R1 and R3a) i.e. markers SPUD 237 and R1AS for R1 and cLET5E4 and GP 185 for R3a have been identified. These markers have been validated in a set of late blight differentials. Later on, these were used to analyse the presence of R1 gene in the parental lines and Indian potato varieties. Results revealed that five parental lines i.e. SM/93-239, HB/82-372, HR 5-2, HR 9-3, CP-3776 and three potato varieties, namely Kufri Sherpa, Kufri Kuber and Kufri Alankar possess R1 gene (Fig. 42). Similarly, for R3a gene, a SCAR marker has been designed and synthesized and is being validated (Fig. 43 & 44) for further confirmation. Once the parental lines/ varieties are identified having the genes individually, efforts will be made to combine them in a single genetic background using MAS.

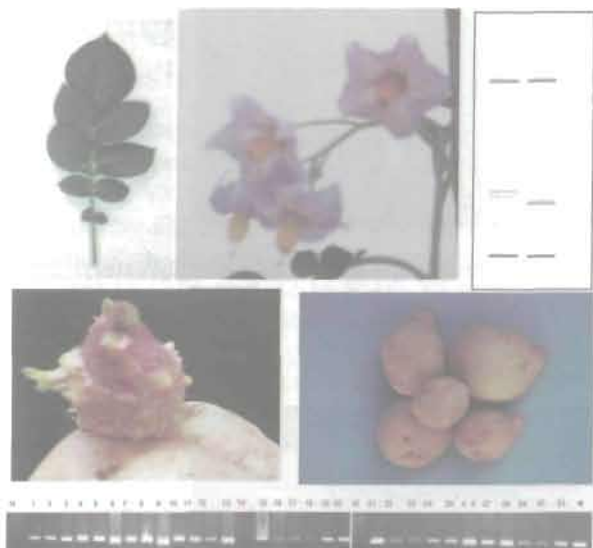


Fig. 40. Leaf, flower, DNA finger print, sprout, tuber and SCAR marker (R_{yadg} gene) of potato genetic stock YY 6/3 C-11

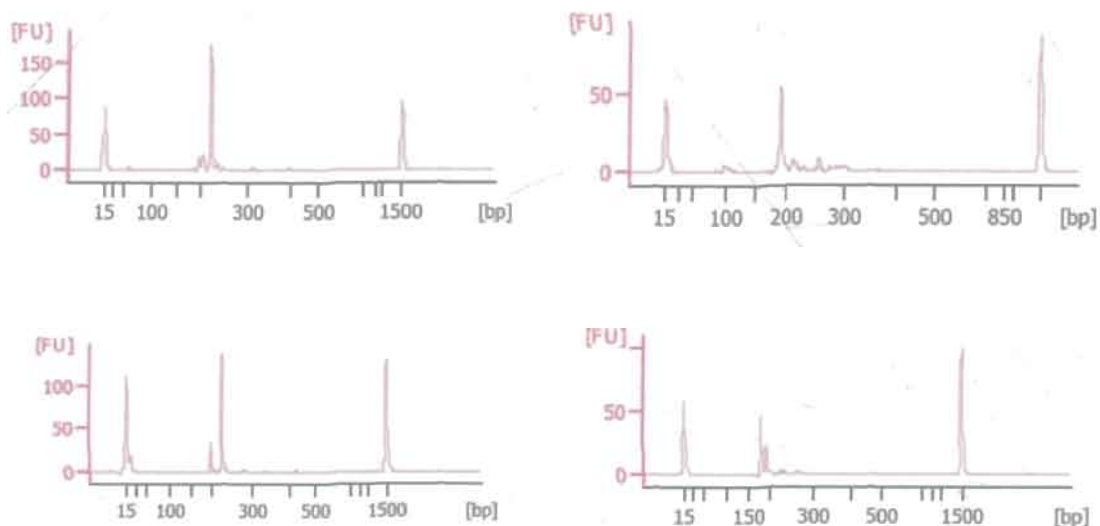


Fig. 41. Fingerprinting profile of advanced hybrid, J/99-48 with STIKA, STINHW, STM007, STU06

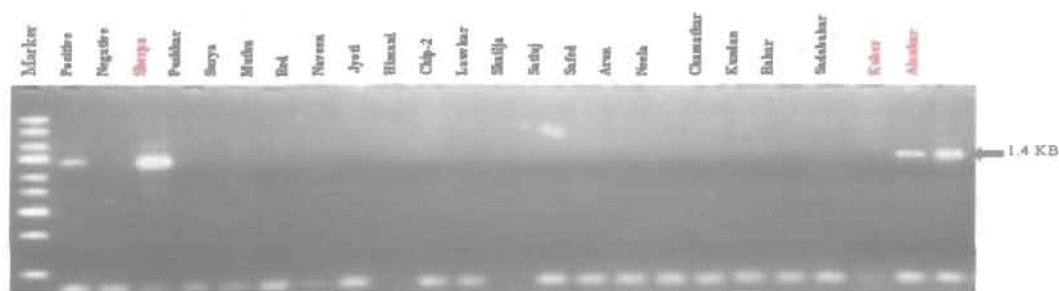


Fig. 42. Validation of R_{AS} in potato varieties Lanes 1-Marker; 3-Water, 4-24 potato varieties



Fig. 43. Validation of R_3 marker, GP 185 in late blight differentials: Lanes 1-Marker; 2-Water; 3-21 LB differentials



Fig. 44. Validation of GP185 R_3 marker in parental lines: Lanes 1-Marker; 29- parental lines

Molecular characterization, detection and management of potato pathogens

Maintenance and mass multiplication of potato viruses for antisera production

Pure cultures of Potato Virus X, S, Y, A, M and PLRV were maintained on standard hosts. PALCV was maintained in infected potato tubers collected from CPRIC, Modipuram, Potato Steak Virus on Cowpea (C-152) and K. Jyoti and PSTVd on tomato and potato germplasms viz., CP Nos.1291, 1641, 1874, 2419, and 3166. Potato Virus A was propagated in large quantities in the propagative host *Nicotiana tabacum* cv. Samsun and the purified PVA particles were used to inject rabbit to raise antisera. Twenty five microlitre of antisera was obtained with 1:500 titer.

Screening of germplasm for virus resistance

Seventy germplasm accessions were planted in the glass house and screened for resistance to PVY and PVX through mechanical inoculation followed by ELISA to check comparative virus accumulation. Fourteen accessions were resistant to PVX and 32 to PVY; 23 accessions showed combined resistance to both PVY and PVX. Similarly, 13 germplasm accessions, earlier selected as resistant to PVY, were again screened for the second year and 10 showed resistance to PVY. Besides, 141 accessions received from the molecular breeding project were screened for PVY resistance, out of which 89 showed resistance to PVY.

Virus testing of potato samples

Forty four germplasm accessions were planted in the glass house and tested for presence of Potato Virus X, S, Y, A, M and PLRV by DAS-ELISA. Six accessions were free from all the viruses and remaining were infected with either one or more of the viruses tested. Seven hundred and seventy two leaf samples of M/s Technico Agriscience Pvt. Ltd., 82 samples of M/s Pepsico India Holding, and 9 samples of Horticulture Training Institute, Uchani, Karnal were tested for the presence of Potato virus X, S, Y, A, M and PLRV by DAS-ELISA under the NCS-TCP accredited test laboratory. All the samples were negative to the viruses tested except one sample from M/s Pepsico which was positive for Potato Virus S, Y and M.

One hundred fifty two samples from the Crop Improvement Division, 19 varieties from M/s Technico Agrisciences Ltd, 3 varieties from M/s Elegant Flower Co Pvt. Ltd, Kolkata and 6 varieties from M/s Mc Cain Food Pvt. Ltd, New Delhi were tested for PSTVd through NASH. Except two samples, CP 2187 and Safed Phool from Crop improvement, Division all were negative for PSTVd. Similarly, 57 samples received from post entry quarantine facility and from private companies were tested for PSTVd through RT-PCR analysis and only two of them were positive for the viroid. Besides, 44 composite samples from Seed Technology Division were tested for PALCV through PCR and 24 composite samples were tested for PLRV and PVX through RT-PCR analysis; all were negative for the viruses tested.

Twenty four mericlones were tested for PVX, PLRV, PVY and PVS through RT-PCR, out of which 22, 11 and 22 mericlones were free from PVY, PVX and PLRV, respectively. All mericlones were positive for PVS.

Post entry quarantine testing

Thirty four *in vitro* potato cultures including fourteen imported for M/s Technico Agri Sciences Ltd through NBPGR, New Delhi, fourteen for M/s Pepsico India Holdings Pvt. Ltd, and six for M/s McCain Food Pvt. Ltd, were tested for quarantined viral (PVT, PYDV, AVB, APMoV, APLV, TRV, TRSV, PSTVd), bacterial (*Clavibacter michiganensis* ssp. *sepedonicus*), fungal (*Phoma exigua* var. *foveata*, *Synchytrium endobioticum* & *Thecaphora solani*) and nematode (*Globodera rostochiensis* & *G. pallida*) pathogens. The *in vitro* cultures were grown in pots in quarantine glass house for expression of symptoms, if any, and also tested in laboratory for detection of these pathogens. All the cultures were free of above listed quarantined pathogens.

Dipstick kits for detection of potato viruses

Dipstick kits based on lateral flow immunoassay have been standardized for the detection of five potato viruses viz., PVX, PVA, PVS, PVM, PVY. The kit contains all the components for detection of potato virus at field level within 10 minutes. For detection of viruses, the infected leaf sample is to be extracted in 500 µl of extraction buffer (supplied in the kit) by homogenizing with micropestle in a 1.5 ml microfuge tube (supplied with the kit). The homogenate is to be left undisturbed at least for 5 minutes for settling down of particulate matters. The strip provided in the kit is to be dipped in the extracts until the solvent reaches the top end. The strip is to be taken out after that and kept horizontally on a flat surface for 10 min for development of visible coloured lines as depicted below (Fig. 45).

The kit developed at CPRI can detect maximum of two viruses simultaneously. Separate kit has

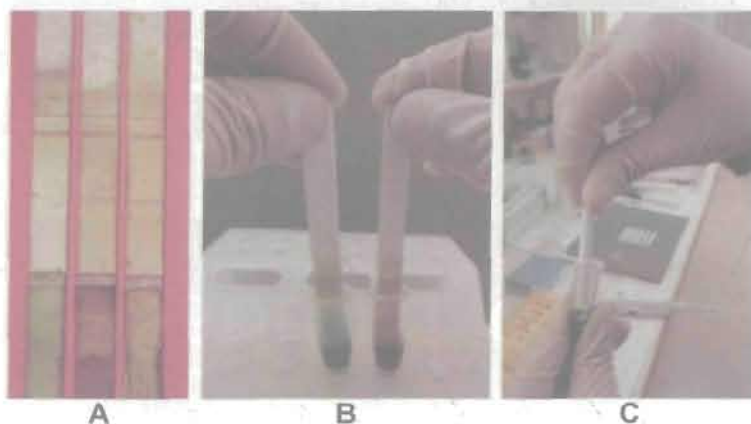


Fig. 45. Steps for using the dipstick kit.

A: Extraction of infected sample, B: dipping the strip in the extract, C: appearance of test and control lines

been developed for simultaneous detection of PVY & PVX, PVA & PVS, PVY & PVM. Three bands (2 for viruses and 1 for control) are detected when the sample is infected with two viruses; one virus-specific band and the control band are detected when it is infected with one virus. A single line in the control zone is a negative result. The kits are now available for commercialization.

PCR protocols for detection of potato viruses

The polymerase chain reaction (PCR) is a powerful technique for detecting very small quantities of virus inoculum in plant tissue. Since reliable ELISA protocol is not yet available for detection of potato apical leaf curl virus, an attempt was made to standardize robust PCR protocol for detection of this virus in infected tissue. Eight set of primers, four each from coat protein and replicase genes of ToLCNDV virus were designed using Primer3 Input (version 0.4) software. Gradient PCR was performed with different annealing temperatures viz., 53°C, 55°C, 57°C, 59°C and 61°C using Veriti 96 well thermal cycler to select the best primer set. Out of eight primer sets, one set of primer amplifying the coat protein gene and four sets of primer amplifying the replicase gene showed expected size of bands in the infected samples without any non-specific bands in healthy control in all the five annealing temperatures. The sensitivity of the technique to detect low level of virus concentration was checked by diluting

the DNA to ten-fold dilutions viz., 1:10² to 1:10⁷ and out of five primer sets three primers were able to detect up to 1:10⁶ dilutions, one up to 1:10⁵ and one up to 1:10³ (approx. 2.5 ng) at 57°C and 61°C annealing temperatures. The selected primer sets were validated by checking twenty four commercial varieties under micro-propagation at CPRI, out of which one primer set did not show any non-specific bands in any of the varieties at 61°C annealing temperature. This primer set was selected for detection of potato apical leaf curl virus in indexed tubers as well as in tissue culture raised microplants of potato. Potato spindle tuber viroid (PSTVd) is so far being detected using radioactivity mediated nucleic acid spot hybridization (NASH). This is a cumbersome technique with associated risk of radioactive hazard. Therefore, a robust RT-PCR technique has been standardized for detection of this viroid (Fig. 46). Similarly, primer sets for robust detection of PLRV and PVX were identified, which showed a single specific amplified band in positive control and without any non-specific amplification in healthy control. Using the selected primer sets, a multiplex RT-PCR protocol has also been standardized for the simultaneous detection of PSTVd, PLRV and PVX with elongation factor 1- α (ef1 α) as internal control (Fig. 47).

Real Time PCR for detection of potato viruses

Ordinary PCR based protocols are incapable of accurate quantification of virus load in infected tissues. On the contrary, Real-time PCR also

known as quantitative PCR (qPCR), offers an accurate and rapid procedure to quantify virus concentration. Accurate quantification is necessary for carrying out experiments on host resistance, vector transmission, epidemiological studies etc. It can also distinguish between different strains of a virus and even can detect point mutations in the virus genome. The major advantage of real-time PCR is that analysis of resulting products using gel electrophoresis is not required. This means that real time PCR can be implemented as a high-throughput technique for sample screening. Real Time PCR protocols based on TaqMan chemistry have been standardized for Potato Apical Leaf Curl Virus, Potato Virus Y (Fig. 48) and Potato Leaf Roll Virus (Fig. 49). The sensitivity of the protocols was ~ 1 fg of viral RNA/DNA.

Recombinant coat proteins for antisera production

Multiplication of potato viruses in corresponding propagative hosts and their extraction is a technically challenging task. On the contrary, heterologous expression of the recombinant CP protein of different potato viruses in *Escherichia coli* can ensure unlimited availability of pure immunogenic epitopes of different viruses that can be used for antisera production. With that objective, attempts are being made to clone and express CP genes of major potato viruses in *E. coli*. The coat protein genes of PLRV and PVY were amplified using gene specific primers with restriction sites and proof reading



Lane 1. 1 kb ladder; Lane 2. Water control; Lane 3. Healthy control; Lane 4. Positive control, Lane 5 -15. Plants raised from PSTVd infected tubers.

Fig. 46. RT-PCR detection of PSTVd from infected germplasms



Multiplex PCR detection of PSTVd, PVX, PLRV along with an internal control

Lane 1. 100bp ladder, Lane 2, 4 and 6 Healthy sample
Lane 3, 5 and 7. Infected sample, Lane 8. 1 Kb ladder

Fig. 47. Multiplex RT-PCR detection of PSTVd, PVX and PLRV along with an internal control. Lane 1. 100bp ladder, Lane 2, 4 and 6 Healthy sample, Lane 3, 5 and 7. Infected sample, Lane 8. 1 Kb ladder.

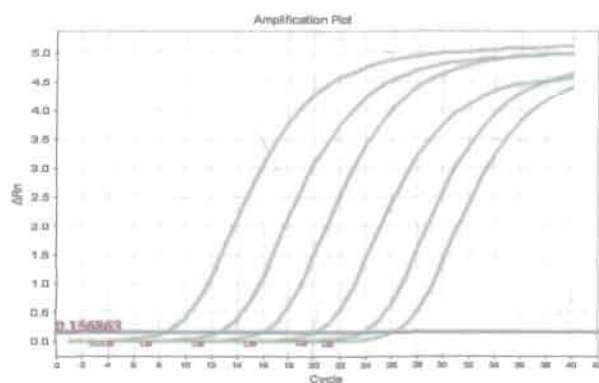


Fig. 48. Real Time PCR plot obtained for different concentration of Potato Virus Y. Number of cycles to reach the threshold value was less when virus concentration was higher. The left most curve represents virus concentration of 700 pg/μl; successive right curves represent decimal dilution of the original virus concentration, i.e. 70 pg/μl, 7 pg/μl, 0.7 pg/μl, 0.07 pg/μl, and 0.007 pg/μl

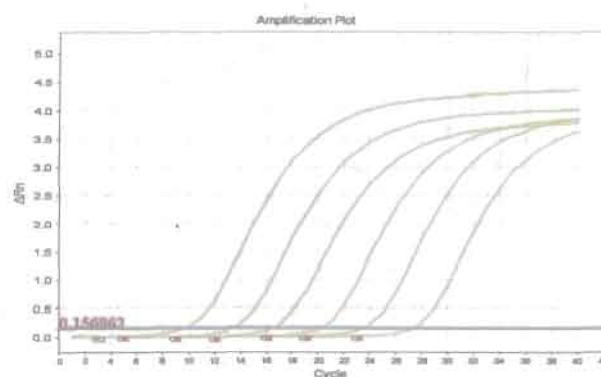


Fig. 49. Real Time PCR plots obtained for different concentration of Potato Leaf Roll Virus. The left most curve represents virus concentration of 630 pg/μl; successive right curves represent decimal dilution of the original virus concentration, i.e. 63 pg/μl, 6.3 pg/μl, 0.63 pg/μl, 0.06 pg/μl, and 0.006 pg/μl.

enzyme. The amplified products were purified and restricted to generate cohesive ends for ligation into the expression vector, pET-28a(+). The ligated products were used in transformation of *E. coli* strain BL21 by heat shock method. The recombinant colonies were identified through colony PCR and finally confirmed through sequencing. Over expression of these recombinant clones was carried out by using inducer Isopropylthio-β-galactosidase (IPTG). Expression of coat protein of PVY was observed in SDS-PAGE analysis of crude protein extract of recombinant *E. coli* expressing coat protein

gene of PVY (Fig. 50) but not in case of PLRV. The expression of coat protein gene of PLRV in mutant strains of *E. coli* like C41 (DE3), C41 (DE3) pLysS, C43 (DE3) and C43 (DE3) pLysS also failed. Since the CP sequence of PLRV contains rare codons, expression of this virus coat protein in *E. coli* strain Rosetta-gami is now being checked.

Recombinant CP protein of Potato Apical Leaf Curl Virus was produced in *E. coli* last year. This year the purified CP protein of PALCV was injected in rabbits at weekly interval for antibody



Fig. 50. Polyacrylamide gel electrophorogram of PVY CP protein extracted from un-induced and induced *E. coli* culture carrying the recombinant expression vector

production and the serum was collected after booster injection. IgG was purified from the serum and its reaction with PALCV in DAS-ELISA was confirmed.

RB transgenic hybrids of Kufri Jyoti

Twenty three F_1C_4 clones of Kufri Jyoti x SP951 were multiplied under contained condition at Shimla and 5 clones (KJ-16, KJ-21, KJ-65, KJ-66, and KJ-77) have been selected for further evaluation. Similarly, five selected clones were multiplied under contained condition at Modipuram and two best clones (KJ-102, Fig. 51 and KJ-45) have been selected.



Fig. 51. RB-transgenic clone KJ-102

Transgenic for virus resistance

Potato apical leaf curl is emerging as a serious disease problem in the vast Indo-Gangetic plains of India. The virus causing this disease belongs to Geminiviridae and is similar to tomato leaf curl virus. Since no conventional source of resistance to this virus is available in potato, transgenic approach is being pursued to develop resistant variety. The replication-associated protein gene (AC1) of the virus is being used for engineering pathogen derived resistance in two popular potato cultivars Kufri Pukhraj and Kufri Badshah. Forty one putative transgenic lines of Kufri Badshah and 22 of Kufri Pukhraj were challenge inoculated with PALCV by either grafting or through vector (whiteflies) transmission in glasshouse after 45 days of planting. Symptom expression (Fig. 52) was noted and viral load in each plant was quantified by real time RT-PCR analysis of the CP gene using TaqMan assay (Fig. 53). The real time PCR analysis was repeated three times and average Ct (Threshold Cycle) value was calculated. Transgenic lines showing Ct values above 30 were selected for further evaluation.



Fig. 52. GTLC2- 127 showing resistance to PALCV infection as compared to untransformed control

Thirty one transgenic lines which were earlier found PCR positive for PVY-CP insert were multiplied in propagation media and kept in glasshouse for hardening. After one week, these lines were planted in pots along with positive

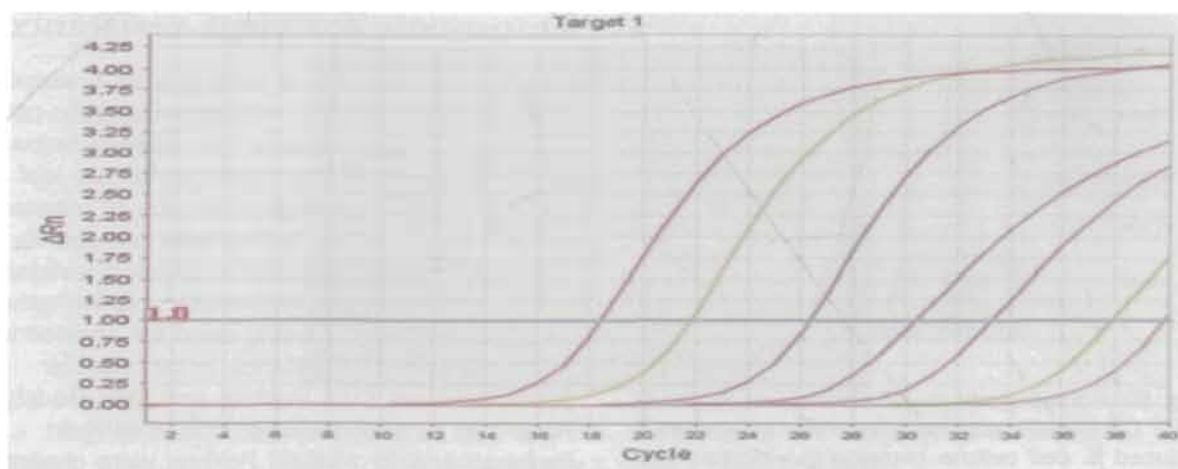


Fig. 53. Real time RT-PCR curves of few rep-transgenic lines of Kufri Badshah

controls (untransformed Kufri Pukhraj) and mechanically inoculated with PVY infected sap and were screened through Das-ELISA after 27 days of inoculation. Symptom expression was noted for each transgenic lines (Fig. 54). Three samples of each lines from different leaves (L=Lower, M=Middle, U=Upper) were

taken along with similarly infected untransformed Kufri Pukhraj as control. The transgenic lines showing ELISA reading ≤ 0.13 were selected for further evaluation. Initially four transgenic lines containing PVY-CP antisense insert along with negative control (untransformed plant) were selected for molecular characterization. Real

time PCR protocol was used to determine the copy number. The elongation factor 1 α gene was used as internal control target. Comparison of the Ct mean values with the internal control indicated the presence of single copy of PVY-CP gene in all four lines.



Fig. 54. The CP antisense transgenic line of Kufri Pukhraj showing resistance to PVY infection as compared to untransformed control

EBD transgenics for bacterial wilt resistance

The putative EBD transgenic lines of Kufri Jyoti (14), Kufri Giriraj (38), and Kufri Surya (15) were screened against *Ralstonia solanacearum* by stem stab inoculation method. One line of Kufri Jyoti (KJEBD-17, Fig. 55) and 8 lines of Kufri Giriraj showed tolerance to bacterial wilt and delayed wilt appearance by more than one month.



Fig. 55. Promising EBD-transgenic lines of Kufri Jyoti showing tolerance to bacterial wilt after 45 days of inoculation by stem stab method

Comparative genome analysis of potato pathogens

Genome analysis of the pathogens will give an idea about its evolutions in time and space. Changes in the nucleotide variation due to either mutation, recombination can be correlated with its virulence and pathogenicity. Effective detection of the pathogen through nucleic acid based technique like RT-PCR, Real time PCR and microarray also demands the information on potato pathogen genomes from different potato growing regions of India. Since PSTVd is not reported to occur in India, the infected germplasms were used as source of the viroid. RT-PCR analysis was carried to amplify the RNA sequence of PSTVd from infected germplasms. Complete RNA sequences of five PSTVd isolates were cloned, sequenced and their sequences were compared with sequences from NCBI by using bioedit software (Fig. 56) and phylogenetic tree was constructed by Mega 4 software. Secondary structure of the

isolates was predicted by using M fold software and compared with other reported isolates. PALCV infected samples were collected from different parts of the country and coat protein gene of eighty PALCV isolates were amplified and sequenced. The virulence genes like *egl*, *pgl* and *hrpB* genes of 40 *R. solanacearum* isolates collected from different regions of India were PCR amplified and sequenced. The ITS region of 40 isolates of *Rhizoctonia solani* were amplified and sequenced. Phylogenetic analysis of internal transcribed spacer (ITS) shows a strong correlation with anastomosis group determination. So multiple sequence alignment and phylogenetic analysis were done to identify anatomosis group by using reference isolates from the entire anastomosis group (AG-1 to AG-12). In the phylogenetic tree, all the forty isolates were grouped along with AG-3 and it clearly indicated they belong to anastomosis group AG-3 (Fig. 57). Twenty isolates of *Alternaria alternata* were characterized by AFLP technique.

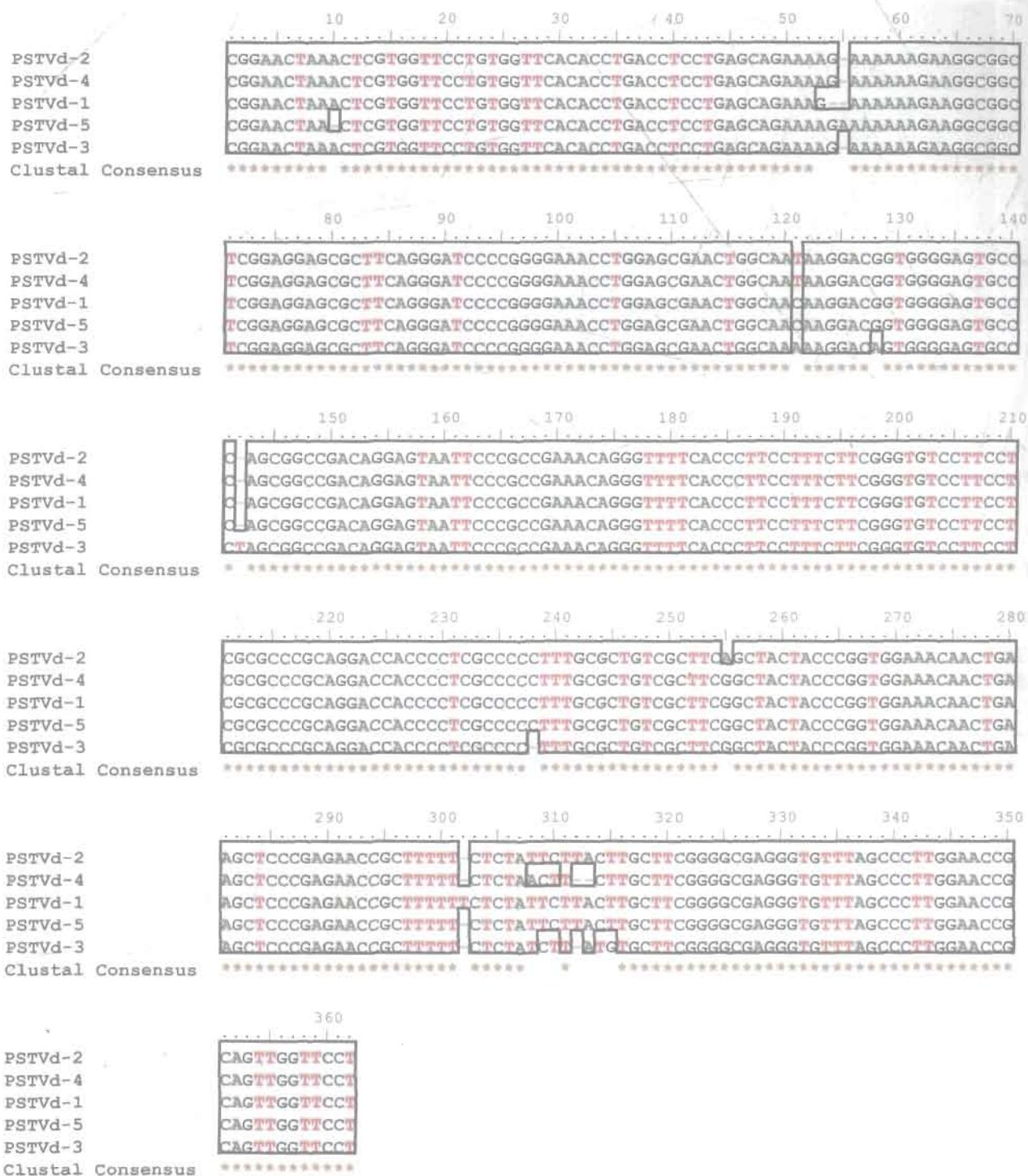


Fig. 56. Multiple sequence alignment of complete RNA sequence of PSTVd isolates from infected germplasms



Fig. 57. Phylogenetic tree of forty *Rhizoctonia solani* isolates collected different potato growing region of the country with reference strains from anastomosis group 3 (AG-3)

Characterization, detection and management of major soil and tuber borne pathogens of potato

Bacterial wilt or brown rot, caused by *Ralstonia* [*Pseudomonas*] *solanacearum*, is of world occurrence and has been estimated to affect 3.75 million acres in approximately 80 countries with global damage estimates exceeding \$950 million per year. In India, the disease is endemic in West coast from Thiruvananthapuram in Kerala to Khera in Gujarat, Karnataka, Western Maharashtra, Madhya Pradesh, eastern plains of Assam, Orissa and west Bengal, Chhota Nagpur plateau and Andaman and Nicobar islands. The disease is also found endemic in North-western Kumaon hills, eastern hills of West Bengal, Meghalaya, Manipur, Tripura, Mizoram, Arunachal Pradesh, Nilgiris, Annamalai and Palani hills of Tamilnadu. The disease has become a limiting factor in potato cultivation in several parts of our country as 30 to 70% losses in yield have been reported in affected areas. Historically, strains of *R. solanacearum* have been classified into five

races based on host range, and into five biovars based on differential ability to produce acid from a panel of carbohydrates. Race 3 biovar 2 has primarily been associated with potato and is distributed worldwide. Common scab caused by *Streptomyces* spp., black scurf caused by *Rhizoctonia solani* and dry rots caused by *Fusarium* spp., are other major tuber diseases which requires attention.

During the year 2010-11, a total of 29 isolates of *Ralstonia solanacearum*, 21 of *Rhizoctonia* and 20 of *Fusarium* spp. were collected and maintained. After preliminary identification on TZC medium, the identity of 47 isolates of *R. solanacearum* was further confirmed by PCR with specific primers Y2 and OLI1 (Fig. 58).

Biovar of 47 *R. solanacearum* isolates, collected from different parts of the country, was determined based on their ability to utilize

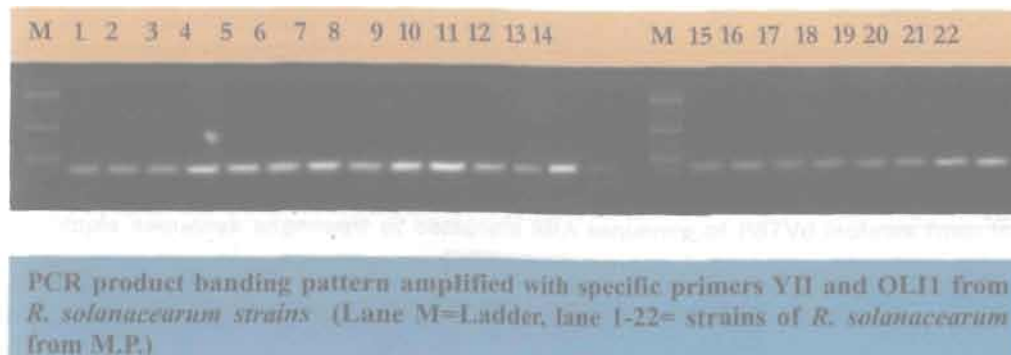
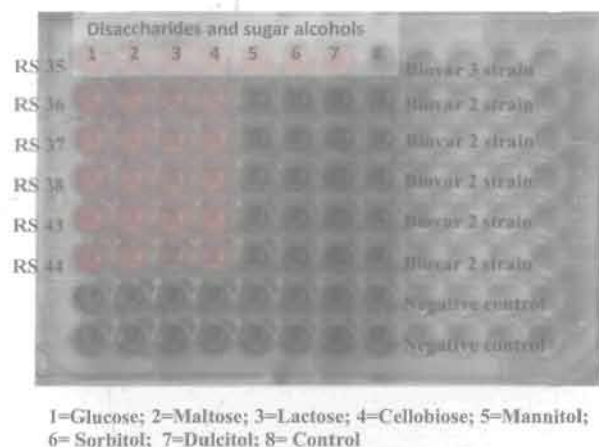


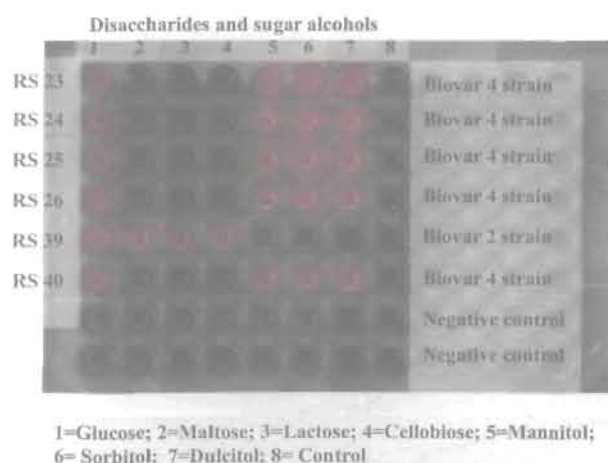
Fig. 58. A total of 47 isolates of *R. solanacearum* collected during 2009-10 and 2010-11 were identified by PCR with specific markers Y2 and OLI1

disaccharides and to oxidize hexose alcohols (Fig. 59 & 60). Of these, 78% belonged to biovar 2 race 3 and were distributed in MP, WB and Assam, 10.7% isolates were of biovar 4 race 1 and dominant in HP, 2.1% of biovar 3 race 1 present in WB, 2.1% of biovar 3A race 1 from MP and rest 6.4% collected from Karnataka did not fall in any of the above category. Pathogenicity tests of the isolates indicated that out of 22 isolates from MP, 20 were pathogenic



Microtitre plates showing the results of biovar test with six strains of *R. solanacearum* from West Bengal

Fig. 59. Out of six isolates collected from West Bengal, 5 were categorized as biovar 2 corresponding to race 3 and one as biovar 3 corresponding to race 1 of the pathogen



Microtitre plates showing the results of biovar test with six strains of *R. solanacearum* from H.P.

Fig. 60. Out of six isolates collected from Himachal, 5 were categorized as biovar 4 corresponding to race 1 and one as biovar 2 corresponding to race 3 of the pathogen

on potato, 18 on tomato, 15 on brinjal and none on chillies. Similarly, 5 of the 6 isolates from WB were pathogenic on potato, all the 6 on tomato and brinjal and none on chillies. All the 6 isolates from HP were pathogenic on potato, tomato, brinjal but not on chillies.

During the year 2010-11, the sequencing of virulence genes *hrpB*, *pgl* and *egl* was carried out by extracting total DNA of 44 *R. solanacearum* isolates and amplification of 16S rRNA. PCR amplification of *egl*, *pgl*, and *hrpB* genes were performed by suitable primers. The expected band size of 850 bp, 504 bp and 1434bp were observed in *egl*, *pgl* and *hrpB* genes (Fig. 61, 62 & 63). The sequences were confirmed by comparing the sequence available in the NCBI through BLAST programme and aligning through Clustal X software. On the basis of nucleotide sequences of multiple genes, the ITS region, the *hrpB* gene, and the endoglucanase gene *egl*, strains can be precisely partitioned into four taxonomic levels: species, phylotype, sequevar and clone.

Management of major soil and tuber borne pathogens of potato

Twenty one potato varieties were evaluated for their performance against storage rots from last week of March to mid of July during storage in heaps at ambient temperature. Observations indicated that Kufri Chandramukhi was most resistant to rots.

Study carried out with tubers injured during harvest, grading and handling in 5 potato varieties revealed that the injured tubers develop 1.0 to 8% rotting under cold storage and 13.6 to 71 % under ambient storage conditions. Seed treatment with 3% boric acid or 3% boric acid + 0.2% carbendazim carried out as per normal practice after about a month of their curing do not provide adequate protection to injured tubers and methods need to be devised to contain this loss.

Screening of commercially available products for control of tuber diseases in a field trial revealed that thiophanate methyl 70%WP (Ditto @ 5ml/l), or pencycuron 22.9% (Moncern @2.5ml/l) were as effective as the recommended 3% boric acid



Fig. 61. PCR amplification of 850-bp region of the *egl* gene using the primer pair Endo-F and Endo-R (Lane M=1 kb ladder, lane 1-19= strains of *R. solanacearum*)



Fig. 62. PCR amplification of 504 bp region of the *pgl* gene using the primer pair Peh-F and Peh-R (Lane M=1 kb ladder, lane 1-28= strains of *R. solanacearum*)



Fig. 63. PCR amplification of 1434 bp region of the *hrpB* gene using the primer pair HRPB-FP1 and HRPB-RP1 (Lane M= 1 kb ladder, lane 1-44= strains of *R. solanacearum*). No amplification occurred in strains 4, 32, 33 and 34

for control of black scurf. However, treatment with 3% boric acid by spray was the cheapest method to manage tuber borne diseases (Fig. 64, 65 & 66).

Soil solarization together with incorporation of stable bleaching power @ 3q/ha or burying of green manure of *Sesbania aculeata* crop together with soil application of mustard cake @16.7 q/ha were found effective for control of russet scab.

Incidence and severity of common scab recorded in Bihar revealed incidence between 21 to 66% and severity between 6.8 to 36.8%. Effect of moisture on the incidence of common scab was studied using infected tubers of three varieties under moisture deficit and moisture excess conditions. Variable results were obtained in different varieties and the trials therefore, requires to be repeated.



Fig. 64. Black surf an important potato tuber disease



Fig. 65. Russet scab of potato an important problem in north western plains



Fig. 66. Spray of boric acid (3%) for the management of tuber borne pathogens

Integrated pest management

Monitoring of potato pests

Myzus persicae was recorded in early crop at Modipuram (max. temp. 22.1°C and min. temp. 11.3°C) and crossed the critical level in mid December, 2010. The first appearance of green peach aphid was recorded in the 2nd week of December, 2010 at Gwalior which crossed the critical level by 1st week of January. The highest population (52/100 compound leaves) was recorded in 4th week of January. Maximum aphids were trapped on bright yellow sticky traps (Fig. 67) while least on blue coloured traps. The predator adults of *Coccinella* appeared a fortnight earlier because of change in weather conditions. Maximum number of aphids were captured at 90 cm height and minimum at 60cm height. South facing traps captured more number of aphids, which might be due to sun light prevalent for longer duration. Mites are the new emerging pests which severely damage early planted crop of Kufri Jyoti at Gwalior alongwith thrips. However, the incidence of whitefly and leafhopper was very low on early and late potato crop.

The incidence of thrips was recorded on early and late potato crop. The highest population of thrips (36 thrips/plant) was recorded during the 4th week of September. The population

of thrips subsequently declined in the month of November-December. However, two peaks were recorded i.e. first in 4th week of September and second in 3rd week of November.

Infestation of *Spodoptera* was observed on potato and it could turn to cutworm if crop is left unattended, harvested late, tubers are exposed and no other crop in nearby fields (Fig. 68 & 69).



Fig. 67. Yellow sticky trap



Fig. 68. Tuber damaged by *Spodoptera*



Fig. 69. *Spodoptera* turned as cutworm

Management of potato pests

Use of yellow sticky traps was effective in monitoring and trapping of aphids. Application of thiacloprid (0.3 & 0.4%) alongwith summer oil (0.06%) gave longer protection against aphid.

Seventeen varieties namely Kufri Dewa, KCM, K. Kanchan, K. Pukhraj, K. Sindhuri, K. Megha, K. Safed, K. Sheetman, K. Ashoka, K. Khyati, K. Himalini, K. Frysona, K. Himsona, K. Girdhari, K. Bahar, K. Surya and K. Chipsona-2 could resist *M. persicae* till first week of January.

Whitefly could be effectively managed by spraying thiacloprid @ 4ml/10lits of water in the month of November, the activity of this insect ceases later as the winter becomes severe.

Application of phorate 10G @ 15kg/ha at the time of planting followed by drenching of ridges with imidacloprid 17.8 SL @ 0.04% at 60 days old crop proved highly effective in reducing vector population and cut worm damage.



Management of potato nematodes

Potato cyst nematodes (PCN) *Globodera rostochiensis* and *G. pallida* and late blight (LB) disease, *Phytophthora infestans* are the major biotic constraints hindering potato production in The Nilgiris. The occurrence of three pathotypes in each species of PCN and more virulent strains of LB organism calls for continued research for developing potatoes possessing combined resistance to these major plant protection problems. The programme aims to develop an integrated nematode management package including deployment of host resistance to manage PCN and increase potato production in Nilgiris.

Breeding for combined resistance to late blight and potato cyst nematodes

During the year, 33,200 hybrid TPS were produced from nine bi-parental crosses involving selected late blight and potato cyst nematode resistant parents. Eleven thousand four hundred seedlings were screened against

late blight and 495 selected. In the early generation 1,303 hybrids were evaluated in single hill/observational rows along with Kufri Girdhari and Kufri Swarna as check varieties and 694 hybrids were selected. Forty one advance generation hybrids were evaluated along with Kufri Girdhari and Kufri Swarna as checks and 27 were selected on the basis of agronomic traits, resistance to potato cyst nematodes and late blight. Of these 5 top yielding hybrids were: OS/04-475(47.4t/ha); OS/01-516 (40.9t/ha); OS/01-497(38.3t/ha); OS/94-I-126(36.2t/ha), OS/01-392 (32.5t/ha) over control: Kufri Girdhari (32.2t/ha) and Kufri Swarna: 18.1t/ha).

Introduction of hybrid into AICRP

The hybrid OS/01-516 found promising consistently during the previous years was introduced into AICRP for multilocation tests in Nilgiris. It is a cyst nematode and late blight resistant hybrid with oval white tubers (Fig. 70).

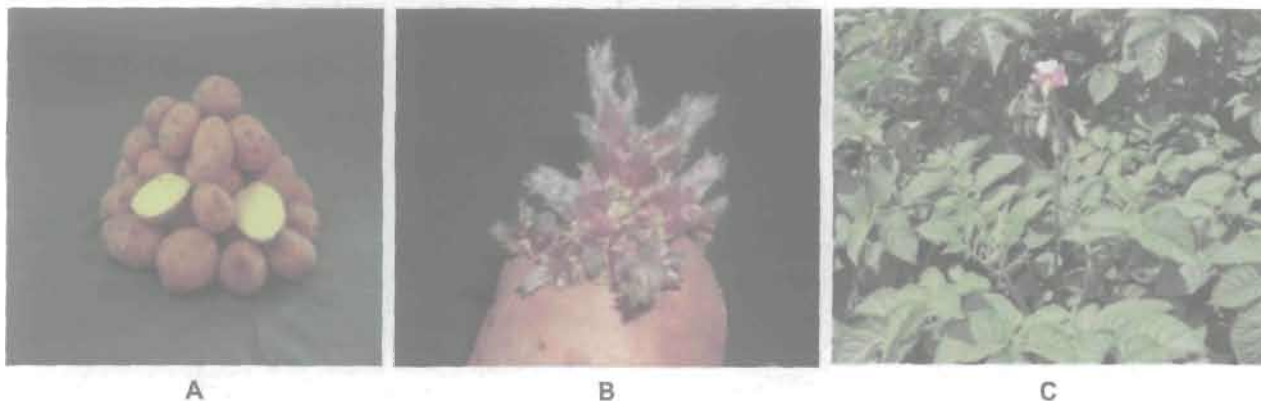
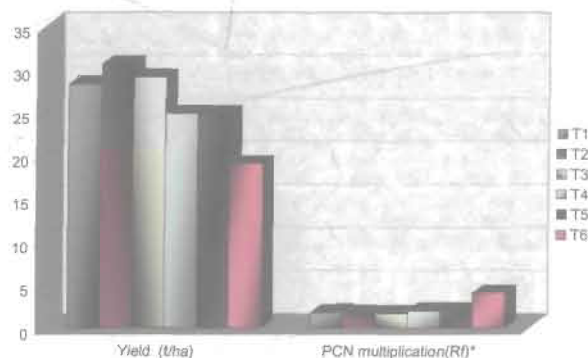


Fig. 70. Promising hybrid – OS/01-516 A: tubers B: tuber sprouts C: foliage and flower

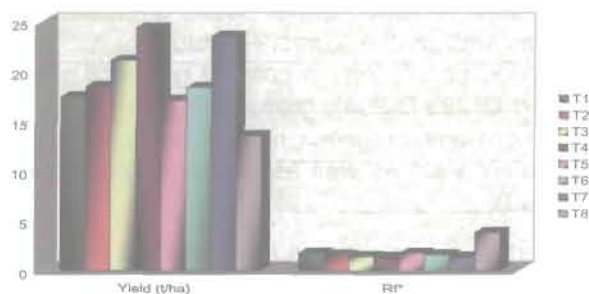
Integrated management of potato cyst nematodes

Evaluation of physical, cultural and chemical management options against PCN: Integration of soil solarisation and soil amendment with neem cake + *Trichoderma viride* recorded 60.89 per cent increase in potato yield and 60.33 per cent decrease in nematode multiplication and this treatment was at par with solarisation combined with carbofuran (Fig. 71).



[T1- Soil solarisation alone; T2 – Soil solarisation + neem cake + *T. viride*; T3 – Soil solarisation + carbofuran; T4 – Neem cake (5t/ha) + *T. viride* (0.5 t/ha); T5- carbofuran alone; T6 – Untreated control] *Rf = nematode reproduction factor

Fig. 71. Effect of soil solarization on the multiplication of PCN and tuber yield of potato



[T1- Cabbage leaves @ 1kg/m²; T2 – Cabbage leaves @ 1kg/m² + polythene covering; T3- Radish leaves @ 1kg/m²; T4 – Radish leaves @ 1kg/m² + polythene covering; T5- Cauliflower leaves @ 1kg/m²; T6 – cauliflower leaves @ 1kg/m² + polythene covering; T7- Carbofuran @ 2 kg a.i./ha; T8 – Untreated control] *Rf = nematode reproduction factor

Fig. 72. Evaluation of biofumigation on potato yield and PCN multiplication

Evaluation of cropping systems and agronomic practices on PCN: Growing potato with Broadbeans in 1:1 ratio recorded the highest potato equivalent yield and recorded the lowest Rf value for PCN in comparison with other intercrop combinations in Kufri Giriraj. In case of advance generation hybrid OS/93-D-204, the yields obtained was higher in comparison with that of Kufri Giriraj and the lowest Rf value was observed in sole potato closely followed by 1:1 intercrop combination with Broadbeans (Fig. 73).

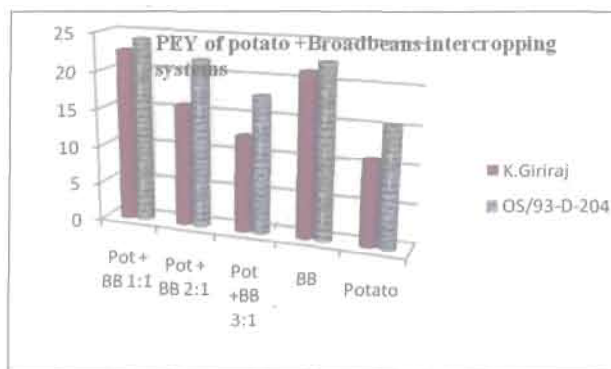


Fig. 73. Potato Equivalent yield of potato + Broadbeans intercropping system

Growing of Rosemary as intercrop in susceptible potato (variety Kufri Giriraj) was found beneficial. Potato + Rosemary intercropping in 1:1 row

Evaluation of biofumigation with incorporation of brassica crops viz., cabbage, radish and cauliflower residues on PCN multiplication revealed that incorporation of radish leaves @ 1 kg/m² together with polythene covering recorded maximum yield in Kufri Giriraj and minimum PCN multiplication and this treatment was at par with carbofuran treatment. (Fig. 72).

Evaluation of chemical pesticide cartap hydrochloride (Dartiz 4%G) on potato yield and PCN multiplication at 3 doses viz., 0.5, 1 and 2 kg a.i./ha and carbofuran @ 2 kg a.i./ha revealed that maximum yield was recorded in carbofuran application @ 2 kg a.i./ha and was at par with cartap hydrochloride @ 2 kg a.i./ha. It was followed by other lower doses of cartap hydrochloride. Kufri Girdhari yielded the maximum followed by OS/93-D-204 and Kufri Swarna.

proportions recorded better potato equivalent yield as well as the lowest Rf value for nematode population. In case of resistant potato (Hybrid OS/93-D-204), growing of sole potato was more advantageous both in terms of potato equivalent yield as well as nematode population (Fig. 40).

Evaluation of various soil management practices on PCN dynamics revealed that the potato equivalent yields were maximum from the improved practice i.e. potato + French beans

intercropping in summer season followed by growing of cabbage in the autumn season. In Kufri Giriraj, growing of potato as monocrop resulted in significant increase in PCN population both after summer as well as autumn season crops. In case of advance generation hybrid OS/93-D-204, monocropping of potato recorded the lowest PCN population and it was closely followed by the recommended practice of growing potato + French beans intercropping followed by cabbage in autumn season.

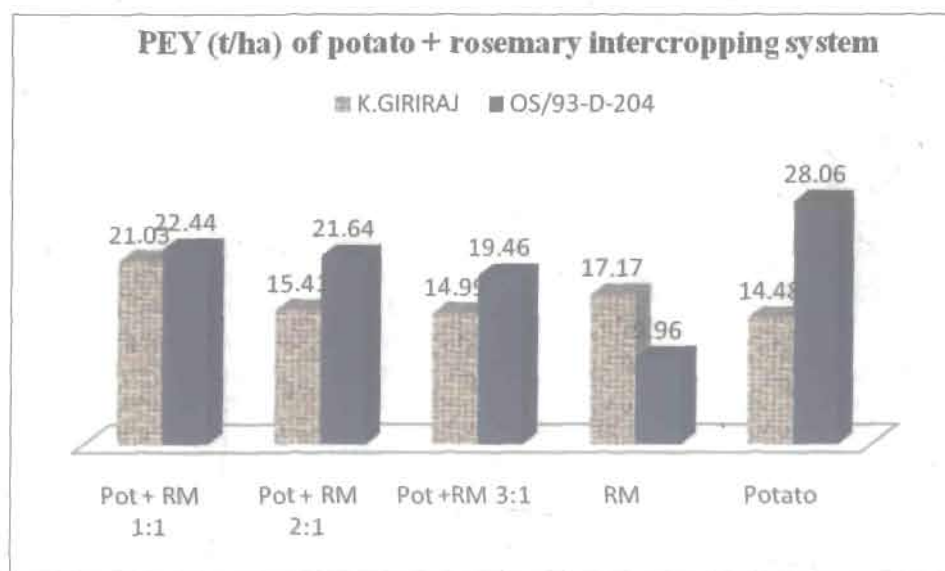


Fig. 74. Potato Equivalent Yield of potato + rosemary intercropping system

DIVISION OF CROP PHYSIOLOGY, BIOCHEMISTRY & POST HARVEST TECHNOLOGY



Nutritional value of potato and potato products

Potato is usually considered to be a rich source of energy but lacking in other nutrients. The fact that potato contributes significantly to the health and well being of people is still not very well known.

Nutrients content in potato varieties

Ascorbic acid, reducing sugars and sucrose content were determined in 44 potato varieties.

Ascorbic acid: Ascorbic acid varied from 13 mg to 26 mg/100g FW with minimum and maximum in Kufri Sutluj and Kufri Surya, respectively. The five varieties showing high ascorbic acid content were Kufri Sindhuri (25 mg), Kufri Chandramukhi (25 mg), Kufri Chipsona-2 (25 mg), Kufri Himsona (24 mg) and Kufri Shailja (23 mg/100g FW).

Reducing Sugars: Reducing sugar varied from 22 mg to 800 mg/100g FW in Kufri Frysona and Kufri Anand, respectively. The low values for reducing sugar content were observed in Kufri Chipsona-1 (29 mg) followed by Kufri Chipsona-3 (31 mg), Kufri Chipsona-2 (45 mg FW) and Kufri Himsona (48 mg/100g FW).

Sucrose content: Sucrose varied from 111 mg to 403 mg/100g FW in Kufri Muthu and Kufri Deva, respectively. Sucrose content of less than 200 mg/100g FW was observed in 32 varieties.

Glyco-alkaloid content in some potato varieties

Glyco-alkaloids, solanine and chaconine were estimated in ten potato varieties harvested from Kufri. The detections were made in the peels and cortex separately as the concentration of alkaloids has been reported to be high in peels

portion. The analysis in peels showed maximum concentration of solanine in cv. Kufri Megha and minimum in Kufri Giriraj. The chaconine content

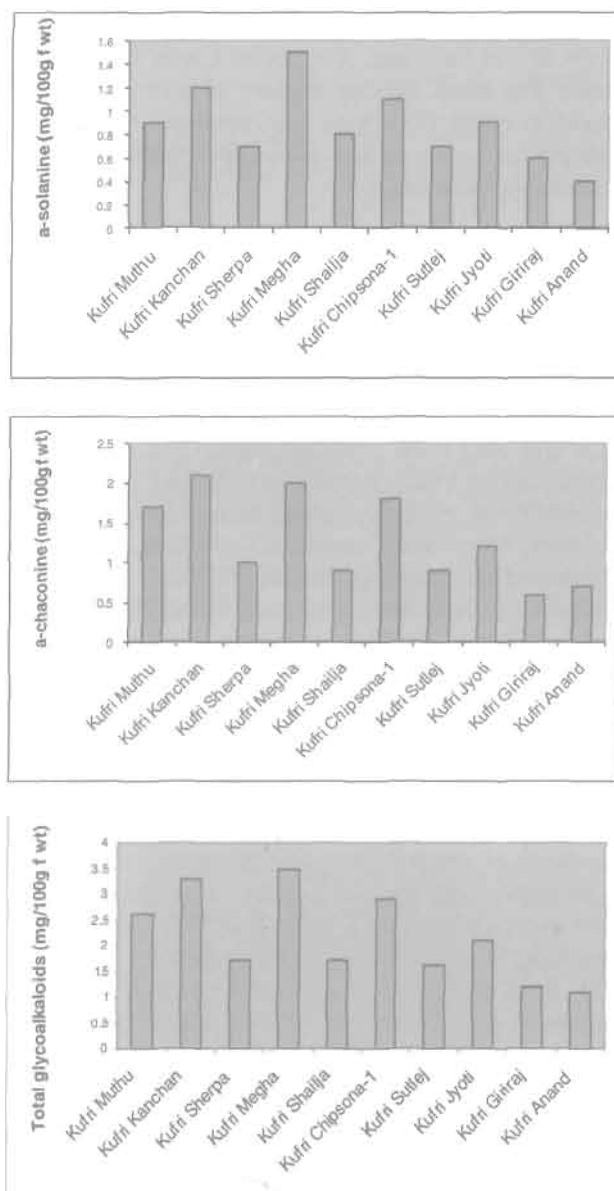


Fig. 75. Glycoalkaloid content in flesh of potato tubers of ten varieties

was also highest in Kufri Megha and minimum in Kufri Giriraj. The total glyco-alkaloids in peels showed similar pattern in these varieties. The content of alkaloids was low in flesh (peeled tubers) compared to peel as has been reported in literature and the varieties had variable pattern of their concentrations. The solanine content was highest in Kufri Megha and minimum in Kufri Anand whereas, the chaconine content was highest in Kufri Kanchan followed by Kufri Megha and least in Kufri Giriraj. The total glyco-alkaloids were highest in Kufri Megha and lowest in Kufri Anand and Kufri Giriraj (Fig. 75). The glyco-alkaloids content of $\geq 20\text{mg}/100\text{g}$ FW is reported to cause health related problems and in none of the varieties, the content was found to reach this level. Higher content of alkaloids were found in peels but these are removed during peeling as potatoes are invariably peeled before cooking/consumption.

Potato: banana blend

Attempts are being made world over to fortify foods to improve nutrition. In countries, where potato constitutes major part of the diet, efforts are being made to enrich it with vitamin A, iron and zinc from other sources. One of the objectives of this programme is to explore the possibility of fortifying potato based foods with nutrients from other sources. As a first step in this direction, flours of potato (cv Kufri Jyoti), banana (cv Nendran) and their blend (50%+50%) were analysed for their nutrients content. Reducing sugar, total sugars, free amino acids, and soluble protein contents are shown in Fig. 76. There was little difference in the reducing sugar content but values for total sugars, free amino acids and soluble protein were higher in potato. The free amino acids and soluble protein contents of potato and banana (50%+50%) blend was higher than that in banana flour. The starch and sucrose content were higher in potato flour resulting in an increase in the blend as well (Fig. 77). Total phenols and carotene content were higher in potato flour while ascorbic acid content was higher in banana flour (Fig. 77). Iron and zinc are the two nutritionally important minerals and both were higher in potato flour and as a result in the potato: banana blend (Fig. 78). The fat content was quite low in both potato (0.4%) and banana (0.4%) flours and their blend (0.4%). These results indicate that for many of

the nutrients analysed, potato showed higher values and by blending potato flour with banana flour, the nutritional value of banana flour can be improved.

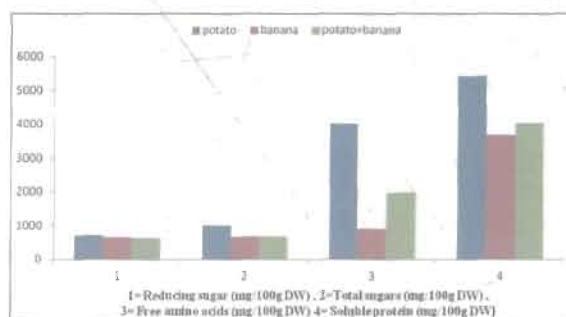


Fig. 76. Nutrients content of potato and banana flours and their blend

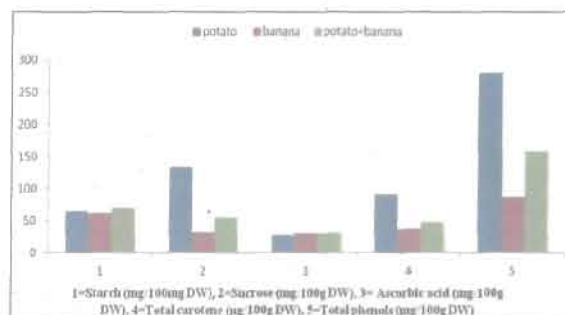


Fig. 77. Nutrients content of potato and banana flours and their blend

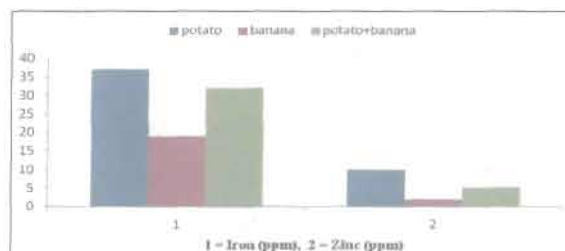


Fig. 78. Minerals content of potato and banana flours and their blend

Development of minimal frying/ microwaveable frozen potato products

Preliminary experiments were conducted on osmotic dehydration (OD) of potatoes with

8 combination treatments of NaCl (2-7%) and sucrose (7.5-45%) and two durations of dipping (2 & 4 hrs). 200 g of freshly cut fries were dipped in 250 ml of the solution (solute to sample ratio= 4:1) for 2 and 4 hrs, washed in water, extra moisture was blotted off, frozen for 24 hrs and fried for 1.5 minutes at 180°C. Moisture percentage in OD products before frying decreased with the increase in solute concentration and duration of dipping. Organoleptic evaluation of fried frozen product was found acceptable with more crispness compared to frozen French fries. The firm texture of the product was retained in some treatments even after 5 minutes of frying. The oil content

in the finished fried product was significantly low (1.8-4.8%) compared to frozen French fries (18.5%).

In another experiment to reduce oil content while maintaining the sensory quality characters, the par fried frozen French fries of processing varieties viz., K. Chipsona-1, K. Chipsona-3, and K. Frysona were cooked in microwave oven for different durations on full power by omitting final frying. Final fries of K. Frysona (after 2.30 minutes cooking in microwave) were found acceptable for taste with more firmness and low oil content (2.7-4.5%) compared to final fried frozen French fries (14.6-18.9%) (Fig. 79).

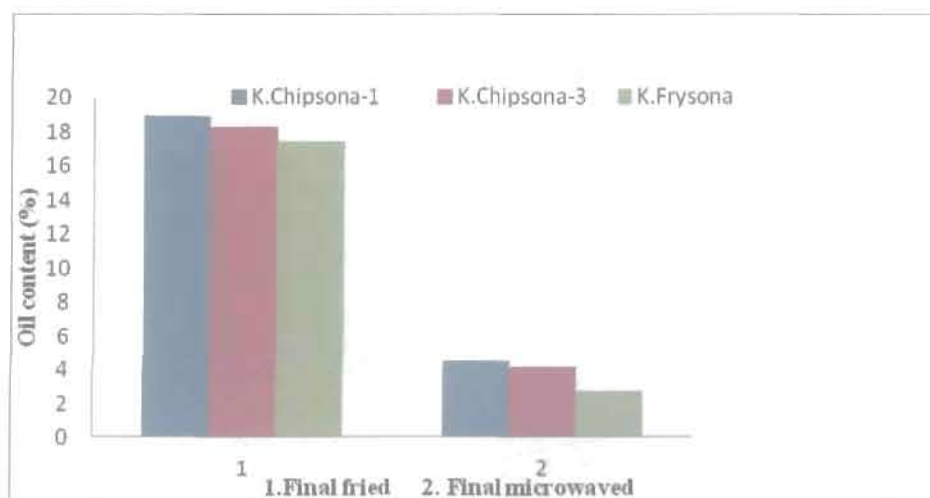


Fig. 79. Oil content of frozen French fries



Potato Storage: Efficient and eco-friendly methods for improved quality

CIPC, though is effective sprout suppressant but is environmentally unfriendly, therefore a pressing need exists to identify and recommend alternatives to CIPC which do not pose any residue problem. Studies on environment friendly compounds for sprout inhibition in table and processing potatoes and identification of dormancy prolonging chemicals for use in seed potatoes were conducted.



Experiments on evaluation of potato genotypes for storability and processing quality under traditional storage systems and elevated temperature storage were continued. Besides efforts were made for transfer of technology on improved heap storage technology to the farmers and the processing industries through on-farm demonstrations and reports/news items in the local news papers.

Storability and processing quality of newly released cultivars under heap and pit storage

Out of 3 newly released cultivars evaluated in comparison to control, Kufri Himsona recorded good storability with reduced losses under heap (15.5%) and pit storage (7.06%) up to 105 days. Losses due to rotting in tubers were higher in Kufri Khyati and Kufri Chipsona-3 particularly in CIPC treatment. Reducing sugar content in CIPC treated tubers of Kufri Chipsona-1, Kufri Chipsona-3 and Kufri Himsona was low (≤ 100 mg/100g FW) and chip colour was highly acceptable up to mid June, whereas cvs. Kufri Jyoti and Kufri Khyati with higher sugars content produced dark coloured chips.

Effect of curing of potatoes on losses under heap storage

Cultivar differences in storability in heaps after treatment with CIPC with/without a curing period of 10 days after harvest were recorded. Total losses and losses due to tuber rots after 90 days of storage were significantly higher in Kufri Bahar treated immediately after harvest (within 3 days) due to bruised skin at the time of CIPC treatment compared to potatoes treated after a 10 day curing period. Whereas, the differences in storage losses within the treatments (cured v/s uncured tubers) were not significant in cv. Kufri Chipsona-1, where the tuber skin was not much bruised after harvest (Fig. 80).



Fig. 80. Potatoes of Kufri Chipsona-1 (left) and Kufri Bahar (right) 3 days after harvest

On-farm storage of potatoes in heaps

An improved heap storage technology involving essential pre and postharvest measures viz. potato tuber maturity, sufficient interval from haulm cutting to harvest, curing and selection of healthy potatoes prior to storage, providing proper ventilation during storage and sprout inhibition with the use of CIPC (isopropyl N-(3-chlorophenyl) carbamate) has been developed for short-term storage of table and processing potatoes. In a demonstration heap of Kufri Pukhraj (65 quintals) laid under the shade of trees in Lawad village (U.P) (Fig. 81) with use of CIPC (GroStop Basis @ 80 ml/tonne), total losses in CIPC treated heap were 5.0% compared to 10% losses in the control after 60 days of storage.



Fig. 81. A potato heap at Lawad village (U.P.)

storage cost compared to refrigerated storage at 12°C.

Adoption of heap storage technology by the potato industry

Technical guidance was provided to Satnam Agri Products Ltd., Pratapara, Jalandhar for storage of 25,000 q of Kufri Chipsona-1 in heaps with improved ventilation in the cold storage Varandah during March-May, 2010 (Fig. 82). Stored potatoes with good processing quality were used in making good quality flakes up to 20th of May, 2010. Thus the industry saved significantly on

CIPC residue in potatoes stored under non-refrigerated stores

CIPC residues (< 7 mg/kg in peels) in potatoes stored in heaps and pits were within the permissible levels. Though the residues in peels reduced during the storage period in most of the cases, there were few exceptions amongst the heap stored potatoes showing that the residues are maintained to some extent.



Fig. 82. Storage of potatoes in improved heaps by the processing industry

Processing quality of potatoes during prolonged storage

Potatoes of four cultivars viz. Kufri Chipsona-1, Kufri Chipsona-2, Kufri Jyoti and Kufri Pukhraj stored at 4, 8 and 12°C with CIPC treatment were evaluated for processing quality after prolonged storage up to 240 days. The reducing sugar content was higher at 0 day of storage even in the two processing cultivars Kufri Chipsona-1 (182 mg/100 g

Chipping quality of processing cultivars during storage at 10-12°C with CIPC

In processing quality evaluation of mature tubers of four cultivars, reducing sugar content was low at the time of storage and increased tremendously at 4°C temperature by 90 days with the exception of Kufri Chipsona-2. Sugar concentration remained low even up to 180 days at 12°C.

Chip colour which was acceptable at the time of storage in the four varieties, deteriorated to unacceptable level after 90 days at 4°C and could not be improved by reconditioning (Fig. 83). At 12°C, chip colour was acceptable up to 90 days in Kufri Chipsona-1 and Kufri Chipsona-2, but colour could not be improved by reconditioning in any variety after 90 and 120 days. In another study with seven processing varieties at 10-12°C, reducing sugar accumulation during storage was very high and chip colour was found acceptable in only Kufri Himsona up to 60 days.

FW) and Kufri Chipsona-2 (183 mg/100 g FW) and the chip colour was unacceptable. By 120 days, reducing sugars and the sucrose content increased and chip colour further deteriorated. While in similar studies in 2009, the reducing sugar content was low in Kufri Chipsona-1, and Kufri Chipsona-2 (67 and 48 mg/100 g FW, respectively) at 0 day of storage, showing thereby considerable variation in the sugar content and processing quality of potatoes on year to year basis. It is confirmation of the fact that the processing quality of a variety is dependent upon various pre and post-harvest factors.

Naturally occurring volatile compounds for sprout suppression

Laboratory experiments were conducted with

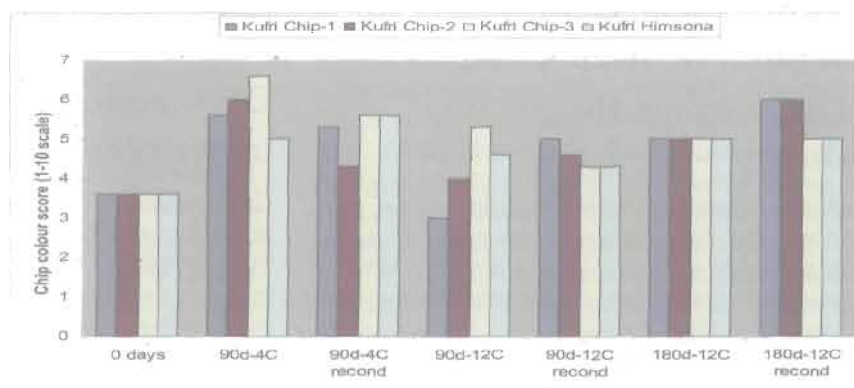


Fig. 83. Chip colour of processing varieties during storage and reconditioning

several naturally occurring volatile compounds at $24\pm2^\circ\text{C}$. Tuber treatment with diphenylamine (750 ppm) recorded maximum sprout suppression with remarkable reduction in sprout weight (92.1%) up to 120 days of storage (Fig. 84).

possibility of breaking sprouts during handling, thus affecting the germination and vigour of the crop. In efforts to enhance dormancy of seed potatoes in the North-western hills under diffused light conditions, a naturally occurring



Fig. 84. Control v/s treated potatoes (diphenylamine-750 ppm) after 120 day of storage.

Enhancing dormancy of seed potatoes in the north-western hills

Due to unavailability of cold storages in hilly areas of the country including Shimla and north eastern region, potato seed is stored under diffused light conditions without refrigeration. Short dormant varieties develop long, lanky and unhealthy sprouts by the planting time with every

substance present in potato tuber skin, 1,4 DMN (1,4-dimethylnaphthalene) was evaluated in two potato varieties. Tubers treated with four concentrations of a commercial formulation named 1, 4 Seed, had no visible sprouting up to 120 days (Fig. 85). However, by 210 days after harvesting, coinciding with the planting in hills, all the treated and control tubers had cent per cent sprouting.



Fig. 85. Sprout growth in seed tubers after 120 days as affected by treatment with 1, 4-dimethylnaphthalene

The length of the longest sprout was more in variety Kufri Giriraj (short dormant) compared to Kufri Jyoti (long dormant) in control, whereas in the treated potatoes, the length of sprouts in Kufri Giriraj could be controlled to some extent and length in the two varieties was at par

(Fig. 86). Sprout weight was also at par in the two varieties showing thereby that by treatment with 1,4 DMN, sprout growth in seed tubers can be controlled and variations due to differences in the dormancy durations in the varieties can be minimized.

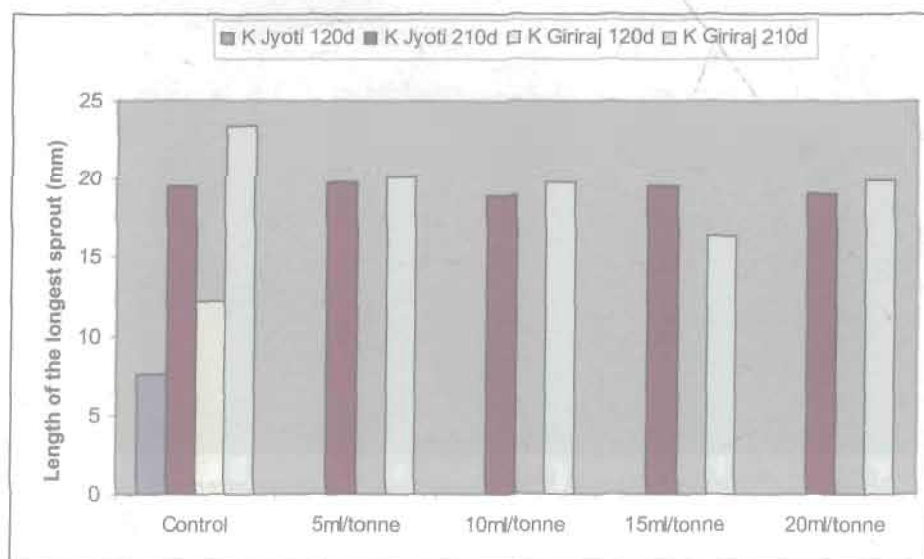


Fig. 86. Length of the longest sprouts in seed tubers as affected by treatment with 1,4-dimethylnaphthalene



Physiological and genetic approaches in managing heat and water stress under sub-tropical environment in potato

The main objectives of this programme are to impart heat tolerance in new potato varieties that is atleast 2°C higher than Kufri Surya, and to impart drought tolerance so that new varieties have high water use efficiency and can save atleast 25% water for comparable yield.

Duration of night temperature and tuberization in potato cuttings

Night temperature is very important for tuberization in potato. In some areas of peninsular India, night temperature comes below 20°C only for a very short duration during early morning. Experiments were conducted to find out the importance of night temperature duration on tuberization in potato. Preliminary results have shown that survival of cuttings was good at 18°C. All cuttings tuberized at 18°C 12 hr night duration. About 40% cuttings tuberized at 20 and 22°C night temperature for 12 hr as well as 22°C for 8 hrs. Highest tuber diameter for tuber fresh weight occurred at 18°C with 12 hrs.

Hybridization and evaluation of clones for heat tolerance

One hundred and ten crosses were attempted at Kufri, out of which 69 were successful and yielded 99219 seeds. During winter 42 successful crosses at Modipuram yielded 99219 seeds. During winter 42 successful

crosses at Modipuram yielded 100128 seeds. Seedlings were raised from 53026 seeds of 54 crosses and 10445 seedlings were transplanted to field. At harvest 747 selections were made based on tuber characters like size, color, shape, synchrony, eye depth etc. At Shimla 1600 seeds from 7 crosses were screened in a heated glass house and 284 selections were made. At Modipuram, F_1C_1 to F_1C_3 were multiplied and evaluated during normal planting season and F_1C_4 to F_1C_6 were evaluated during early planting conditions under heat stress. The results are shown in table 5.

Selection of hybrids for drought tolerance

Potato germplasm was screened for high water use efficiency and high water mining capacity based of isotope ratio of carbon and oxygen. Both these characters were combined through conventional breeding. Sixteen hybrids selected last year from 2005 series were exposed to irrigation at 20, 25 and 30 mm CPE (Table 6). Irrigation at 20 mm served as control and 25 and 30 mm were two levels of water stress. Fifteen hybrids yielded more than control varieties Kufri Pukhraj and Kufri Bahar at all the irrigation levels. Six hybrids showed less than 10% reduction in yield at 30 mm CPE compared to more than 25% for control cvs. K. Pukhraj and K. Bahar. Two hybrids WS/05-146 and WS/05-165 were very high yielding and had stable yield at different stress levels.

Table 5. Field evaluation of heat tolerant material at Modipuram

Stage	Clones evaluated	Selected	Season	Kind of trial
F1C1	832	303	Main	Seedling crop
F1C3	130	39	Main, early	Multiplication, row trial
F1C4	19	5	Early	Multiplication, row trial
F1C5	15	3	Early and late	Replicated trial
F1C6	3	2	Early and late	Replicated trial

Table 6. Tuber yield (q/ha) of selected potato hybrids under well watered control and water stress (75% irrigation) condition at Modipuram during 2008-09

Sl. No.	Genotype	CPE water level				
		20mm	25 mm		30 mm	
		Yield (q/ha)	Yield (q/ha)	% yield reduction	Yield (q/ha)	% yield reduction
1	WS/05-120	654	631	3.5	575	12.1
2	WS/05-146	561	528	5.8	509	9.2
3	WS/05-108	590	529	10.3	499	15.4
4	WS/05-165	528	512	3.0	494	6.4
5	WS/05-144	550	498	9.5	493	10.3
6	WS/05-206	546	514	5.9	492	9.9
7	WS/05-119	606	542	10.6	486	19.8
8	WS/05-103	592	478	19.3	465	21.6
9	WS/05-174	515	474	8.1	462	10.3
10	WS/05-152	621	605	2.7	444	28.5
11	WS/05-137	530	532	-0.3	438	17.4
12	WS/05-121A	499	481	3.7	427	14.5
13	WS/05-147	508	509	-0.1	416	18.1
14	WS/05-204	446	414	7.2	402	9.7
15	WS/05-141	414	393	5.0	377	9.0
16	WS/05-151	387	334	13.5	283	26.8
17	K. Pukhraj	418	386	7.8	327	21.8
18	K. Bahar	383	327	14.5	286	25.3

Screening technique for drought tolerance

Possible use of root pulling force was tested in two drought tolerant and two drought susceptible varieties. Drought tolerant varieties had higher root pulling force that further increased under water stress. On the other hand root pulling force was lower in drought susceptible varieties that further decreased under water stress (Fig. 87.)

Paclobutrazole improves harvest index and tuber yield under heat stress

Paclaburtazole had a beneficial effect on tuber yield and harvest index in three varieties grown under heat stress during early planting. Data on fresh weight of different plant parts at harvest showed a significant decline in shoot height, shoot weight and leaf weight (table 7). The

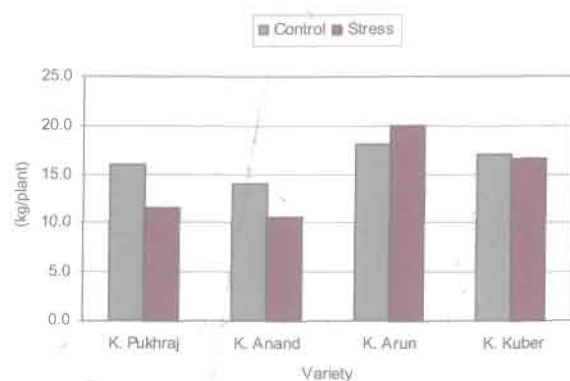


Fig. 87. Root pulling resistance at 35 DAP in potato cultivars under water stress

harvest index was significantly higher (8-10% over untreated control) particularly in repeated sprays. Considering the response of the 5 and 10 ppm doses and timings of sprays, larger yield trial needs to be conducted to validate the results and trend among the cultivars particularly in those which are recommended for early crop season.

Optimization of fertilizer requirement for Kufri Surya in Bihar

Experiment at three locations in Bihar was conducted for optimization of fertilizer dose. The data will be analysed after adding data from two locations in Punjab for which experiments have already been done. The optimum tuber yield was obtained at 160 kg N, 50 kg P and 80 kg K/ha in trials conducted in Bihar (Fig. 88).

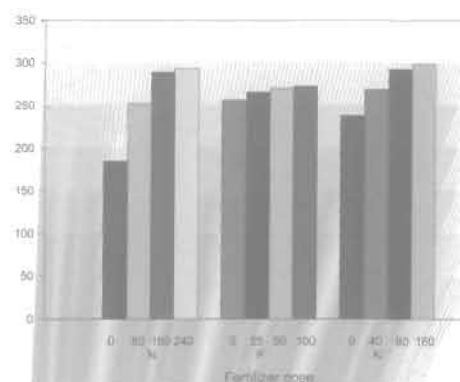


Fig. 88. Fertilizer requirement of Kufri Surya at Patna

Table 7. Effect of paclobutrazole on morphological traits and tuber yield at 75 DAP (mean of three varieties) during heat stress condition of early planting at Modipuram

Treatment	Shoot height (cm/plant)	Shoot wt (g/plant)	Leaf wt (g/plant)	Biological yield (g/plant)	Tuber yield (g/plant)	Harvest index (%)
T1 Control	34.3	22.4	51.7	218.5	135.0	61.6
T2 5ppm-S	27.2	22.1	53.2	253.2	164.1	64.9
T3 10ppm-S	22.0	19.1	39.2	220.4	151.2	68.9
T4 5ppm-R	20.6	15.1	39.3	214.0	149.1	69.8
T5 10ppm-R	19.2	18.4	41.4	229.6	161.2	70.3
LSD 5%	4.3	3.0	6.7	NS	NS	4.2

S: Single spray 28 days after planting

R: Repeated spray at 28 and 42 days after planting

DIVISION OF SEED TECHNOLOGY



Production of breeder seed of potato through conventional and hi-tech system

Potato is cultivated in 1.81 million hectares in different agro climatic zones of India. Potato seed tuber forms a critical input in potato cultivation and accounts for about 50% of the total cost of cultivation. Seed stocks should be free from viral and other seed-borne diseases to maintain higher productivity. A technically sound seed production programme is necessary which provides high quality seed. In this context seed technology division in the institute has been set up with the mandate to produce disease free

basic seed of notified varieties developed by the institute both through conventional seed potato production programme involving tuber indexing and multiplication of breeder seed through different stages and high-tech seed production methods involving production of large number of *in vitro* microplants, microtubers and minitubers. The nucleus and breeder seed production is carried out and monitored by the division at five different regional stations located in different regions of the country.

Conventional seed production system

i) Tuber indexing

A total of 17,604 tubers of different commercial potato varieties were indexed at Modipuram (7,772), Jalandhar (2,360), Gwalior (2,800), Patna (1,004) and Kufri (3,668). Health status recorded during tuber indexing on the above centers was 96.5, 90.0, 97.7, 100.0 and 95.3 percent respectively.



ii) Nucleus seed production

a) Stage-I: The clonal multiplication was under taken in 2.49 hectare in plains and 0.38 hectare in hills and a production of 215.57 and 57.47 quintal was obtained respectively (Table 8). The average production at Modipuram, Jalandhar, Gwalior, Patna and Kufri was 143.26, 114.43, 39.55, 65.51 and 151.24 quintal per hectare, respectively. Health status recorded in field on the above centers was 95.9, 94.0, 95.9, 99.33 and 98.70 percent respectively.



b) Stage-II: The clonal increase was undertaken in 9.75 hectare and a total production of 1,347.13 quintal was achieved at all stations in the plains whereas in hills only 1.10 hectare area was planted and a production of 168.60 quintal was obtained (Table 8). The average production at Modipuram, Jalandhar, Gwalior, Patna and Kufri was 155.27, 133.56, 103.53, 171.30 and 153.27 quintal per hectare, respectively.



Table 8. Station wise, stage wise area planted and production obtained during 2010-11

S. No.	Variety	Stage-I		Stage-II		Stage-III		Stage-IV		Total	
		Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Modipuram											
1	K. Bahar	0.36	5.61	2.63	38.480	2.00	45.630	22.50	549.900	27.49	639.620
2	K. Pukhraj	0.10	1.459	0.45	7.430	1.00	20.850	3.85	86.065	5.4	115.804
3	K. Anand	0.04	0.482	0.2	3.317	0.25	4.900	0.90	25.090	1.39	33.789
4	K. Surya	0.06	0.869	0.85	16.250	0.25	4.820	0.30	7.080	1.46	29.019
5	K. Chipsona-1	0.03	0.314	0.16	2.585	0.50	10.530	1.20	40.400	1.89	53.829
6	K. Chipsona-3	0.03	0.362	0.11	1.545	0.25	6.670	-	-	0.39	8.577
7	K. Badshah	0.03	0.470	0.18	3.163	0.30	6.830	1.35	29.550	1.86	40.013
8	K. Himsona	0.02	0.140	0.19	1.875	0	0	0.30	9.400	0.51	11.415
9	K. Sadabahar	0.10	1.572	0.25	6.294	0.50	13.500	0.60	13.500	1.45	34.866
10	K. Frysona	0.03	0.275	0.19	2.467	0.70	16.250	-	-	0.92	18.992
11	K. Sullej	0.02	0.150	0.09	1.413	0.20	6.270	0.40	7.310	0.71	15.143
12	K. Chipsona-4	0.01	0.095	0.50	5.240	-	-	-	-	0.51	5.335
13	K. Khyati	0.05	0.809	-	-	-	-	-	-	0.05	0.809
Total		0.88	12.607	5.80	90.059	5.95	13.625	31.4	768.295	44.03	1007.211
Jalandhar											
1	K. Jyoti	0.27	3.048	0.60	9.420	2.50	55.000	11.70	255.706	15.07	323.174
2	K. Pushkar	0.002	0.035	-	-	-	-	0.10	4.104	0.102	4.139
3	K. Pukhraj	0.01	0.050	0.05	0.220	0.1	2.600	3.70	93.249	3.86	96.119
4	K. Badshah	0.01	0.050	0.05	0.200	0.1	2.7.0	1.6	41.932	1.76	44.882
5	K. Chandramukhi	0.006	0.090	0.05	0.177	0.1	2.900	2.0	44.528	2.156	47.695
6	K. Chipsona-1	-	-	-	-	-	-	0.60	22.179	0.6	22.179

Contd...

Contd...

S. No.	Variety	Stage-I		Stage-II		Stage-III		Stage-IV		Total	
		Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
7	K. Chipsona-3	-	-	-	-	1.0	20.816	-	-	1	20.816
8	K. Surya	-	-	-	-	1.30	22.139	-	-	1.3	22.139
9	K. Sulej	0.001	0.020	-	-	-	-	-	-	0.001	0.020
10	K. Khyati	0.001	0.140	-	-	-	-	-	-	0.001	0.140
	Total	0.003	3.433	0.075	10.017	5.10	106.155	19.7	461.698	25.85	581.303
Gwalior											
1	K. Sindhuri	0.1	0.476	0.45	4.970	1.34	26.400	4.13	84.214	6.02	116.060
2	K. Jyoti	0.27	1.023	0.54	6.434	1.23	21.700	2.79	33.483	4.83	62.640
3	K. Chipsona-1	0.14	0.436	0.57	5.665	0.75	12.450	2.43	36.741	3.89	55.292
4	K. Chandramukhi	0.12	0.586	0.22	3.160	0.50	5.760	1.13	16.970	1.97	26.476
5	K. Chipsona-2	-	-	0.19	1.215	0.50	6.950	2.20	20.857	2.89	29.022
6	K. Lauvkar	0.45	1.760	0.74	6.708	1.40	18.250	2.35	30.752	4.94	57.470
7	K. Arun	-	-	0.13	1.250	0.20	3.000	0.92	10.663	1.25	14.913
8	K. Chipsona-3	0.05	0.199	-	-	0.90	17.533	-	-	0.95	17.732
9	K. Surya	-	-	-	-	0.52	3.653	-	-	0.52	3.653
10	K. Himsona	-	-	-	-	-	-	0.65	9.325	0.65	9.325
11	K. Bahar	0.05	0.187	-	-	-	-	-	-	0.05	0.187
	Total:	1.18	4.667	2.84	29.402	7.34	115.696	16.6	243.005	27.96	392.770
Patna											
1	K. Jyoti	0.0353	0.250	0.0816	1.300	0.35	9.040	2.10	47.500	2.5669	58.090
2	K. Arun	0.0547	0.350	0.096	1.835	0.30	4.200	0.40	5.947	0.8507	12.332
3	K. Kanchan	-	-	-	-	-	-	1.25	21.809	1.25	21.809
4	K. Pukhraj	0.0378	0.250	0.128	2.100	0.80	16.230	-	-	0.9658	18.580

Contd...

Contd...

S. No.	Variety	Stage-I		Stage-II		Stage-III		Stage-IV		Total	
		Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
	Total	0.1278	0.850	0.3056	5.235	1.45	29.470	3.75	75.256	5.6334	110.811
	G. Total Plains (A)	2.488	21.557	9.75	134.713	19.84	387.571	71.45	1548.254	103.47	2092.095
Kufri											
1	K. Jyoti	0.19	3.000	0.8	10.300	1.0	14.780	2.70	26.635	4.69	54.715
2	K. Himalini	0.06	0.918	0.07	2.050	0.12	2.700	0.40	2.910	0.65	8.578
3	K. Kanchan	0.02	0.320	0.03	0.575	0.04	1.140	0.25	1.730	0.34	3.765
4	K. Shailja	0.02	0.218	0.04	1.470	0.12	1.425	0.20	0.985	0.38	4.098
5	K. Giritraj	0.02	0.309	0.05	0.900	0.20	1.500	0.05	0.250	0.32	2.959
6	K. Girdhari	0.06	0.918	0.07	1.235	0.14	3.200	0.15	1.400	0.42	6.753
7	K. Himsona	0.01	0.064	0.04	0.330	0.12	0.840	0.08	0.600	0.25	1.834
	G. Total Hills (B)	0.38	5.747	1.1	16.860	1.74	25.585	3.83	34.510	7.05	82.702
	Grand total (A+B)	2.868	27.304	10.85	151.573	21.58	413.156	75.28	1582.764	110.52	2174.797

c) Stage-III: The bulk increase in this stage was planted in 19.84 hectare at all the four stations in the plains and a total production of 3875.71 quintal was achieved, whereas, in the hills the production obtained was 255.85 quintal in 1.74 hectare (Table 8). The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 228.99, 208.15, 157.62, 203.24 and 147.04 quintal per hectare, respectively.

iii) Breeder seed production

Stage-IV: The breeder seed in the plains was planted in 71.45 hectare and 15482.54 quintal production was achieved which includes RFS-II area of 16.23 ha and production of 3677.53 quintal. Station wise area planted and production achieved under RFS-II was 10.0, 2.0, 2.13 and 2.1 ha and 2362.50, 440.0, 400.03 and 475.0 quintal respectively at Modipuram, Jalandhar, Gwalior and Patna. In the hills, production of 345.10 quintal was achieved in an area of 3.83 hectare (Table 8). The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 244.68, 234.36, 146.39, 200.68 and 90.10 quintal per hectare, respectively.

Hi-Tech seed production technology

i) Nucleus seed production

A) Maintenance and multiplication of virus free buffer stocks: Disease free buffer stock tubers of twenty five varieties were planted under controlled conditions in the poly house. During its growth period samples were collected and tested for viruses PVX, PVS, PVY, PVM, PVA, PLRV, PALCV and PSTVd by ELISA and PCR. All the samples, were found free from all the viruses tested. A total of 63845 *in vitro* plantlets of 28 varieties and 27876 micro/minitubers of 25 varieties were produced at CPRI, Shimla. A total of 13650 *in vitro* plantlets were used for planting at CPRI, Shimla and about 10565 *in vitro* plantlets of different varieties were transferred to liquid media for microtuber production. About 29070 *in vitro* plantlets were supplied to different regional stations for further multiplication.

B) Nucleus and Breeder seed production through tissue culturally developed material:

a) Generation 0: A total of 4,47,524 minitubers

were produced from 70,258 microplants and 20,476 microtubers and 6,07,782 tubers were produced from aeroponic tubers (9,191 from 2006) and recycling of <3 g (5,98,591 from 1,26,098) minitubers at different regional stations (Table 9).

b) Generation 1: A total production of 1909.95 quintal was achieved in generation-1 from an area of 9.77 hectare both in hills and plains. In this generation 9.47 hectare was planted at all the four stations in the plains and a total production of 1868.45 quintal was achieved, whereas, in the hills the production obtained was 41.50 quintal in 0.30 hectare (Table 10). The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 212.86, 112.64, 58.02, 214.71 and 138.33 quintal per hectare, respectively.

c) Generation 2: A total production of 6224.5 quintal was achieved in generation-2 in an area of 26.41 hectare both in hills and plains. In this generation 25.79 hectare was planted at all the four stations in the plains and a total production of 6168.60 quintal was achieved, whereas, in the hills the production obtained was 55.90 quintal in 0.62 hectare (Table 10). The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 266.71, 226.56, 74.58, 207.12 and 90.16 quintal per hectare, respectively.

Production of breeder seed during 2010-11

A total production of 22052.14 quintal was achieved in stage-IV and generation-2 from an area of 101.69 hectare both in hills and plains. A total of 97.24 hectare was planted at all the four stations in the plains and a total production of 21651.14 quintal was achieved, whereas, in the hills the production obtained was 401.0 quintal in 4.45 hectare (Table 8 and 10).

Supply of breeder seed during 2008-09 and 2009-10

A total of 26428.70 and 25931.23 quintal breeder seed were supplied to various agencies during 2008-09 and 2009-10 respectively from plains and hills (Table 11 and 12).

Table 9. Station-wise microplants, microtubers and minitubers (<3 g) planted and production obtained during 2010-11.

Station	Planting material	Planted (Nos.)	Establishment (%)	Mini/tuber produced (Nos.)	Minitubers <3g (%)
Modipuram	Microplants	61579	52665	248595	121000
	Microtubers	15929	10307	47038	21970
	Minitubers (<3 g)	96350	92460	298021	-
	Aeropinc minitubers	2044	2006	9191	2575
Jalandhar	Microplants	9791	8763	64611	27750
	Microtubers	2417	2296	9755	4710
	Minitubers (<3 g)	15282	15282	66463	-
Kufri	Microplants	8054	7659	30707	12437
	Microtubers	1069	717	1583	1423
	Minitubers (<3 g)	3380	2992	10311	-
Gwalior	Microplants	771	402	4211	2326
	Microtubers	5695	2551	18238	11360
	Minitubers (<3 g)	8480	5980	28881	-
Patna	Microplants	5398	769	3045	1625
	Microtubers	3858	3355	11316	5610
	Minitubers (<3 g)	9410	8372	192450	-
Ooty	Microtubers	1686	1250	8425	562
	Minitubers (<3 g)	1197	1012	2465	-
Total Microplants		85593	70258	351169	165138
Total Microtubers		30654	20476	96355	45635
Total Minitubers (<3 g)		34099	126098	598591	-
Aeroponic minitubers		2044	2006	9191	2575
Total/Average		252390	218838	1055306	213348

Table 10. Station wise, generation wise area planted and production obtained during 2010-11

S. No.	Variety	Generation-I		Generation-II		Total	
		Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Modipuram							
1	K. Bahar	4.00	83.86	4.50	114.50	8.50	198.36
2	K. Chipsona-3	1.50	29.10	4.00	103.25	5.50	132.35
3	K. Surya	0.85	19.35	2.70	75.72	3.55	95.07
4	K. Sutlej	0.001	0.02	0.10	1.70	0.101	1.72
5	K. Anand	0.05	1.46	1.40	43.61	1.45	45.07
6	K. Chipsona-4	0.004	0.07	-	-	0.004	0.07
7	K. Himsona	0.50	16.65	1.25	39.95	1.75	56.60
8	K. Pukhraj	0.30	4.39	0.15	3.70	0.45	8.09
9	K. Himalini	0.10	0.10	-	-	0.1	0.10
10	K. Khyati	0.195	4.82	-	-	0.195	4.82
11	K. Sadabahar	0.17	3.46	0.60	10.10	0.77	13.56
12	K. Badshah	-	-	0.15	3.43	0.15	3.43
13	K. Chipsona-1	-	-	0.20	7.05	0.20	7.05
14	K. Chipsona-2	-	-	0.10	1.05	0.10	1.05
Total		7.67	163.26	15.15	404.06	22.82	567.32

Contd...

Contd...

S. No.	Variety	Generation-I		Generation-II		Total	
		Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Jalandhar							
1	K. Pukhraj	0.30	3.02	1.10	28.05	1.40	31.07
2	K. Chandramukhi	0.30	1.54	1.10	25.75	1.40	27.29
3	K. Badshah	0.25	1.83	0.70	18.90	0.95	20.73
4	K. Suttlej	0.01	1.60	-	-	0.01	1.60
5	K. Himsona	0.01	0.28	-	-	0.01	0.28
6	K. Jyoti	0.01	0.98	-	-	0.01	0.98
7	K. Chipsona-3	0.01	0.14	0.60	5.93	0.61	6.07
8	K. Pushkar	0.01	0.36	-	-	0.01	0.36
9	K. Khyati	0.01	0.52	-	-	0.01	0.52
	K. Chipsona-1	-	-	0.05	1.80	0.05	1.80
	Total	0.91	10.25	3.55	80.43	4.46	90.68
Gwalior							
1	K. Lauvkar	0.17	1.12	0.33	2.30	0.5	3.42
2	K. Bahar	0.09	0.45	0.38	2.55	0.47	3.00
3	K. Sindhuri	0.06	0.32	0.09	1.15	0.15	1.47
4	K. Chandramukhi	0.03	0.10	0.27	1.90	0.3	2.00
5	K. Chipsona-1	0.001	0.03	-	-	0.001	0.03
6	K. Chipsona-3	0.01	0.06	0.006	0.15	0.016	0.21
7	K. Jawahar	0.001	0.02	-	-	0.001	0.02
8	K. Surya	0.012	0.07	0.01	0.05	0.022	0.12
	Total	0.374	2.17	1.086	8.10	1.46	10.27
Patna							
1	K. Pukhraj	0.088	2.45	4.25	90.40	4.338	92.85
2	K. Kanchan	0.2232	3.44	0.70	15.23	0.9232	18.66
3	K. Ashoka	0.088	2.31	0.45	5.27	0.538	7.58
4	K. Surya	0.01	0.23	-	-	0.01	0.23
5	K. Jyoti	0.0704	1.72	0.40	9.46	0.4704	11.18
6	K. Chipsona-3	0.0352	0.83	0.20	3.92	0.2352	4.75
7	K. Khyati	0.0052	0.20	-	-	0.0052	0.20
	Total	0.52	11.17	6.0	124.27	6.52	135.44
	G. Total plains (A)	9.47	186.85	25.786	616.86	35.256	803.71
Kufri							
1	K. Jyoti	0.05	0.30	-	-	0.05	0.30
2	K. Himalini	0.05	1.25	0.20	1.96	0.25	3.21
3	K. Giriraj	0.05	0.29	0.20	1.10	0.25	1.39
4	K. Himsona	0.06	0.65	0.02	0.26	0.08	0.91
5	K. Kanchan	0.04	0.36	0.05	0.37	0.09	0.73
6	K. Shailja	0.02	0.93	-	-	0.02	0.93
7	K. Girdhari	0.03	0.38	0.15	1.90	0.18	2.28
	G. Total hills (B)	0.3	4.15	0.62	5.59	0.92	9.74
	Grand total (A+B)	9.77	191.00	26.406	622.45	36.176	813.45

Table 11. Agency and variety-wise supply of breeder seed during the year 2008-09 (q.)

Varieties/ States	K. Bahar	K. Jyoti	K. Ch.-1	K. Pukhraj	K. Anand	K. Sindhuri	KCM	K. Badshah	K. Chip-3	K. Sutlej	K. Pushkar	K. Surya	K. Lauvkar	K. Kanchan	K. Chip-2	K. Ashoka	K. Giriraj	K. Arun	K. Shailja	TOTAL
A. Govt. supply																				
UP	4271.0	-	520.0	100.0	500.0	323	65.0	150.0	80.0	200.0	-	210.0	-	77.0	-	-	-	25.0	-	6521
MP	-	393.50	377.5	32.0	-	119.1	62.4	-	45.0	-	20.0	30.0	96.5	-	-	30.0	-	-	-	1206
Punjab	70.0	300.0	-	200.0	-	150.0	250.0	250.0	120.0	100.0	190.0	-	100.0	-	-	-	-	-	-	1730
Bihar	-	-	-	360.0	156.478	-	-	146.0	-	-	-	-	-	13.0	-	15.0	-	-	-	690.478
HP	-	757.0	-	-	-	-	200.0	-	-	-	-	-	-	-	-	-	6.0	-	-	963
NHRDF	250.0	30.0	50.0	6.0	100.0	-	-	-	-	-	-	-	-	70.0	-	43.0	-	-	-	549
WB	-	300.0	-	-	-	-	65.0	-	-	-	-	97.0	-	-	10.0	20.0	-	-	-	492
Uttarakhand	-	325.0	-	-	-	-	-	-	45.0	-	-	-	-	-	110.0	-	10.0	-	-	490
Chhattisgarh	-	-	20.0	50.0	-	-	-	-	-	-	-	-	-	-	138.0	20.0	-	-	-	228
NSC	200.0	360.0	-	80.0	-	-	135.0	70.0	40.0	-	70.0	-	50.0	-	-	-	-	-	-	1005
J&K	-	157.0	3.0	-	-	80.0	-	40.0	-	-	-	-	3.5	-	-	6.0	-	-	-	293
Haryana	40.0	-	24.0	70.0	28.0	-	-	70.0	-	98.0	20.0	-	-	-	-	-	-	-	-	350
Jharkhand	-	-	50.0	50.0	-	-	-	-	-	-	-	-	-	-	63.0	19.15	-	-	-	182.15
SFCI	60.0	40.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
Sikkim	-	32.0	-	-	-	-	-	-	-	-	-	-	-	7.5	-	-	-	12.5	-	52
Meghalaya	-	30.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.0	-	-	36
Nagaland	-	25.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-	-	30
Arunachal	-	10.0	-	-	-	-	-	-	-	-	-	-	-	2.0	-	-	5.0	-	3.0	20
Rajasthan	-	-	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-	-	-	20
Karnataka	-	15.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
Gujarat	-	-	-	10.0	-	-	-	-	-	-	10.0	-	-	-	-	-	-	-	-	20
Manipur	-	2.1	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	0.64	-	-	2.94
(A) Sub Total	4891.00	2776.60	1044.50	958.0	784.478	672.10	777.4	726.0	350.0	398.0	310.0	337.0	250.0	232.7	261.5	147.15	38.64	25.0	15.5	14995.568
B. Others																				
University	8.00	-	4.00	42.00	-	-	-	20.00	26.00	-	-	6.00	-	45.00	-	-	-	-	-	151.00
Farmers	1647.67	1638.72	631.65	1050.19	857.72	307.35	531.34	331.83	294.05	334.25	421.00	234.30	345.47	77.10	17.89	66.48	15.50	7.70	5.60	8831.61
Free of cost	16.10	43.49	104.70	122.20	2.37	-	1.53	0.91	57.75	2.92	1.55	31.40	-	20.10	3.00	18.70	7.50	-	0.20	436.50
Auction	919.50	2.50	68.75	86.50	111.70	-	0.55	59.63	114.70	83.00	0.72	51.10	-	-	17.90	-	-	-	-	1516.55
B. Sub Total	2591.27	1694.71	809.10	1300.89	971.79	307.35	533.42	412.37	492.50	420.17	423.27	322.80	345.47	142.20	38.79	87.18	23.00	7.70	5.80	10935.66
Grand Total (A + B)	7482.27	4461.31	1853.6	2258.89	1756.268	979.45	1310.82	1138.37	842.5	818.17	733.27	659.8	595.47	374.9	300.29	234.33	61.64	32.7	21.3	25931.228

Table 10. Agency and variety-wise supply of breeder seed during the year 2009-10 (q.)

States	K. Bahar	K. Jyoti	K. Chip-1	K. Pukhraj	K. Anand	K. Sindhuri	KCM	K. Badshah	K. Chip-3	K. Sutlej	K. Pushkar	K. Surya	K. Lauvkar	K. Kanchan
UP	4002	54	491.1	255	502	310	70	215	225	202	-	276	9	117.5
MP	1	154.5	283	18	-	30	365	-	100	-	-	-	110	-
Punjab	100	440	80	500	-	160	272	-	300	100	270	-	40	-
Bihar	-	-	-	317	-	129	-	-	-	-	-	-	-	167
HP	-	1051	-	-	-	-	70	-	-	-	-	-	-	-
NHRDF	300	50	-	-	200	-	-	-	25	-	-	125	-	-
WB	-	0.5	0.5	-	-	-	-	-	-	-	-	0.5	-	-
Uttarakhand	30	137	50	-	-	-	-	-	60	-	-	-	-	-
Chhatisgarh	-	-	-	-	-	-	30	-	-	-	-	-	-	-
NSC	200	253	-	100	-	-	-	60	100	-	-	-	-	-
J&K	-	450.5	-	30	-	-	-	50	-	-	-	-	-	-
Haryana	56	-	24	154	-	-	-	100	-	-	-	-	-	-
Jharkhand	-	-	-	78.67	-	-	-	-	-	-	-	-	-	50
SFCI	90	-	-	-	-	-	-	-	-	-	-	-	-	-
Sikkim	-	20	-	-	-	-	-	-	-	-	-	-	-	50
Meghalaya	-	70	-	-	-	-	-	-	-	-	-	-	-	-
Nagaland	-	40	-	-	-	-	-	-	-	-	-	-	-	-
Arunachal	-	20	-	-	-	-	-	-	-	-	-	-	-	10
Rajasthan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Karnataka	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gujarat	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orissa	-	2	-	1.5	-	-	-	-	-	-	-	-	-	-
Manipur	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Andaman	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tripura	-	18	-	-	-	-	20	-	-	-	-	-	-	-
NRHM	-	-	-	-	-	-	-	-	-	-	39.9	-	-	-
Ministry of Science	5	-	-	-	-	-	-	-	-	-	-	-	-	-
NHRDF	-	35	-	-	-	-	-	-	-	-	-	-	-	-
Sub-total	4784	2795.5	928.6	1454.17	702	629	827	745	810	302	329.9	401.5	159	417.5
Private/ farmers	2657.35	1614.03	390.5	481	286.5	239.03	247.6	167	445.6	80.3	343.53	450.23	43.4	21.03
Auction/ Market	851.3	0.55	49	200.75	34.8	-	0.2	42.45	92.7	39	0.25	36	-	-
Free/Exp.	14.5	72.25	57.35	110.6	5.5	-	1.3	30.1	149.75	3.35	1.1	57.7	-	-
University	-	79.05	0.15	104.7	0.1	0.1	0.15	20.1	138.15	-	0.2	40	0.3	0.25
Sub-total	3523.15	1765.88	497	897.05	326.9	239.13	249.25	259.65	826.2	122.65	345.08	583.93	43.7	21.27
Total	8307.15	4561.38	1425.6	2351.22	1028.9	868.13	1076.25	1004.65	1636.2	424.65	674.98	985.43	202.7	438.77

K. Chip-2	K. Ashoka	K. Giriraj	K. Arun	K. Shailja	K. Lalima	K. Himalaini	K. Himsona	K. Girdhari	K. Sadabahar	K. Jawahar	K. Khiati	Total
-	-	-	74	-	-	-	-	-	-	-	-	6802.7
276.9	-	-	3.5	-	-	-	-	-	-	-	-	1341.9
-	-	-	-	-	-	-	-	-	-	-	-	2582
100	84.5	-	-	-	-	-	-	-	-	-	-	817.5
-	-	12	-	-	-	-	-	-	-	-	-	1133
-	-	-	-	-	-	-	-	-	-	-	-	700
-	-	-	-	-	-	-	-	-	-	-	-	1.5
50	-	5	-	-	-	18	20	3	-	-	-	373
-	24	-	-	-	-	-	-	-	-	-	-	54
-	-	-	-	-	-	-	-	-	-	-	-	713
-	-	15	-	15	-	20	-	-	-	-	-	583.5
-	-	-	-	-	-	-	-	-	-	-	-	354
-	40	-	-	-	-	-	-	-	-	-	-	168.67
-	-	-	-	-	-	-	-	-	-	-	-	90
-	-	-	-	10	-	-	-	-	-	-	-	80
-	-	10	-	10	-	-	-	-	-	-	-	90
-	-	5	-	5	-	-	-	-	-	-	-	50
-	-	5	-	5	-	-	-	-	-	-	-	40
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	1.5	-	-	-	-	-	-	-	-	-	-	5
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	38
-	-	-	-	-	-	-	-	-	-	-	-	39.9
-	-	-	-	-	-	-	-	-	-	-	-	5
-	-	-	-	-	-	-	-	-	-	-	-	35
426.9	150	52	77.5	45	-	38	20.1	3	-	-	-	16097.67
44	9.5	15.55	128.53	11.8	2.5	50.55	281.13	7.35	-	-	-	8018
2	-	-	-	-	-	-	5.5	-	1.5	-	-	1356
-	4.5	2.11	0.5	.02	-	3	48.35	2.2	-	-	-	564.18
0.1	4.1	-	0.1	-	0.1	-	5	-	-	.10	.10	392.85
46.1	18.1	17.66	129.13	11.82	2.6	53.55	339.98	9.55	1.5	.10	.10	10331.03
473	168.1	69.66	206.63	56.82	2.6	91.55	360.08	12.55	1.5	.10	.10	26428.70

Production and supply of quality seed

A total of 14.21 hectare area was planted under quality seed and a total production of 1444.09 quintal was achieved at CPRS, Ooty and Shillong.

Revenue generated in revolving fund scheme (RFS)

During the financial year 2009-10, a total of Rs. 3,70,83,566 was generated from the sale of breeder seed of potato and the expenditure was 2,60,53,348 as per the record of audited balance sheet.

Production of rotational crop

About 2407 quintals yield of rotational crop comprises of wheat, gram, mustard, bajara, oat and maize was obtained from 137.25 hectare land and Rs. 20.54 lakh revenue were generated from the same under supervision of Seed Technology Division.

Health status of nucleus seed crop

Modipuram: The health status of all the varieties was high (92-100%) in tuber indexing. The healthy percentage of clones was 91.9- 98.7% in most of the varieties except Kufri Frysona (81.2%) and Kufri Chipsona-4 (83.8%) during stage-I testing. The maximum incidence of PVS (4.8%) and PVM (4%) was recorded in Kufri Chipsona-1 and Kufri Chipsona-3 respectively during tuber indexing. The maximum incidence of PVS and PVX was 16.3% and 7.5% in Kufri Frysona while 10% and 5% in Kufri Chipsona-4 during stage-I. The majority of the varieties were free from all the test viruses in tuber indexing as well as stage-I (Table 13).

Jalandhar: Tuber indexing eliminated on an average 10% of the tubers infected with one or other virus. Planting of disease free material in stage-1 improved significantly health standards of all the varieties in stage-I (93.3-100%, Table 14).

Table 13. Health status of nucleus seed during tuber indexing and stage-I testing at CPRIC, Modipuram.

Variety	No. of clones/ samples tested	Virus incidence (%)						Healthy clones/ samples (%)
		PVX	PVS	PVY	PVM	PVA	PLRV	
K. Anand	125 (360)	0.0 (0.0)	0.0 (0.0)	3.2 (0.3)	0.0 (3.3)	0.0 (1.1)	0.0 (0.0)	96.8 (96.8)
K. Badshah	30 (296)	0.0 (0.0)	0.0 (1.4)	0.0 (0.0)	0.0 (1.4)	0.0 (0.0)	0.0 (0.0)	100.0 (98.6)
K. Bahar	650 (3547)	1.9 (2.3)	0.2 (0.3)	0.0 (0.2)	1.1 (0.8)	0.0 (0.2)	0.0 (0.0)	97.2 (96.7)
K. Khyati	125 (465)	1.6 (1.1)	0.0 (0.0)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	98.4 (98.7)
K. Pukhraj	175 (992)	2.9 (4.4)	0.6 (0.0)	1.1 (0.4)	0.0 (0.5)	0.0 (1.2)	0.0 (0.0)	96.0 (93.6)
K. Sadabahar	250 (971)	0.8 (2.1)	0.0 (0.0)	0.0 (0.8)	3.6 (0.2)	0.0 (0.4)	0.0 (0.0)	95.6 (96.9)
K. Surya	125 (546)	0.0 (3.7)	2.4 (4.4)	0.0 (0.0)	2.4 (0.4)	0.0 (0.2)	0.0 (0.0)	95.2 (91.9)
K. Chipsona-1	125 (288)	0.0 (0.0)	4.8 (1.4)	0.0 (0.0)	3.2 (0.7)	0.0 (0.0)	0.0 (0.0)	92.0 (97.9)
K. Chipsona-3	150 (258)	1.3 (1.6)	0.7 (3.1)	0.0 (0.0)	4.0 (1.5)	0.0 (0.0)	0.7 (0.0)	93.3 (96.9)
K. Chipsona-4	125 (80)	0.0 (5.0)	0.0 (10.0)	0.0 (2.5)	0.0 (3.8)	0.0 (0.0)	0.0 (0.0)	100.0 (83.8)
K. Frysona	63 (80)	0.0 (7.5)	0.0 (16.3)	0.0 (1.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	100.0 (81.2)
K. Himsona	(160)	(0.0)	(2.5)	(2.5)	(0.0)	(0.0)	(0.0)	(95.0)
K. Suttlej	(160)	(0.0)	(0.0)	(2.5)	(0.0)	(0.0)	(0.0)	(97.5)
Total/Average	1943 (8205)	1.2 (2.2)	0.62 (0.9)	0.10 (0.3)	1.7 (0.9)	0 (0.4)	0.05 (0)	96.5 (95.9)

All the above value given in parentheses are for the stage-I.

Table 14. Health status of nucleus seed during tuber indexing and stage-I at CPRS, Jalandhar.

Variety	No. of clones/ samples tested	Virus incidence (%)					Healthy clones/ samples (%)
		PVX	PVS	PVY	PVM	PVA	
KCM	15 (14)	6.6 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	93.4 (100.0)
K. Sutlej	05 (04)	20.0(0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	80.0 (100.0)
K. Pukhraj	15 (10)	6.6 (0.0)	6.6 (0.0)	13.3(0.0)	0.0 (0.0)	6.6 (0.0)	66.7 (100.0)
K. Badshah	15 (11)	6.6 (0.0)	6.6 (0.0)	6.6 (0.0)	0.0 (0.0)	6.6 (0.0)	73.4 (100.0)
K. Jyoti	500 (453)	1.8 (0.0)	3.0 (0.0)	1.6 (1.5)	1.4 (3.3)	1.6 (7.0)	90.6 (93.3)
K. Pushkar	20 (20)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	100 (100.0)
K. Khyati	20 (19)	5.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	95.0 (100.0)
Total/Average	590 (531)	2.4 (0.0)	2.9 (0.0)	1.8 (1.3)	1.2 (2.8)	1.7 (6.0)	90.0 (94.0)

All the above value given in parentheses are for the stage-I.

Gwalior: The percentage of healthy clones were comparatively high (94-100%) in tuber indexing and more or less similar to stage-I (95.3-96.7%). The virus incidence of PVX was maximum 6% in Kufri Sindhuri during tuber indexing while 3.2% in Kufri Lauvkar during stage-I. Kufri Chipsona-3 was infected with PVM (3.3%) in the stage-I (Table 15).

Patna: The healthy clones 100% in the varieties under test during tuber indexing and which was 98.9-99.65% in stage-I. All the three varieties under ELISA test were found free from the test viruses in tuber indexing. The overall health status in both the stages was excellent at this center (Table 16).

Table 15. Health status of nucleus seed during tuber indexing and stage-I at CPRS, Gwalior.

Variety	No. of clones/ samples tested	Potato virus incidence (%)					Healthy clones/ samples (%)
		PVX	PVS	PVY	PVM	PVA	
KCM	100 (230)	0 (3.0)	1(3.5)	1 (2.2)	0 (1.7)	0 (0.0)	98.0 (95.7)
K. Jyoti	100 (529)	0 (0.4)	0 (0.0)	2 (1.1)	0 (2.1)	0 (1.7)	98.0 (95.3)
K. Sindhuri	100 (207)	6 (0.5)	2 (0.5)	0 (1.0)	1 (2.4)	0 (0.0)	94.0 (96.1)
K. Lauvkar	100 (874)	0 (3.2)	0 (1.1)	0 (2.4)	0 (1.5)	0 (0.3)	100.0 (96.0)
K. Chipsona-1	100 (276)	0 (0.7)	2 (1.8))	0 (1.4)	0 (1.1)	1 (0.4)	97.0 (96.4)
K. Chipsona-3	100 (92)	0 (0.0)	0 (0.0)	0 (0.0)	0 (3.3)	0 (0.0)	100.0 (96.7)
K. Arun	100 (90)	1 (0.0)	1 (0.0)	1 (2.2)	2 (1.1)	0 (0.0)	97.0 (96.7)
Total/Average	700 (2298)	1.0 (1.7)	0.9 (1.0)	0.6 (1.7)	0.4 (1.7)	0.1 (0.6)	97.7 (95.9)

All the above value given in parentheses are for the stage-I.

Table 16. Health status of nucleus seed during tuber indexing and stage-I testing at CPRS, Patna.

Variety	No. of clones/ samples tested	Potato virus incidence (%)					Healthy clones/ samples (%)
		PVX	PVS	PVY	PVM	PVA	
K. Jyoti	93 (361)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.83)	0.0 (0.28)	100.0 (98.90)
K. Arun	98 (399)	0.0 (0.0)	0.0 (0.0)	0.0 (0.25)	0.0 (0.0)	0.0 (0.25)	100.0 (99.50)
K. Pukhraj	60 (283)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.35)	0.0 (0.0)	100.0 (99.65)
Total/Average	251 (1043)	0.0 (0.0)	0.0 (0.0)	0.0 (0.10)	0.0 (0.39)	0.0 (0.19)	100.0 (99.33)

All the above value given in parentheses are for the stage-I.

Kufri/Fagu: The health status ranged between 88.0 to 97.5% during tuber indexing. The health standards of all the varieties were increased from tuber indexing to stage-I (97.9-100%). Kufri Himsona was maximum (8.0%) infected with PVY and PVM during tuber indexing. Kufri Giriraj and Kufri Girdhari were infected with PVS (4%). The health status of stage-I was very good in the all the test varieties (Table 17).

Kufri Pukhraj and Kufri Jyoti at CPRS, Jalandhar. At CPRIC, Modipuram all the cultivars from different source of seed performed statistically at par and the germination varied from 97 to 99.2%. Significantly higher numbers of seed tubers were recorded in generation-2 crop over stage-4 crop in cvs. Kufri Bahar and Kufri Pukhraj. However, no significant difference was observed at CPRS, Jalandhar.

Table 17. Health status of nucleus seed during tuber indexing and stage-I testing at CPRS, Kufri/Fagu

Variety	No. of clones/ samples tested	Virus incidence (%)						Healthy clones/ samples (%)
		PVX	PVS	PVY	PVM	PVA	PLRV	
K. Jyoti	400 (383)	2.5 (0.0)	0.75 (0.0)	0.25 (0.0)	1.00 (0.0)	0.0 (0.0)	(1.3)	95.7 (98.7)
K. Girdhari	150 (144)	0.0 (1.4)	4.0 (0.0)	0.66 (0.0)	0.0 (0.0)	0.0 (0.0)	(0.7)	96.0 (97.9)
K. Himalini	150 (142)	0.66 (0.0)	2.66 (0.0)	2.00 (0.7)	1.3 (0.0)	0.0 (0.0)	(0.7)	95.3 (98.6)
K. Kanchan	50 (48)	2.0 (0.0)	2.0 (2.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	(0.0)	96.0 (97.9)
K. Himsona	25 (22)	0.0 (0.0)	0.0 (0.0)	8.0 (0.0)	8.0 (0.0)	0.0 (0.0)	(0.0)	88.0 (100)
K. Giriraj	50 (44)	0.0 (0.0)	4.0 (0.0)	4.0 (0.0)	2.0 (0.0)	0 (0.0)	(0.0)	90.0 (100)
K. Shailja	40 (39)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.5 (0.0)	(0.0)	97.5 (100)
Misc.	52 (49)	0.0 (0.0)	1.92 (0.0)	1.92 (0.0)	0.0 (0.0)	0.0 (0.0)	(0.0)	96.2 (100)
Total	917 (871)	1.3 (0.2)	1.8 (0.1)	1.1 (0.1)	1.0 (0.0)	0.1 (0.0)	(0.8)	95.3 (98.7)

All the above value given in parentheses are for the stage-I.

Seed research

Performance of different potato cultivars in aeroponic system and in field: A total of 151 microplants of three varieties viz. Kufri Surya, Kufri Chipsona-3 and Kufri Khyati planted in the system and 9126 mini tubers were harvested at an average of about 60 mini tubers per plant. Aeroponically produced minitubers of three cultivars viz. Kufri Surya, Kufri Chipsona-3 and Kufri Bahar were divided into three groups viz <3g, 3-5g and >5g then planted in net house. The results indicated that the germination of all size of mini tubers was very good ranging from 92.3 to 100%. Production of progeny tubers was recorded from 93.4g plant⁻¹ to 173.2g plant⁻¹ in different cultivars and grades.

Comparison of crops raised with tissue culture v/s conventional seed tubers: An experiment was conducted with equal size seed tubers from stage-3, generation-1, stage-4 and generation-2 crop of three potato cultivars namely Kufri Bahar, Kufri Pukhraj and Kufri Sadabahar at CPRIC, Modipuram and four cultivars viz., Kufri Chandramukhi, Kufri Badshah,

Virus profiling in Uttar Pradesh and Punjab:

The results revealed that better health of potato crops was found in Meerut division than in Agra division. In totality 94.9% samples were found infected at least by one virus in Meerut division, while 96.9% in Agra division which were at par. In both the divisions, highest infection was observed due to PVX. The other viruses like PVM, PVS, PLRV, PVY and PALCV were also observed in both the divisions. Presence of PALCV was noticed in all districts of Agra division, while in Meerut division this virus was found only in Bulandshahar district. In Agra division, PVY and PLRV was recorded 13.5% and 12% respectively which is very high, while this infection was only 3.4% and 6% in Meerut division. The surveyed area of Jalandhar, Hoshiarpur, Amritsar and Bhatinda districts revealed that PALCV was most predominant in all the localities and the incidence of the PALCV ranged between 0 to 43.7 per cent. Severe mosaic was the next most prevalent virus and the incidence of which ranged between 0 to 11.7%. Other prominent viruses present in potato crop are potato virus X, S, Y, M and M.

Monitoring aphid population build up in seed crop at CPRS, Jalandhar: Weekly observations revealed that thrips and mites were major insect problem in early crop. Thrips upto 12 per 100 compound leaves were present early in the season but their population declined subsequently. Population of *M. persicae* in unsprayed crop attained critical limit of 20/100 compound leaves in the first week of December. However, in the crop sprayed with insecticides the population of *M. persicae* remained between 1 to 3 /100 compound leaves.

Exploring possibility for early planting of seed crop: Ten major commercial potato varieties viz., K. Chandramukhi, K. Ashoka, K. Chipsona-3, K. Surya, K. Badshah, K. Pushkar, K. Pukhraj, K. Chipsona-1, K. Khyati and K. Jyoti was planted on September 21, 2010 and compared with crop planted normally on October 13, 2010 at CPRS, Jalandhar. Damage caused by thrips was a major problem in early planted crop which varied between 5.3 to 28.3% while it was negligible in the normal time planted crop. Incidence of mite damage between 6 to 15% was observed in some varieties in the early crop. Incidence of PALCV disease was observed between 1.0 to 8.3% in variety Kufri Ashoka in early crop. Total yield obtained in early crop in different potato varieties was significantly low and ranged between 14.7 to 34.7 t/ha as compared to 31.4 to 60.3 t/ha in crop planted on normal dates. Damage due to thrips, mites and the low yield were major constraints for the early seed crop.

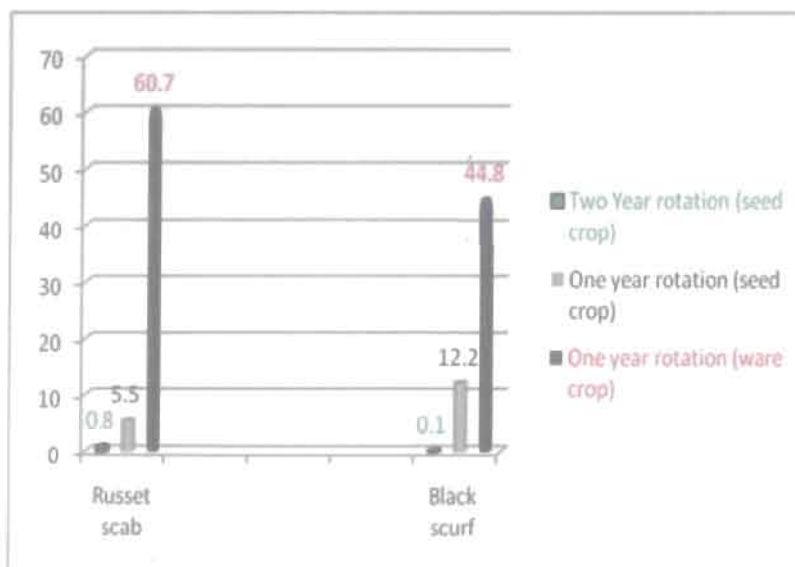
Management of soil and tuber borne diseases in seed crop: Potato cultivar Kufri Chandramukhi grown in plots with two year rotation at Jalandhar revealed a very low incidence of 0.8% russet scab and 0.07% black scurf in the progeny tubers whereas, the incidence of russet scab was 5.5% and black scurf (12.2%) in plots where the same variety was grown once every year using the treated seed, green manure but without rotational wheat crop. Crop grown with untreated seed year after year in the same plots with no crop

rotation exhibited 60.7% incidence of russet scab and 44.8% black scurf diseases. Similar trend was observed in potato variety Kufri Badshah.

Study on phenotypic changes during hi-tech seed potato production system: Results obtained at CPRIC, Modipuram revealed that maximum number of phenotypically changed tubers were produced in cv. Kufri Bahar (44%) followed by Kufri Khyati (5%), Kufri Sadabahar (3.6%) and Kufri Surya (0.72%), while phenotypically changed tubers have not been observed in cvs. Kufri Pukhraj, Kufri Chipsona-3 and Kufri Chipsona- 4. Phenotypic changes were observed more in bigger size tubers than in small size tubers.

Study on effect of microbes on in vivo establishment of microplants: Effect of six microbes on establishment of microplants and yield were studied in potato variety Kufri Badshah. Dipping of roots of microplants or microtubers for 10 minutes in solution containing *Bacillus subtilis* (B5 @0.5%), *Trichoderma viride* (10^7 /ml), *Trichoderma harzianum* (10^7 /ml), PSB (Native @0.5%), *Azospirillum brasilense* (Noctin @0.5%) or Mancozeb (0.3%) before planting in net house did not significantly improve survival of microplants, microtubers, number and yield of tubers produced from the treated microplants and microtubers as compared to plantlets treated with 0.3% mancozeb as a standard treatment or the untreated control.

Effect of rooting hormones on in vivo microplant establishment: An experiment with



IAA, IBA and NAA (125, 250 and 500 ppm) was conducted by dipping of basal cut end of microplants (Kufri Pukhraj). It is inferred that IAA and IBA at 125-250 ppm is found to be suitable for induction of roots.

Effect of antimicrobial agents on in vitro morphological characters of potato varieties:

It has been observed that cephotoxime 100-200 mg/l or carbenicillin 50-100 mg/l or plant preservative mixture 0.1-0.15% can be used for controlling the microbes without affecting the plant growth characters.

Effect of growth rooms on potato

microplantlet characters: The insulated growth room accelerated almost all the morphological characters in majority of varieties as compare to non-insulated growth room. But, as per the visual scoring, majority of the varieties produced more vigorous and sturdy plantlets in non-insulated room. In case of biochemical characters, non-insulated growth room increased the chlorophyll-a (185.5%), Chlorophyll b (118.8%), total chlorophyll (159.8%), carotenoids (158.3%) and phenol (41.5%).



DIVISION OF SOCIAL SCIENCES



Impact of potato production technologies developed by the institute

Economic impact of potato production technologies in India

Impact of cold storage technology at elevated temperature

Importance of storage in potato business is very high throughout the world. However, this importance further increases in India due to the hot temperature the country has to face after the harvest of about 90% produce. The conventional potato storage at 2-4°C entails accumulation of reducing sugars in the tubers that make such tubers unfit for processing. Such storage causes sweetening of tubers which is also an undesirable character for table purpose utilization of potato. To solve this quality deterioration of potatoes intended to be used for processing or table purpose consumption the technology of storing potatoes at elevated temperature (10-12°C) was devised. At such temperature tubers don't get additional reducing sugars but sprouting occurs which is checked by treatment with sprout suppressants.

A survey of cold stores capable of storing potatoes at elevated temperature was conducted in Gujarat and National Capital Region. From farmers' point of view the storage rental of cold stores adopting elevated temperature technologies was on an average 22% higher than the conventional cold stores. For table purpose the average consumer paid 28-43% higher price for potatoes stored at elevated temperature, however, the farmers received 18-29% higher price for their produce stored at elevated temperature. This indicates that the

middlemen were cornering higher share in the value addition due to this technology.

The cold storage capacity using this technology was estimated at 0.37 million t. out of which 0.12 million t. was in NCR and its nearby areas. MP, Gujarat and W. Bengal were other important states adopting this technology. However at conservative estimate, about 10 million t. is the estimated potential of elevated temperature potato storage technology in India. At FAO estimate of 34.39 million t. national potato production during 2009-10 this potential accounts for only 29% of the national potato production. However, aggressive estimates take up to 60% of national potato production as potential cold storage at elevated temperature.

This technology saves 47 kilo watt per t. (stored potato) electricity in a season which is nearly 40% of the power consumption in conventional cold storage. At current level of potato cold storage at elevated temperature 17.32 million kilo watt is the electricity saving during 2010 due to this technology. However, at conventional estimates the technology has a potential of saving 470 million kilo watt at national level. About 10% additional employment is generated by this technology due to more careful handling of leno bags, regular CO₂ flushing and higher supervision which is a positive in country with excess labour force.

Impact of Indian seed potato production system

Potato crop is mainly propagated through tubers through vegetative mode of reproduction. Infections inherent in the tubers are easily carried over to the next generation of crop

through this mode and as a result potato crop needs quality seed potato at shorter intervals of seed replacement. As the seed rate in potato crop may exceed 3 tonne per hectare the estimated expenditure on seed in total cost of cultivation of potato ranged from 28 to 57%.

For assessing impact of seed potato quality on the crop productivity, per ha expenditure on seed was considered the proxy for quality of seed. Accordingly the farmers were divided into two categories (higher 50% and lower 50%) as per expenditure on seed potato. Results showed very clear yield distinctions between these two categories and the benefit-cost ratio of potato farmers in higher 50% category was considerably higher than the lower 50% category. This ratio was 2.09 versus 1.71 in Gujarat; 1.81 versus 1.62 in West Bengal; 1.85 versus 1.70 in UP; and 2.19 versus 1.87 in Punjab for higher 50 and lower 50%, respectively.

At all India level the requirement of seed potato was estimated 2.95 million tonnes every year. In the absence of Indian seed-potato production system the minimum requirement of imported seed potato from developed countries was estimated at 81,900 tonnes every year. Through domestic seed potato production system, we at national level are saving foreign currency to the tune of \$ 102.38 million/ yr (INR 481 crore/ yr) every year. If we compare Bangladesh, who imports seed-potato every year from European countries, Indian potato productivity is 20% higher. However, for better comparison at similar agro-climatic conditions potato productivity in West Bengal (Indian state) is 62% higher than that of the Bangladesh. Hence, the impact of Indian seed potato production system is just not limited to the saving of foreign currencies instead insurance of much important crop health has also been achieved through this endeavor.

Impact assessment of extension strategies for potato technology dissemination

Assessment of selected potato technologies

Under this project, fifteen on-farm demonstrations were laid out at farmer's field in five villages of Shimla district of Himachal Pradesh namely Talai, Bekhalti, Mundaghat, Koti and Chail during the year 2010-11. Three improved varieties of potato, Kufri Girdhari, Kufri Himalani and Kufri Kanchan were given to the farmers and these varieties were raised using recommended package of practices of potato developed by CPRI. Farmers planted Kufri Jyoti as a control plot using their own cultivation practices. Data were collected from both demonstration plot as well as control plot on plant protection and yield gap. The incidence of early blight was observed in control plot of Kufri Jyoti to the extent of 35-40 % while none of the three varieties of demonstration plot showed any symptom of early blight. White grub infestation was found in K. Girdhari, Kufri Himalani and Kufri Kanchan to the extent of 2-3 % while in Kufri Jyoti there was 8-10 % infestation of white grub. Yield level of demonstration plot was compared to the control plot. Maximum increase in yield was recorded in potato varieties like Kufri Himalani (32.7%) and Kufri Girdhari (25.7%). Yield level at demonstration plot was 23.9 t/ha for Kufri Himalani, 22.6 t/ha for Kufri Girdhari and 19.8 t/ha for Kufri Kanchan while yield of Kufri Jyoti at control plot was found to be only 18.0 t/ha. Thus it can be concluded that there was significant increase in yield of potato by using high yielding varieties and recommended package of practices.

Transfer of technology

Farmers training programmes at CPRI, Shimla

Division of Social Sciences organised various 3-day training programmes for farmers of different parts of the country. Course contents covered all aspects of potato cultivation from planting to harvesting, storage and marketing during these training. The participants were exposed to a series of lecture on varietal selection, time and method of planting, disease and pest management, water management, harvesting, processing, storage and marketing of potato in India. Besides this, a field visits were also organised for farmers to CPRS, Kufri and Fagu where seed potato production is going on under supervision of experts of institute. The details of training organised are given in Table 18.

In addition to these trainings, concluding ceremony of "Aloo Pathshala-2008" was also organized on Nov. 8, 2010 and those 9 farmers who have participated and given correct answer to the quiz on potato production were awarded. On this occasion, a two days training was also conducted on "Quality seed potato production" which was attended by 18 potato growers of different districts of Himachal Pradesh.

Awareness camp at una district, HP

CPRI organized an awareness camp for farmers of Una district of Himachal Pradesh on "Disease and pest management in seed potato production". Experts provided information to farmers mainly on control of viruses in seed potato through management of aphids and control of other diseases and pest. Nearly 100 farmers were present in this camp and they were also given some extension bulletins free of cost.

Participation in live phone-in programme and radio talk

The Institute was involved in potato technology dissemination throughout the year by means of its programme on AIR, Shimla and Doordarshan Kendra, Shimla. The expert scientists from CPRI took part in altogether 8 live phone-in programmes and 2 chat show on Doordarshan. The major topics covered under this were potato variety selection, seed preparation, planting, intercultural operations, disease & pest management, fertilizer application, harvesting,

Table 18. Trainings organised at CPRI, Shimla

Sl. No.	Title of the training course	Date and duration	No. of farmers	Sponsoring agencies
1	Advance technique for seed potato production	29-31 May, 2010 (3 days)	10	ATMA, Aurangabad (Bihar) & Kshitij Agro Pvt. Ltd, Patna
2	Modern techniques of seed potato production	28-30 Oct., 2010 (3 Days)	27	ATMA, Uttarkashi (Uttarakhand)
3	Modern techniques of seed potato production	18-20 Nov., 2010 (3 Days)	20	ATMA, Chaibasa (Jharkhand)
4	Modern techniques of seed potato production	2-4 March, 2011 (3 Days)	13	ATMA, Anand (Gujarat)
5	Modern techniques of seed potato production	24-26 March, 2011 (3 Days)	10	ATMA, Moga (Punjab)

marketing & storage of potato. In addition to this, Director CPRI, Dr. BP Singh delivered 2 radio talks on "Disease & Pest Management in Mid Hills of HP" and Dr. Sanjeev Sharma took part in *Akashvani* programme "Krishi Jagat" and delivered talk on potato diseases and their management during the period under report.

Activities of agriculture technology information centre (ATIC)

Sale and distribution of books: A total of 1,697 books and technical bulletins were sold through ATIC. 15 CDs of PPM (Potato Pest Manager) and 17 CDs of CAASPS (Computer Aided Advisory System for Potato Crop Scheduling) software were also sold. This generated revenue of Rs 59,296 for the institute. In addition to this, several crop calendars, leaflets and extension bulletins related to modern potato technologies were distributed free of cost to the farmers, extension workers and scientists who visited CPRI in the year 2010-2011.

Dissemination of knowledge to visitors: The centre has some panels to display information on various technologies developed by the institute. The methodology and advantages of these technologies were explained by ATIC staff to the visitors. Different exhibition panels exhibit information through posters, charts and pamphlets which helped the stakeholders to strengthen their knowledge about potato cultivation. A total of 2369 stakeholders visited

institute during said period. It included 1520 B.Sc. and M.Sc. students of different Universities, 644 farmers of different states of country and 205 scientists and state level agricultural officers.

Film shows: Various institute activities are displayed through three documentary films on Potato that is "CPRI in tune with time" of 21 minutes duration, "Seed Potato Production in Hills" of 20 minute duration and "Pahadi Kshetro Mein Aloo Ki Kheti" (Hindi Film) of 20 minute duration. These films were shown to the visitors of the CPRI which helped them to get acquainted with modern potato technologies.

Participation in agricultural fairs and exhibitions: CPRI participated in many exhibitions, *Kisan Melas* and industrial fair organised in different parts of the country through ATIC. The centre showcased modern potato technologies through its stall in these exhibitions and fairs. Thousands of people visited CPRI stall and got benefitted. Many crop calendars, leaflets and extension bulletin were distributed free of cost to these visitors. Following is the list of agricultural fair and exhibitions where CPRI participated.

Farmers training programmes at CPRS, Patna

On Campus training: A total of 20 on-campus one day training programmes were conducted at CPRS, Patna during the period under report. These training programmes were conducted to enhance the knowledge

Sl. No.	Name of the fair/exhibitions	Date & duration	Location
1.	- India International Potato Expo	8-9 July, 2010 (2 days)	New Delhi
2.	National Mushroom Mela	10th Sept., 2010 (1day)	DMR, Solan (HP)
3.	Exhibition on mobilizing mass media support for sharing agro information	20 Oct., 2010 (1 day)	CIPHET, Ludhiana (Punjab)
4.	ICAR-Industry Meet	18-19 Nov., 2010 (2 days)	Umiam, Meghalaya
5.	Kisan Mela & Sanghosthi	23rd Jan., 2010 (1 day)	DWR, Jabalpur (MP)
6.	Regional Agricultural Fair	23-26 Feb, 2011 (4 days)	NIT, Hamirpur (HP)
7.	Bihar Agricultural Mela	04-08 March, 2011 (5 days)	Patna, Bihar
8.	Regional Agricultural Fair Exhibition	07-10 March, 2011 (4 days)	Patna, Bihar
9.	Kisan Mela	14-15 March, 2011 (2 days)	RAU, Samastipur (Bihar)
10.	Kisan Gosthi	25 March, 2011 (1 day)	Suni, HP
11.	National Farmer fair	27 March, 2011 (1day)	IIVR, Varanasi (UP)

and skills of potato growers in terms of seed potato production; scientific potato cultivation, late blight management and processing/ potato chip making. Nearly 569 farmers of different districts of Bihar viz. Vaishali, Purnea, Katihar, Madhepura, Saharsa, Jehanabad, Gaya, Samastipur, Muzaffarpur, Khagaria etc. were trained in collaboration with Krishi Vigyan Kendra and BAMETI (Bihar Agriculture Management and Extension Training Institute), Patna. During these trainings lectures cum live demonstration on different aspects of potato cultivation viz. use of HYV of potato, seed-bed preparation for TPS, plant protection, seed treatment and storage were discussed. Literature was provided to the farmers and they got adequate exposure to farm operation such as rouging, spray of pesticides, use of agricultural implements.

On-farm training: Two off-campus training programmes each of one day duration were also organised by CPRS Patna through NAIP (National Agricultural Innovation Project) and VASFA (Vasihali Area Small Farmers Association). Altogether 79 farmers participated in these training programmes

Farmers training and exposure visit at CPRIC, Modipuram

Altogether, 15 one-day trainings were conducted at CPRIC, Modipuram during the year 2010-11. These trainings were mostly on "Package of practices of seed/ware potato production". More than 500 farmers from different districts like Muzaffarnagar, Ghaziabad, Aligarh, Etawah, Kausambi of UP, Alwar & Dholpur of Rajasthan and Sagar district of MP participated in these trainings. Along with lectures on different package of practices for seed and ware potato, demonstrations on processing of potato for chips and French fries were also given to farmers.

In addition to these trainings, 5 exposure visits were also organised by the campus for 80 farmers from Faridabad (Haryana), Mainpuri and Unnao districts (UP). They were exposed to modern potato technologies developed by CPRI. These farmers also visited seed potato farms and got first hand information about seed potato production.



Externally funded projects

Project 1: Value chain on potato and potato products (National Agriculture Innovation Project, funded by World Bank & ICAR)

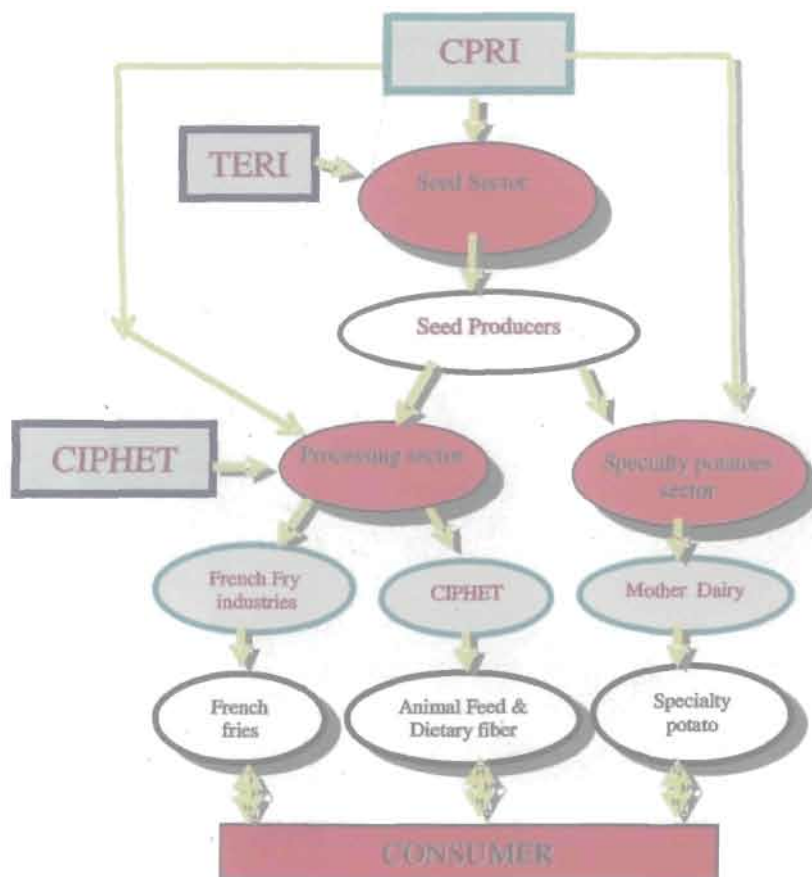
In the seed component of the project, dip stick kits for detection of major potato viruses like PVX, PVY, PVS, PVM and PVA were standardized and released. The kit can detect the above five viruses individually or in combination of two. In the processing component, Kufri Frysona was developed to provide French fry grade potatoes to the industry. The French fry variety has higher yields and better quality as compared to the presently used Indian variety Kufri Chipsona-1.

Kufri Frysona produces attractive white skinned, oblong to long shaped tubers with shallow

eyes and white flesh. Tubers do not show knobbiness as is the case with Kufri Chipsona-1. It possesses very high field resistance against late blight disease. The variety Kufri Frysona has been found to maintain superior French fry quality after six months of storage at elevated temperature with application of CIPC. The industrial testing has shown the superiority of this variety over controls for French fry sensory character like taste, texture and colour. The agro-technique for production of French fry grade potatoes include, variety Kufri Frysona; planting time- 15-20 October; crop geometry- 67.5 × 25 cm (59,300 plants, seed size 50-60 g); seed depth- 10 cm; fertilizer dose- 270 kg N + 80 kg P_2O_5 + 150 kg K_2O ; Ca- 100 kg/ha; chemical maturity- 110-120 days. By following the above technology farmers can realize potato yields up to 40 t ha⁻¹ of which 56% would be

of French fry grade. Ca nutrition (200 kg half at planting and half at earthing up) through zypsum increased the French fry grade and total tuber yield substantially in Kufri Frysona. French fry grade percentage and average French fry grade tuber weight also increased due to Ca nutrition.

In the specialty component, Kufri Surya was identified as the nutritionally rich potato variety (high ascorbic acid, carotenoids and moderate in total phenol) in case of fresh tubers as well as after cooking (baking and boiling) and during storage. Suitable packing material was identified, labels designed and packets developed and marketed in retail outlets, super markets etc. in National Capital Region. In waste utilization component, animal feed pellets were prepared from unmarketable potato. Composition of feed pellets is barley-35%, maize-20%, potato pulp-15%, mustard oil seed cake-



20%, mineral mixture-1% and husk-9%. Texture of feed ranges from 0.99 -1.47 mega Pascal. The process of extraction of dietary fibre from potato peel using enzymatic-chemical method was standardized and its properties viz., fat absorption, water retention, swelling, hydrated density, bulk density, true density, average particle size and water solubility index were determined.

Project 2: Phytophthora, fusarium and ralstonia diseases of horticultural and field crops (ICAR outreach project)

A total of 196 isolates of *Phytophthora infestans* were collected this year from different parts of country and 256 isolates maintained. Studies on 88 isolates for racial spectrum revealed that population composed of 9-11 genes. Studies on metalaxyl sensitivity revealed that 66.7% of pathogen population in Ooty was tolerant to 400 ppm, 100 % population in Shillong to 300 ppm, 66.7 % population in Punjab, 33.3% in West Bengal, 17 % in HP hills, 16 % in UP and 14% in Karnataka was found tolerant to 200 ppm. Analysis of 169 isolates for mating types revealed that A2 mating type is dominating in the hilly region of the country while A1 in sub-tropical plains. Mt haplotyping of 118 isolates has been done which indicated that Indian population was composed of Ia and Ib haplotypes. Standardized the PCR protocol for the detection of latent infection in host tissues with sensitivity to detect 10 fg of genomic DNA and up to 20 mm away from the infected tissue. Transformed two Indian potato cultivars, Kufri Khyati and Kufri Pukhraj, with RNAi gene constructs for late blight resistance. Work for transformation of these cultivars with amiRNA gene constructs has also been initiated. Obtained about 200 adventitious buds from regenerating co-cultivated explants and multiplication is in progress. Validated R1 AS Markers (F: CAC TCG TGA CAT ATC CTC ACT A and R: CAA CCC TGG CAT GCC ACG3') in a set of late blight differentials. The presence of R1 gene was confirmed in 3 varieties namely Kufri Sherpa, K. Kuber and K. Alankar only. Screening of parental lines was completed and 19 parental lines were confirmed for the presence of R3a gene. A molecular linkage map of *Solanum chacoense* has been prepared containing 152 markers. The data generated could resolve only 10 linkage groups. Seventeen

new microbial isolates were collected and a total of 42 isolates were characterized for their bio-surfactant and biocontrol properties. Two *Pseudomonas* spp. effective against *P. infestans* have been identified. At 25°C, Ridomil (0.2%) showed degradation after 14 days of spraying and in other three fungicides no degradation was recorded. Developed yield loss assessment model.

Project 3: Engineering late blight resistance in susceptible Indian potato cultivars (ICAR/ABSP II collaboration)

Eleven F_1C_4 hybrids of Kufri Jyoti and one of Kufri Bahar, selected earlier, were planted in a containment facility at Shimla. Counterparts of all the hybrids were screened for late blight resistance under controlled environment chamber. All the hybrids performed very well and very high level of late blight resistance was observed in all of them. Based on late blight resistance, tuber characters, yield and tuber infection, five promising hybrids of Kufri Jyoti (KJ-16, KJ-21, KJ-65, KJ-66, and KJ-77) and one of Kufri Bahar (KB951-15) have been selected for further evaluation. Ten selected hybrids from last year's trial were evaluated under contained condition at CPRI Campus, Modipuram during 2010-11. Based on yield performance and late blight resistance, 2 most promising lines (KJ-102, Fig. 89 and KJ-45) have been selected for large scale trial.



Fig. 89. RB-transgenic clone KJ-102

Project 4: Development of transgenic potato with resistance to major viruses (ICAR Network project on transgenics in Crops).

The CP gene of PVY and the rep gene of potato apical leaf curl virus have been cloned and transformation vectors containing the PVY CP gene in sense, antisense and non-translatable orientations have been constructed in pBinAR. Similarly, PALCV rep constructs in antisense and hairpin-loop orientation have been constructed in pBinAR. The early potato cultivar Kufri Pukhraj and the medium-maturing variety Kufri Badshah were transformed with the CP and rep constructs for conferring resistance to PVY and apical leaf curl virus. Forty one putative transgenic lines of Kufri Badshah and 22 of Kufri Pukhraj were challenge inoculated with PALCV by either grafting (Fig. 90) or through vector (whiteflies) transmission in glasshouse after 45 days of planting. Concentration of virus in each transgenic line after 30 days of inoculation was quantified by Real Time PCR. Thirty three lines of Kufri Badshah and 20 of Kufri Pukhraj showed high level of resistance to apical leaf curl virus. Similarly, 31 putative transgenic lines of Kufri Pukhraj encoding PVY-CP sequence were mechanically inoculated with PVY infected sap and were screened through Das-ELISA after 27 days of inoculation. Most of the transgenic lines showed very high level of resistance to PVY.

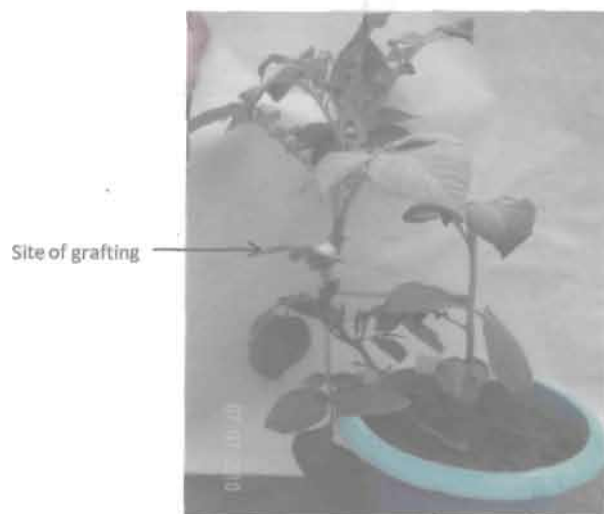


Fig. 90. Transgenic plant showing successful grafting with PALCV infected leaf

Project 5. Impact assessment of climate change on potato in India (ICAR sponsored network project on climate change)

Mean monthly 30 years (1951-1980) weather data obtained from IMD database for about 350 locations in India were interpolated to daily weather using Marksim weather generator. This weather database was analysed and the maximum thermally suitable growing period available for potato in the different locations were determined using a temperature based rule set. The potential total biomass yield and the expected harvest index during the growing season were also determined for the delineated growing period using the summary model of Versteeg and van Keulen. The expected change in temperature and rainfall in different months in 2020 under A1F1 scenario was incorporated in the weather database and the analysis as in the case of the baseline scenario was repeated. Thematic maps of the three attributes viz. total biomass yield, available growing period and expected harvest index in the baseline and climate change scenario were developed to study the impact of climate change.

The results showed that available growing period decreased due to climate change (Fig. 91). The available growing period decreased to less than 70 days in Maharashtra, parts of Karnataka, Andhra Pradesh and the other southern states except for a pocket around the Nilgiri hills in Tamil Nadu and near Pune in Maharashtra under Climate Change scenario. Even in the traditional potato growing belt there is a transition of growing season i.e. a long duration season becomes a medium duration crop zone while the medium duration zone becomes a short duration crop zone. Moreover, the boundary of the short duration crop zone and the medium duration crop zone moved up northwards under the climate change scenario.

It is primarily the mean night temperature of tuber growing period which affects potato yield. The increase in temperature due to climate change would lead to decrease in harvest index (HI) in large parts of Maharashtra, parts of Karnataka and Andhra Pradesh. In the traditional potato growing belt in the Indo-Gangetic plains, the HI would remain more or less the same but pockets of high HI would diminish (Fig. 92).

The potential biomass yield of most of the peninsular region is expected to range from 8000 – 12000 kg/ha under climate change scenario indicating that these are the areas for deployment of heat tolerant varieties. However, large parts of the traditional potato

growing belt in the Indo-Gangetic plains would have high potential biomass productivity even under Climate Change scenario, indicating that adjustment in planting schedules is sufficient to adapt to climate change in this region (Fig. 93).

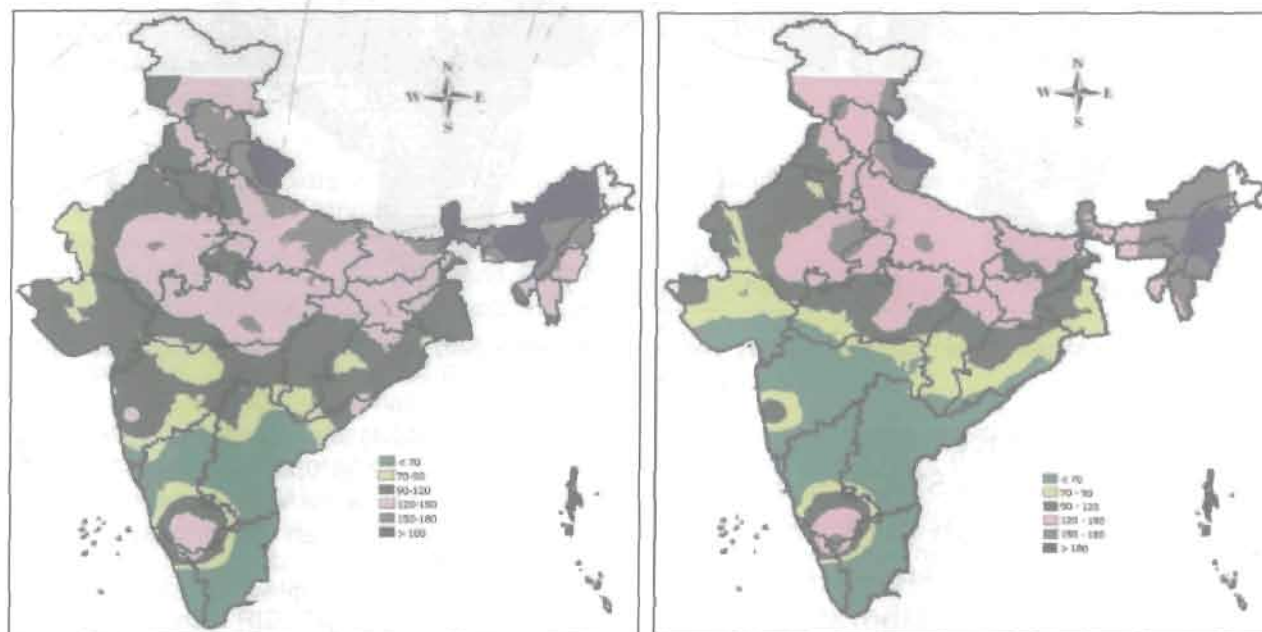


Fig. 91. Maps showing the growing period under baseline (left) and climate change (right) scenario

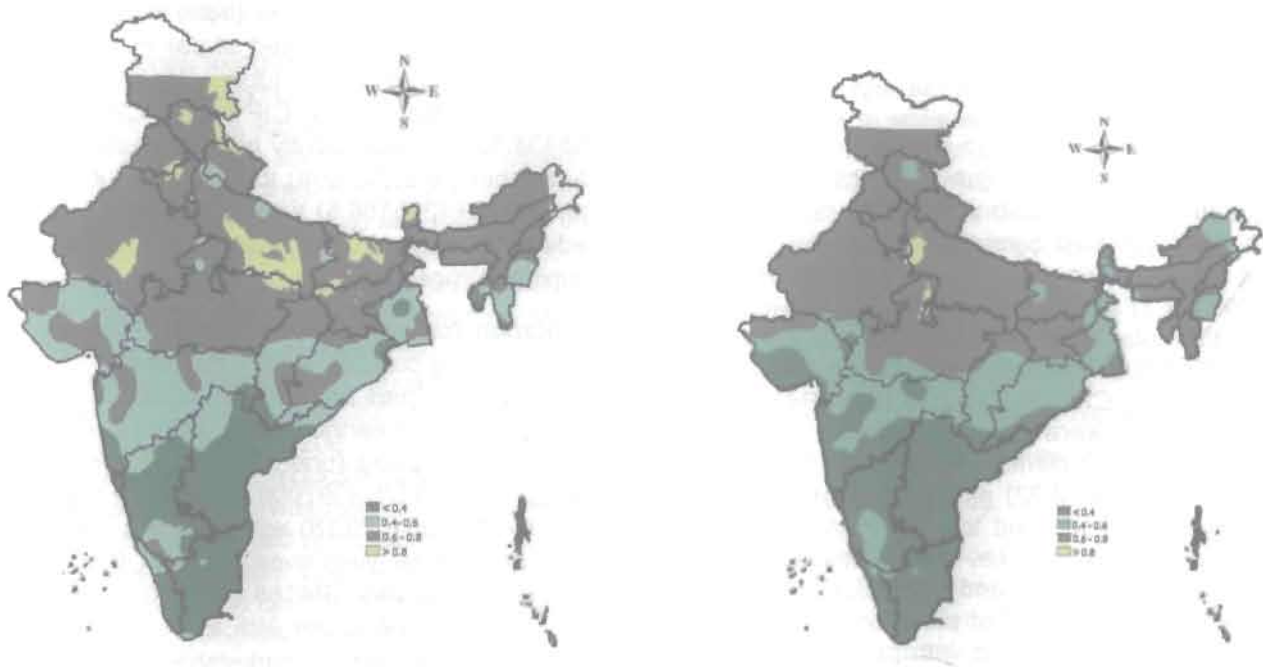


Fig. 92. Maps showing the expected harvest index under baseline (left) and climate change (right) scenario

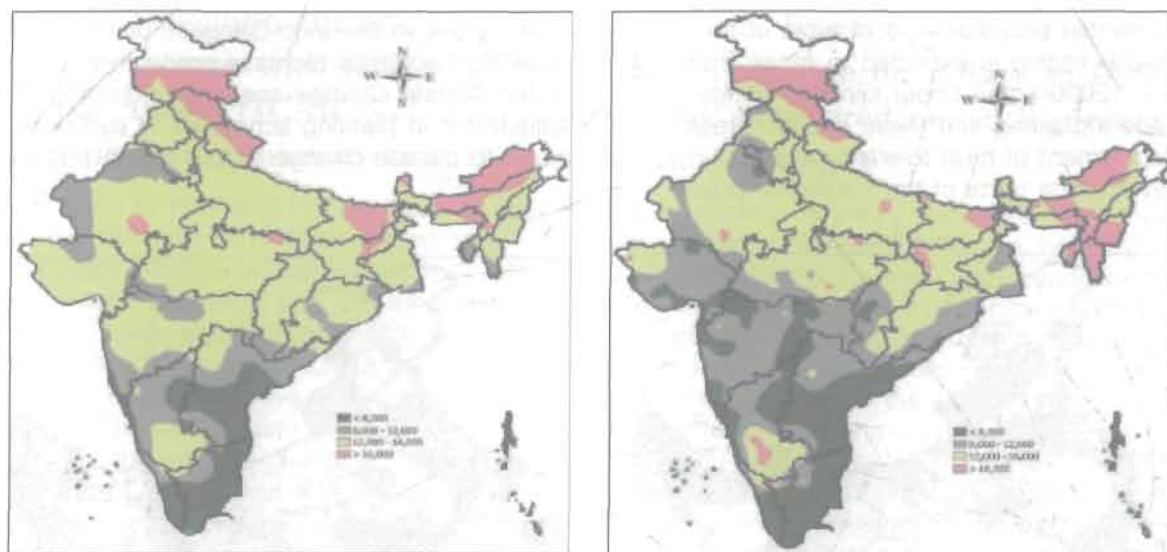


Fig. 93. Maps showing the potential biomass yield under baseline (left) and climate change (right) scenario

Project 6: Enhanced food and income security in SWCA through potato varieties with improved tolerance to abiotic stress (GTZ project with CIP collaboration)

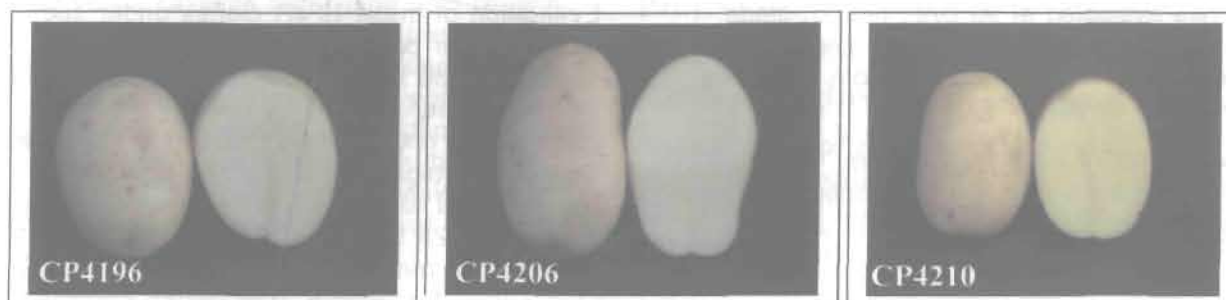
Evaluation of advanced clones: Seventeen CIP advance clones were evaluated at Modipuram. Two clones namely CP4196 (388615.22) and CP4200 (392781.1) produced at par marketable (34 and 36 t/ha) and total tuber yield (34 and 37 t/ha) with Kufri Bahar (34 and 35 t/ha) at 80 DAP. Under heat tolerance at Peth, Pune (Maharashtra), out of 17 CIP clones evaluated during kharif season, CIP clone CP4196 (388615.22) produced at par total tuber yield of 33 t/ha with best control Kufri Lauvkar (41 t/ha) at 80 DAP. Two other clones namely CP4181 (399101.1) and CP4204 (393536.13) with 31 and 30 t/ha total tuber yield, respectively were found promising. CIP advance clones namely CP4176 (397036.7), CP4184 (301029.18), CP4197 (388972.22) were found suitable for processing into chips. CIP clones CP4184 (301029.18) and CP4197 (388972.22) produced significantly high processing grade and total tuber yield than the processing varieties i.e. Kufri Chipsona-3, Kufri Chipsona-4, Atlantic and FL1533. Clone CP4176 (397036.7) produced at par processing grade as well as total tuber yield with processing varieties.

Evaluation of these clones was also done at Ladol (Gujarat) at 80 days. Clones namely

CP4206 (393708.31) with 63.82 t/ha, CP4184 (301029.18) with 62.38 t/ha and CP4181 (399101.1) with 60.14 t/ha were found better than best control Kufri Badshah (52.97 t/ha).

Ten CIP clones were evaluated at Burdwan (West Bengal) at 90 DAP. CIP clones CP4206 (393708.31) produced significantly high marketable (66 t/ha) and total tuber yield (70 t/ha) than best control Kufri Surya (60 & 63 t/ha), whereas clones CP4196 (388615.22) and CP4210 (395434.1) produced at par marketable (65 and 61 t/ha) and total tuber yield (67 and 63) with Kufri Surya. CIP clones CP4210 (395434.1) with significantly high processing grade tuber yield (52 t/ha) than Atlantic (41 t/ha) and CP4209 (395186.6) with at par processing grade tuber yield (43 t/ha) were also suitable for chipping purposes.

Evaluation for water-stress: Nine CIP clones along with two controls were evaluated at three water regimes i.e. normal, moderate (two irrigations at earthing, and 30 days after earthing) and severe (one irrigation at earthing). CIP clones CP4175 (397006.18) with 31.5 t/ha and CP4184 (301029.18) with 31.4 t/ha recorded significantly better yield over control K Bahar (26.9 t/ha), whereas CP4168 (392780.1) with 29.7 t/ha remained at par with this control. Kufri Pukhraj recorded higher marketable yield (35.9 t/ha) over the genotypes and the productivity of



Promising CIP advance clones

MS/6-1947 (37.5 t/ha) was also comparable to Kufri Pukhraj. Alike marketable tuber yields in CIP Clones CP4184 (301029.18) with 34.1 t/ha, CP4175 (397006.18) with 33.2 t/ha and CP4168 (392780.1) with 32 t/ha out-yielded control K. Bahar (28.5t/ha) to a level of significance. But other control K Pukhraj (38.2 t/ha) performed better and MS/6-1947 (41.1 t/ha) also remained at par with K. Pukhraj. Severe and moderate drought caused significant yield loss of 56.7 and 35.4%, respectively. Maximum tuber dry matter content was recorded in CP4184 (301029.18) (24.5%) comparable to CP4168 (392780.1) (23.8%). Lowest tuber dry matter content was observed in MS/6-1947 (17.7%) and severity of moisture stress improved this parameter and moderate (20.9%) and severe (23.9%) drought had better percentage of dry matter over normal water regime (18.8%).

Five CIP clones along with two controls were evaluated during second year at three water regimes *i.e.*, normal, moderate (two irrigations at earthing, and 30 days after earthing) and severe (one irrigation at earthing). Highest and significantly superior marketable (37.2 t/ha) and total (38.3 t/ha) tuber yields were observed in CP4176 (397036.7) followed by CP4193 (381381.26) which had 31.5 t/ha and 34.2 t/ha marketable and total tuber yields, respectively. Reduction in tuber yield was minimum in genotype CP4193 (381381.26) with 10.31% and CP4206 (393708.31) with 17.20% under moderate soil moisture stress. CP4206 (393708.31) with 26.9% had least yield reduction under severe moisture stress which was followed by CP4192 (381381.13) having yield reduction of 40.6%. Highest tuber dry matter content was recorded in CP4206 (393708.31) (24.3%) followed by CP4202 (392797.22) (23.6%) and CP4192 (381381.13) (23.4%). Deficit of soil moisture availability tended to improve tuber dry matter content and moderate (22.1%) and severe (23.8%) drought had

significantly higher tuber dry matter content over normal water regime (20.3%).

Project 7: Pot-Bio: Generating biomarkers for breeding healthy potatoes

The project is being pursued in collaboration with Laboratory of Plant Breeding, Dept. of Plant Sciences, Wageningen, The Netherlands FAU, Erlangen, Germany; CSIC, Madrid, Spain; and SCRI, Dundee, UK. The major objectives of the project are: (i) Screening of markers for traits of interest (with other EU partners), (ii) phenotyping under different condition, and (iii) screening for content of health giving compounds (with WUR). A launch meeting was held during 21-26 February, 2011 which was attended by Dr. Salome Prat, CSIC, Madrid, Spain, and Dr. Bjorn Kloosterman, Laboratory of Plant Breeding, Dept. of Plant Sciences, Wageningen, The Netherlands. Populations and suitable markers for analysis of glycoalkaloids, carotenoids and dry matter content have been identified. Similarly, potato genotypes and marker for studying effect of day length and temperature on tuberization have been identified.

Project 8. Development and evaluation of potato germplasm and varieties with improved tolerance to abiotic stress and viruses (CIP-ICAR collaborative project)

Early generation selection: For developing CIP-CPRI potato progenies 36121 true seeds of 39 CIP × CPRI families were produced and seedlings raised. In total, 653 promising clones of 33 families were selected. In F_1C_1 stage 252 promising clones of 52 families were selected on the basis of tuber characters from the 963

clones evaluated at 90 DAP. In F_1C_2 stage thirteen promising clones were selected on the basis of tuber characters from 23 clones evaluated at 90 DAP.

Evaluation of advanced clones: CIP advanced LTVR clones were evaluated under early planting condition at Modipuram. Five CIP advance clones namely CP4038 (390637.1), CP4047 (395193.6), CP4054 (397065.28), CP4056 (397073.7) and CP4057 (397079.6) produced at par tuber yield with best control Kufri Ashoka (15 t/ha) under early crop (75 days) at Modipuram. The incidence of mite burn (5%) and hopper burn (2%) in CIP clone CP4054 (397065.28) were quite less than heat tolerant variety Kufri Surya (7% and 12% respectively). Under normal planting conditions, out of eleven CIP advance clones evaluated at 80 DAP, four CIP clones namely CP4038 (390637.1), CP4047 (395193.6), CP4052 (397029.21) and CP4054 (397065.28) produced significantly high total tuber yield than Kufri Bahar (35 t/ha). Two CIP clone namely CP4047 (395193.6) and CP4052 (397029.21) produced at par total tuber yield with best control Kufri Pukhraj (43 t/ha).

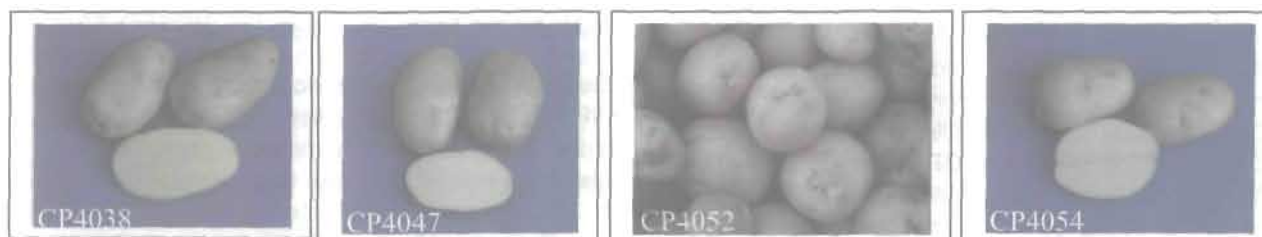
These CIP advanced clones and seven varieties were evaluated during kharif season at 90 DAP at Pune following seed plot techniques and farmer practices. Under seed plot technique, CIP advance clones namely CP4038 (390637.1), CP4039 (391846.5), CP4047 (395193.6) and CP4052 (397029.21) produced at par total tuber yield of 31, 33, 30 and 22 t/ha total tuber yield respectively with Kufri Surya (30 t/ha). Under farmer practices, CIP clone CP4038 (390637.1), produced significantly higher tuber yield (21 t/ha) than the best control Kufri Surya (15 t/ha), whereas CP4039 (391846.5), CP 4041 (394034.7), CP4047 (395193.6), CP 4053 (397065.2) and CP 4057 (397079.6) produced at par tuber yield (11, 19, 15, 17 t/ha respectively) with Kufri Surya (15 t/ha).

Evaluation of these LTVR clones under seed plot & farmer practices at Dessa with three varieties at 80 DAP showed that under seed plot technique, CIP clones namely CP4052 (397029.21) and CP4054 (397065.28) produced significantly high marketable (43 t/ha & 40 t/ha) and total tuber yield (45 and 41 t/ha) than K Lauvkar (28 t/ha) and K Surya (31 t/ha) but remained at par with Kufri Badshah (43 t/ha). Under farmer practices, CIP clones namely CP4052 (397029.21) and CP4054 (397065.28) produced significantly high marketable (39 t/ha & 42 t/ha) and total tuber yield (41 and 43 t/ha) than the best control Kufri Badshah (37 & 38 t/ha).

Under heat stress conditions at Ladol (Gujarat), out of 11 CIP clones evaluated at 80 DAP, three CIP clones namely CP5054 (397065.28) with 64.26 t/ha, CP4052 (397029.21) with 53.12 t/ha and CP4044 (395109.29) with 51.31 t/ha were found better than best control Kufri Badshah (49.68 t/ha).

Project 9: Biotechnological approaches for reduction of cold-induced sweetening in potato

Cold-induced sweetening is a complex physiological phenomenon and success of any attempt for reduction of cold-induced sweetening requires robust and durable approaches. Therefore, attempt has been made for integration of both approaches of RNAi-mediated gene silencing of genes involved in cold-induced sweetening, and over-expression of tobacco invertase inhibitor gene for inactivation of invertase enzyme. The purpose of integration of both RNAi and over-expression of tobacco invertase inhibitor is to get robust and durable level of reduction of cold-induced sweetening so that industrially desired level of chip colour is obtained.



Promising CIP advance clones

Binary vector cassette harbouring both Nt-Inhh and RNAi gene constructs were developed for potato transformation for reduction of cold-induced sweetening. Three Indian potato cultivars, Kufri Chipsona-1, Kufri Chipsona-3 and Kufri Surya, were transformed with the vector cassette and 1000 putative transgenic lines. So far 900 putative lines were screened and 20 lines were found to be positive.

Project 10: Artificial microRNA-mediated silencing of UDP-glucose pyrophosphorylase and vacuolar acid invertase gene for reduction of cold-induced sweetening in potato

Glasshouse trial of 179 transgenic lines of three Indian potato cultivars, Kufri Chipsona-1, Kufri Chipsona-3 and Kufri Surya, developed by transformation with artificial microRNA gene constructs (Fig. 94), was conducted at Central Potato Research Station, Jalandhar. Fifty transgenic lines possessing acceptable chip colour at fresh harvest were selected and planted in soil in glasshouse at Central Potato Research Institute, Shimla for evaluation of cold-chipping attributes. Seven transgenic lines showed improvement in chip colour compared to wild type control directly after 45 days of cold storage at 5 °C; while 12 transgenic lines showed improvement in chip colour after 21 days of reconditioning.

Project 11: Central sector scheme for protection of plant variety and farmers' rights

Conservation of references varieties:

Reference collection of 158 varieties/numbers was maintained; 124 *in vitro* at Shimla and 105 in fields at Kufri and Modipuram. These included 44 CPRI released varieties, 3 state varieties, 5 Indian number released elsewhere, 20 exotic varieties in cultivation in India, 57 indigenous varieties/ number and 29 UPOV example varieties.

Testing and meristem-tip culture for virus freedom:

Micropropagation of 40 virus infected accessions/cultivars was done for their meristem tip culture and will be supplied for testing their freedom from viruses. The results of 25 clones supplied last year revealed that all of them were free from viruses.

Characterization of varieties: Fifty-nine varieties/samples (other than CPRI), collected from farmers fields were characterized for morphological and tuber characters at Modipuram as per DUS descriptors. Photographs for variation observed for various characters in reference collection were taken. The variation observed for sprouts and leaf characters are shown in Fig. 95 and 96, respectively.

Registration of extant varieties: Applications for registration of 16 extant varieties of potato have been submitted to NBPGR, New Delhi for onward submission to the PPV&FR Authority.

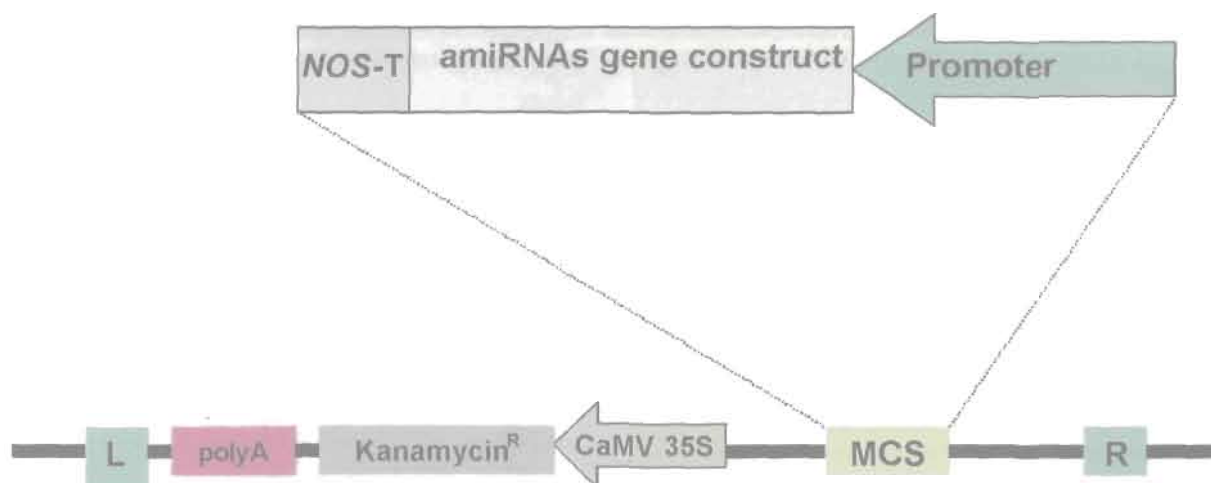


Fig. 94. Map of T-DNA region of binary vector cassette of pCAMBIA2300 harbouring amiRNA gene constructs.

Documentation: Computer databases regarding availability of various reference varieties at different conservation sites were created in Microsoft Access.

There was significant positive interaction between N and K. At each level of N, increasing levels of K application increased the tuber yield. Potassium and nitrogen application also



Fig. 95. Variation in sprouts characters in reference potato varieties



Fig. 96. Variation in leaves of reference potato varieties

Project 12: Potassium and nitrogen management in potato variety Kufri Pukhraj (Funded by Potash Research Institute of India, Gurgaon)

Two field experiments, one on potassium nutrition of potato under different levels of nitrogen application was conducted at the research farm of CPRS, Patna and second on potassium nutrition of potato var. Kufri Pukhraj was laid out at farmers field in the village Janpara (located about 50 Km from Patna) in Patna district of Bihar.

improved tuber size by increasing the large and medium grades yield and decreasing the small and very small sized tubers. On an average K application increased percentage of large tubers from 14.5 % at 0 Kg K_2O/ha to 21.8% at 50 Kg K_2O/ha and further up to 26.1% at 100 Kg K_2O/ha . The total tuber yield increased on an average by 36.4, 51.8 and 57.6% due to application of 50, 100 and 150 Kg K_2O/ha , respectively as compared to no K application. The effect was more evident on the yield of large sized tubers where the yield increased by 35, 51 and 62%, respectively at 50, 100 and 150 Kg K_2O/ha as compared to no K application.

In the second experiment on farmers fields the total tuber yield increased significantly with each increment of potassium dose. The tuber yield increased from 25.26 t/ha (0 Kg K_2O /ha) to 31.99 t/ha (150 Kg K_2O /ha). The increase in tuber yield was 13.5, 24.1 and 26.3 percent at 50, 100 and 150 kg K_2O /ha, respectively. The potassium application improved the tuber yield by increasing the large grade tuber yield and decreasing the small grade tuber yield. The percent contribution of large grade tubers to the total tuber yield was increased from 29.1% at 0 Kg K_2O /ha to 36% at 50 Kg K_2O /ha and 41% at 100 Kg K_2O /ha and 44% at 150 Kg K_2O /ha, respectively. The yield of large size tubers increased by 21.3, 37.7 and 44.3 percent at 50, 100 and 150 kg K_2O /ha as compared to no K application.

Project 13: Towards understanding vermicompost technology: Analysis, experimentation and standardization of practices (DST sponsored project)

Local species of earthworms were collected from different places in and around Meerut. These were obtained mainly at basement of water flowing channels. Each species was multiplied in two media (dung+neem leaves and dung + local leaves), collected in pits of size 2.40 X 0.75 m. The observations revealed that some

species survived only in soil, from where these were collected and they died in dung + leaves mixture. The low temperature (4°C) during night hours was again not congenial for their survival. The activity, including multiplication of all species collected, slowed down during extreme cold. With passage of time, the older earthworm died first and subsequently none survived. The one, collected from top plough layer was at par with commercial species for vermicompost production (Fig. 97).

Project 14: National project on organic farming (Funded by Department of Agriculture and Co-operation, Ministry of Agriculture, Govt. of India, New Delhi)

Ten training programmes each of two days duration were organized on the organic farming system to acquaint the farmers about the organic farming practices (Fig. 98). The number of farmers varied from 30-40 in each training course. The course constituted the basic principles of organic farming, different sources of organic nutrients, vermin-compost preparation and utilization, bio-pest control, crop rotation, green manuring and weed management in organic farming system and certification of organic farms/organic cluster. Twenty farmers from each training course were selected and given vermiculture (2 Kg/farmer) for preparation of vermicompost and vermi-wash (Fig. 99).



Fig. 97. Taxonomic classification of local species of earthworms



Fig. 97. Vermicompost ready for use



Fig. 98. Farmers training programme on organic farming at Kaner village, Shimla



Fig. 99. Demonstration for the preparation of vermi-compost

Project 15: Farmers participating action research programme (Funded by Ministry of Water Resources, Govt. of India, New Delhi)

Base line survey of 75 farmer's families from 21 Panchyats of Solan and Shimla districts of Himachal Pradesh was conducted. Majority of the area is under rainfed and drought during summer and winter months which adversely affect crops yield. On the other hand during Kharif season excess rains create drainage problem and disease intensification. In Shimla district, farmers mainly grow potato, cauliflower and french beans as a summer crop followed by

cabbage and maize as a Kharif crop and barley, wheat and peas as a Rabi crops. To overcome the problem of the drought during summer and Rabi seasons, soil and water conservation measures such as *in-situ* and *ex-situ* water harvesting techniques will be demonstrated as per the action plan.

Project 16: Training entrepreneurial skills to farmers in potato based farming system of Himachal Pradesh (Mini Mission-I)

Under centrally sponsored scheme "Technology Mission for Integrated Development of

Horticulture in Himachal Pradesh (MM-I)", this project was started in October, 2010. The project duration is of three years and 5 districts of Himachal Pradesh namely Shimla, Mandi, Kangra, Sirmour and Una have been selected for this project.

During the year 2010-11, two on-farm trainings were conducted at KVK, Una and at Karsog of Mandi district where about 80 farmers participated. These vegetable growers were trained in commercial cultivation of potato, pea and other vegetables. They were trained in different aspects like plant protection, water management, nutrient management, marketing and storage of these vegetables. In Mandi district total 48 farmers participated in training programme, 15 of which were farm women. The data regarding improvement in knowledge and skills before and after training was collected through a comprehensive questionnaire. The analysis of data from training in Mandi district showed that there was overall 26.88 per cent increase in knowledge level of farmers after training.

One on-campus training was also conducted at CPRI, Shimla for farmers of nearby areas of Shimla district. A total of 20 farmers participated in this training and they were trained in potato seed production, management of late blight, water management & organic farming of potato, marketing and storage of potato. The data regarding improvement in knowledge and skills

before and after this training was collected and analyzed. The results revealed that there was an improvement of 28 per cent in the knowledge and skills of farmers after training.



Project 17: *In vitro* mass micropropagation and protected production of micro/ minitubers of processing and common potato varieties suitable for hills under Mini Mission-I

Production of planting material : A total of 22518 microplants, 10391 microtubers, 123990 minitubers and 372145 tubers of eight varieties suitable for hills viz., Kufri Chandramukhi, Kufri Giriraj, Kufri Jyoti, Kufri Kanchan, Kufri Shailja, Kufri Himalini, Kufri Himsona and Kufri Girdhari were produced under *in vitro* and *in vivo* conditions against a target of 15000 microplants, 4000 microtubers, 73000 minitubers and 365000 tubers. The effect of different concentrations of ammonium nitrate in Murashige and Skoog (MS) medium on the *in vitro* morphological characters of five potato genotypes viz., Kufri Chandramukhi, Kufri Girdhari, Kufri Himalini, Kufri Kanchan and Kufri Sindhuri was studied. The ammonium nitrate concentrations in the basic MS medium was altered to 10mM, 15mM, 20mM (normal), 25mM, 30mM, 35mM. The results showed that the



ammonium nitrate concentrations and varieties were significantly influenced all the morphological characters studied. In general, reducing the ammonium nitrate regime in culture medium below normal level (20 mM) increased the microplant height as well as inter-nodal length. It was inferred that for obtaining optimum height of microplants in the above test cultivars the ammonium nitrate concentration in the MS medium is to be reduced from normal (20 mM) to 10-15 mM.

Project 18: Refinement of technology for potato crop management through botanicals and their effect on soil pest dynamics, crop growth and soil health (Funded by MM-1: Horticulture Mission for North East and Himalayan States)

Plant extracts, cattle urine extract, water extract and extracts in methanol were prepared and the bio-efficacy of prepared extracts was tested in different stages of cutworm in the lab. One farmers training programme was organised at Kandaghat, Solan on the importance of botanicals for pest management in potato crop. More than 30 farmers participated in this programme. Pamphlets on bio-intensive

management of the potato pests were also distributed in this programme.

Project 19 : Accredited test laboratory under national certification system for tissue culture raised plants (DBT)

Seven hundred and seventy two leaf samples of M/s Technico Agriscience Pvt. Ltd., 82 samples of M/s Pepsico India Holding, and 9 samples of Horticulture Training Institute, Uchani, Karnal were tested for the presence of Potato virus X, S, Y, A, M and PLRV by DAS- ELISA under the NCS-TCP accredited test laboratory. All the



Farmers awareness cum training camp at Kandaghat.

samples were negative to the viruses tested except one sample from M/s Pepsico which was positive for Potato Virus S, Y and M.

Project 20: Refinement of rapid multiplication technique for recalcitrant potato cultivar suitable for Himachal Pradesh.

The project was started in January 2011, developed the *in vitro* cultures of Kufri Jyoti, Kufri Giriraj, Kufri Himalini and Kufri Girdhari through nodal/sprouts required for experimentation. Experiment on effect of macro nutrient (ammonium nitrate) and growth regulators was initiated in the recalcitrant variety Kufri Jyoti along with other varieties suitable for hills.

Project 21: Production of planting material of potato through high-tech system of seed production for the hills of Himachal Pradesh

The project was started in January 2011. A total of 800 microplants of two cultivars viz., Kufri

Jyoti and Kufri Girdhari were produced under *in vitro* conditions against the target of 2000 microplants in 1st year. Similarly, 4000 minitubers were produced against 8000 minitubers targeted in 1st year.

Project 22: Developing, commissioning, operating and managing an online examination system for NET/ARS-Prelim Examination for ASRB, ICAR

Civil works for installation of servers and peripherals, procurement of computer tables and chairs, ACs and other facilities for 50 sitting capacity have been created at the institute for the conductance of online examination.



Library and documentation services

Introduction: In accordance of one of the CPRI mandate "To act as national repository of scientific information relevant to potato" CPRI Library and Documentation Services unit was established in 1956 with a modest collection of 256 documents. Presently this library stacked more than 60 thousands documents and has attained the position of most sought-after library on potato R & D in India. Since its inception this library has acted as repository and clearinghouse of potato literature and information. 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 600 documents were purchased, procured and added to library resources. The total collection at Shimla stand at 35764 documents comprised of 14069 books, 14368 back volume of journals, 2497 serials, 2131 annual reports, 582 theses, 251 standards, 51 maps/atlasses, 1663 reprints and 152 CD's. The libraries at six regional stations and one campus at Modipuram are

having their own library collection of 27115 books; journals back volumes and other documents *i.e.* AR/reprints and bulletins *etc.* as per the details below (Table 19).

Periodicals and serials management

Fifty one serial titles *i.e.* advances, annual reviews, reference annuals, yearbooks and statistical data publications *etc.* were purchased. A total of 208 current journals comprising of 57 foreign and 151 Indian have been subscribed at Shimla. Out of which 44 foreign and 134 Indian journals were subscribed on payment basis and rest on exchange or gratis. In all 1291 issues of such journals were received, marked and kept in library for use. Besides 86 titles of different journals were subscribed at CPRS libraries. 757 entries of library documents were made in Library Automation Software and 382 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.

Table 19. Library collection of CPRIC & CPRS

Regional stations	Books	Back vols. of journals	Other documents (AR/Rpr/Bull)	Total	Current journals subscribed (Indian)
1 CPRIC, Modipuram	4174	5526	2211	11911	25
2 CPRS, Jalandhar	3011	1401	1157	5569	28
3 CPRS, Patna	1902	1280	14	3196	15
4 CPRS, Gwalior	803	4	60	867	1
5 CPRS, Ooty	1535	1864	536	3935	13
6 CPRS, Shillong	1353	-	140	1493	4
7 CPRS, Kufri	144	-	-	144	-
TOTAL	12922	10075	4118	27115	86

Computerized and net based services

The institute scientists were facilitated with online full text access to 32 institute's subscribed foreign journals and more than 3000+ journals through ICAR's e-resources consortia (Consortia for E-Resources in Agriculture). The library resources e.g. library catalogue (OPAC), foreign journals, CD Net searching, and Current Journals Received Last Week were regularly updated and maintained on library web page. Now scientists are making use of mostly library resources online from their desktop. Many relevant web sites were visited and information downloaded was for scientists' use.

Readers and reference service

A total of 913 documents were circulated (borrowed and returned) for home studies and 4530 readers consulted 7535 documents within the library. Besides, 24 outside scientists and research scholars of various research organizations consulted the library resources. 29 new members were enrolled and 12 old members withdrew their library membership due to their transfer or retirement. At present 151 readers are active members of library including RAs/SRAs. Library received 7589 reference queries from the users of the library and responded to them satisfactorily. Besides, 966 job requests were received for 2,00,641 copies of photocopying and printing work of different scientific and administrative documents.

Documentation and information services

1291 issues of journals (747 issues of national and 544 issues of international journals) were

scanned for potato literature. Besides, the in-house documentation services in the form of 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 and utilization

The library has generated the revenue of Rs. 1,33,164 which include the amount charged on account of rendering CDROM searching & photocopying services (Rs. 5,904), IGNOU computer practical (Rs. 21,900) and library discount (Rs. 1,05,360) in addition to normal 10% GOC discount saved on purchase of library books and journals through CPRI Book store. A total of Rs. 35,90,805 was spent (under Plan Rs. 24,53,649; Non-Plan Rs. 9,94,813 and Rs. 1,42,343 under XIth Plan IPR Scheme) on library resources and developments like purchase of books (Rs. 6,79,464), and subscription of journals (Rs. 26,07,632) at HQ library Shimla and Rs. 3,03,709 on CPRS libraries.

CDS/ISIS practical training

As per MOU between CPRI and IGNOU, New Delhi, 17 days computer, IT, and database creation and operation practical session was organized during 26th July – 11th August 2010 for 9 MLIS and 23 BLIS students of IGNOU Study Center, Shimla.

Infrastructure development

One CD DVD Mirror Server having 4 TB storage space has been procured and installed to facilitate digital content storage and searching of scientific documents.

Institute research council meeting

The first Institute Research Council meeting, 2010 was held at CPRI, Shimla on 26th June, 2010. It was attended by 40 scientists from the headquarters and stations. The basic objective of this meeting was mid term review of the achievements during 2009-10 of different research programmes.

The second Institute Research Council Meeting, 2010 was held at CPRI, Shimla on 8-9 October, 2010. It was attended by 50 scientists from the headquarters and the stations. The basic objectives of this meeting were to review the action taken report on the recommendations of IRC meeting 2009 and formulate new research programmes of different divisions. Seventeen research programmes of the Institute were approved for 2010-11 to 2014-15. The other major recommendations of these meetings are given below.

- More emphasis should be laid on development of early maturing processing varieties of about 80-90 days crop duration and having high dry matter ($\geq 20\%$) and low reducing sugars.
- Water use efficient hybrids should be identified.
- Work on combining resistance to late blight & viruses should be strengthened.
- Validate the results of experiment on application of plant extract for pest management.
- Hybrid OSO1/516 may be included in AICRP (P).
- Alternatives to CIPC may be searched and large scale trials with volatile compounds may be planned.
- Advanced hybrids will be introduced into AICRP(P) based on the recommendation of IRC. This year, hybrids viz. MS/4-2261, and 2000-P-14 were recommended for introduction in AICRP (P) trials.
- All the necessary information including DNA fingerprinting of hybrids proposed for AICRP (P) will be generated by respective breeders before introducing the hybrid into AICRP (P).
- Work on homogeneity in TPS population will be initiated using 2n gametes of dihaploids of early bulking parents.
- Teams going for any calamity assessment must go along with GPS and report the exact location and extent of damage. The GPS instrument may be collected from Dr. VK Dua, Sr. Scientist, division of Crop Production.
- Dr. (Mrs.) K Manorama will take up the work on *kharif* potato also in addition to southern hills. Necessary research activity may be developed in consultation with Head, Crop Production. The sprinkler irrigation may also be tried at Ooty.
- Adaptation strategies are to be developed for climate change aspects for biotic and abiotic stresses and all aspects are to be included by associating the scientists from other concerned divisions.
- Micro-nutrients content in tubers and also in produce of different crops of long term manurial experiments should be analysed.
- There is need to develop suitable attachments for inter cultural operation, ridging and digging etc. which can be used with power tiller. All engineers must meet and finalize the design and power requirements and they should also discuss development of potato combine harvester for Indian situation.
- The earliest arrival of virus vector in plains should be monitored closely and arrangement for trapping this population at commercial level should be made.

- Data on aphid build up should be collected systematically at all the seed producing stations and published every three years.
- Attempts should be made to reduce the level of growth regulators in micropropagation to reduce the phenotypic changes during subsequent multiplications.



Publications

A. Papers published in Referred Journals

1. Aggarwal, G., A.K. Nath, C. Sharma, S.V. Bhardwaj and S.K. Chakrabarti. 2010. Characterization of *Prunus armeniaca* L. germplasm using RAPDs. *The Asian and Australian Journal of Plant Science and Biotechnology*. **4**(1): 53-56.
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B. Popular Articles

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C. Scientific / Technical Review

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D. Abstracts / Papers presented

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- ### E. Technical / Extension Bulletins
1. Management of bacterial wilt/brown rot (in Khasi language)
 2. Management of late blight in potato (in Khasi language)
 3. Management of major insect pest of potato (in Khasi language)

4. Package of practise for potato (in *Khasi* language)
5. Rajpal Singh (2010). *Aloo ki phasal mae mrada avam kando ki bimarion avam unki roktham*. CPRI Revised Technical Bulletin.
6. Seed potato production technology manual.

Misc. Publications

1. Kufri Frysona - An excellent potato variety for French fries- (NAIP publication)
2. Specialty Potato (Kufri Surya: An antioxidant rich potato) -For deriving health benefits from potatoes- (NAIP publication)



Institute activities

1. Farmers training on **Modern techniques in potato seed production** was organized on 6th December 2010
2. Divisional meeting of **Crop Production Division**, CPRI, Shimla held at the Campus on 1st September, 2010
3. **Hindi Pakhwara** during 14-29 September, 2010.
4. Training course on **Improved cultivation practices of potato** during 9-12 November, 2010 sponsored by Directorate of Agriculture, Kokrajhar, Assam.
5. **Institute Management Committee** meeting held at the CPRI Campus, Modipuram on 5th February, 2011.
6. National Consultation on **Production of Disease Free Quality Planting Material Propagated through Tubers and Rhizomes** held at CPRIC Modipuram, Meerut during 4-5 March, 2011.
7. **Udyan Mela-2011** held at the CPRI Campus during 5-6 March, 2011, sponsored by CPRI, IPA, Shimla and Uttar Pradesh State Horticulture Mission, Lucknow.
8. Farmers training on **Improved Potato Production Technology** under Horticulture Mission for North East and Himalayan States (MM-I) on 18th March, 2011 at CPRS Shillong.
9. On Farm training on **Scientific Method of Potato Cultivation** on 24th January, 2011 at Mawjriong village, Meghalaya.



Dr. TK Bag, Head, CPRS, Shillong delivering lecture at training programme



Field demonstration of improved potato production technologies to the farmers

Distinguished Visitors

Date	Dignitaries
08.10.2010	Shri OS Myriaw, Member, National Commission for Scheduled Tribes to CPRS, Shillong
15.10.2010	Sh. Basudeb Acharia, MP & Chairman Committee on Agriculture at CPRI, Shimla.
18.11.2010	Sh. H.N. Gandan, Hon'ble Minister (Horticulture), Govt. of Arunachal Pradesh at CPRI, Shimla.
20.11.2010	Dr. S. Ayyappan, Secretary DARE and Director General, ICAR at Modipuram
04.03.2011	Dr. H.P. Singh, DDG (Hort.), ICAR, New Delhi at Modipuram
04.03.2011	Dr. C.D. Mayee, Chairman, ASRB, New Delhi at Modipuram
04.03.2011	Dr. Umesh Srivastava, ADG (Hort.), ICAR, New Delhi at Modipuram
05.03.2011	Shri Lakshmi Shankar Vajpayee, Director, AIR, New Delhi at Modipuram
11.03.2011	Dr. KD Kokate, DDG (Agriculture extension), ICAR, New Delhi at CPRI, Shimla



Shri OS Myriaw, Member, National Commission for Scheduled Tribes visiting CPRS, Shillong

Hindi day celebration at CPRS, Shillong

दिनांक 1 अक्टूबर 2010 को केंद्रीय आलू अनुसन्धान केंद्र, शिलांग के परिसर में हिंदी दिवस समारोह का आयोजन किया गया। इस आयोजन में श्री आर. डी. गोंड, वरिष्ठ स्थापना एवं लेखा अधिकारी, सर्वे ऑफ़ इंडिया, शिलांग मुख्य अतिथि के रूप में उपस्थित थे।

कार्यक्रम का शुभारम्भ मुख्य अतिथि के सम्मान में किया गया। तत्पश्चात श्री ए.के. श्रीवास्तव, कार्यवाहक अध्यक्ष, केंद्रीय आलू अनुसन्धान केंद्र, शिलांग ने सभा को संबोधित किया। उन्होंने अपने संबोधन में संस्थान में हिंदी में कार्यों तथा हिंदी के विकास हेतु उठाये जाने वाले कदमों से अवगत कराया। हिंदी दिवस के उपलक्ष्य में केंद्रीय आलू अनुसन्धान केंद्र, शिलांग में भाषण और अनुवाद प्रतियोगिता का आयोजन किया गया, जिसमें सभी कर्मचारियों ने उत्साहपूर्वक भाग लिया। मुख्य अतिथि श्री आर.डी. गोंड ने प्रतियोगिता के विजेताओं, श्री बी. खरीर, श्री एस. नंगरुम, सुश्री टी. नंगख्लाव तथा श्री ऋषि राय को पुरस्कृत किया। मुख्य अतिथि ने अपने संबोधन में राजभाषा हिंदी तथा हिंदी दिवस पर प्रभाव डाला। उन्होंने केंद्र में हिंदी के विकास हेतु किये जाने वाले प्रयासों की सराहना की। उन्होंने हिंदी भाषा को प्रोत्साहित करने के लिए विभिन्न कार्यक्रमों का आयोजन करने की सलाह दी तथा कर्मचारियों को हिंदी में बातचीत करने को प्रोत्साहित किया।



मुख्य अतिथि का संबोधन

Awards, honours and foreign visits

2010	ICAR Award for outstanding interdisciplinary team research in agriculture and allied sciences for the biennium 2007-2008	Drs. JS Minhas, Devendra Kumar, TA Joseph, SM Paul Khurana, SK Pandey, BP Singh, PS Naik, SV Singh
2010	Shivashakthi Life Time Achievement Award	Dr. Suman Kumar Pandey
2010	Kaushalaya Sikka Award	Dr. Dinesh Kumar
2010	Associateship of NAAS	Dr. Brajesh Singh
2011	Best Worker Award (Tech.) for 2007	Sh. Islam Ahmed
2011	LC Sikka Endowment Award	Dr. P.S. Naik, Project Coordinator
2010	Fellowship award 2010 by Hi-Tech horticultural society for understanding and recognition in the field of horticulture	Dr. S.V. Singh, Principal Scientist
2011	Best poster paper award in: National consultation on production of disease free quality planting material propagated through tubers and rhizomes	Kumar Rajeev, B. P. Singh, S. Rawal, P. Kumar, Sukhwinder Singh, S. V. Singh, Pawan Kumar, Sanat Kumar and Neeraj Saini.
2010	Dr. Borlaug Life Time Award - 2009	Dr. Name Singh, Sr. Scientist
2010	Major R.S. Yadav SRDA Award -2010	Dr. Name Singh, Sr. Scientist
2010	Appointed as "Editor-in-abroad" by the Crop Science Society of Japan	Dr. Jai Gopal
2010	Dr. J.P. Verma Memorial Lecture Award 2010 of Indian Phytopathological Society.	Dr. S.K. Chakrabarti
2010	Best poster award of Indian Phytopathological Society for their article on "Status of bacterial wilt of potato in Malwa region of Madhya Pradesh"	Drs. Vinay Sagar, RK Arora, AK Somani, Sanjeev Sharma, SK Chakrabarti and BP Singh
2011	Best poster award for article on "Detection of Potato apical leaf curl virus through polymerase chain reaction" during National Consultation on Production of Disease Free Quality Planting Material Propagated through Tubers and Rhizomes'	Drs. Jeevalatha, Priyanka Kaundal, EP Venkatsalam, SK Chakrabarti and BP Singh

Foreign Visits of CPRI Scientists

1	Dr. Jagesh Kumar, Scientist, CPRI, Shimla for undergoing Training in the area of Marker Assisted Selection at CIP, LIMA- Peru during 07.6.2010 – 4.9.2010.
2	Dr. Vinod Kumar, Sr.Scientist & Ofg. Head CPRS, Kufri, Shimla for undergoing International Training in Plant Variety Protection and DUS Testing for Indian Experts at the National Institute of Agricultural Botany (NIAB), Cambridge, U.K., from 28.6.2010 - 09.7.2010.
3	Dr. SV Singh, Principal Scientist, CPRI Campus Modipuram attended International Symposium on Agronomy and Physiology of potato at Nevsehir, Turkey from 20.9.2010 - 24.9.2010.
4	Dr. Parveen Kumar, Sr. Sci, CPRI Campus Modipuram attended International Symposium on Agronomy and Physiology of potato at Nevsehir, Turkey from 20.9.2010 - 24.9.2010.
5	Dr. BP Singh, Director, CPRI, Shimla as a part of Indian delegation visited Bhutan w.e.f 20.9.2010 - 25.9.2010.
6	Sh. AK Singh, Chief Admn. Officer, CPRI, Shimla participated in exposure training and orientation to research grants management, project monitoring at Cornell University, Ithaca, USA during 4.10.2010 -15.10.2010.
7	Deputation of RK Arora, PS, CPRS, Jalandhar for participation in the Regional workshop of seed potatoes for Asian countries at Bandung, Indonesia during 19.10.2010 - 21.10.2010.
8	Deputation of Dr. BP Singh, Director, CPRI, Shimla for participation in the ABSP-II Partner level meeting during 3.11.2010 - 4.11.2010.
9	Deputation of Dr. SK Kaushik, Jt. Director, CPRIC, Modipuram for participation in the ABSP-II Partner level meeting during 3.11.2010 - 4.11.2010 at Dhaka, Bangladesh.
10	Deputation of Dr. SK Chakrabarti, Head, Divn. of Plant Protection, CPRI, Shimla for participation in the ABSP-II Partner level meeting during 3.11.2010 ~ 4.11.2010 at Dhaka, Bangladesh..
11	Deputation of Dr. PM Govindakrishnan, PS, Divn. of Crop Production, CPRI, Shimla for participation in the "CIP Study and Exchange Program" during 16.11.2010 - 28.11.2010 at CIP Lima, Peru.
12	Deputation of Dr. SK Chakrabarti, Head, Divn. of Plant Protection, CPRI, Shimla for participation in the Annual Board Meeting of ABSP-II during 29.1.2011 - 1.2.2011 at Dhaka, Bangladesh.
13	Deputation of Dr. RK Arora, PS, CPRS, Jalandhar for participation in 40th session of the UNECE specialized section on standardization of seed potato" at United Nations, Geneva w.e.f 14.3.2011 -16.3.2011.

Education and Training

Conferences / Symposia and Workshop

Drs. A.K.Somani, Anuj Bhatnagar, Murlidhar J. Sadawarti, JS Minhas, RK Arora, RP Kaur, Ashwani Kumar, A Jeevalatha, NK Pandey, Rajesh K. Rana, Rajpal Singh, Vinay Singh, Dhruv Kumar, Name Singh, Bandana, Kamlesh Malik, N. C. Upadhyay, Sukhwinder Singh, SK Chakrabarti, Eradasappa. E, Mr. AK Srivastava, Mr. MS Gurjar, Rahul R Bakade	Participated in National consultation meet on 'production of disease free quality planting material propagated through tubers and rhizomes' and Kisan Mela at CPRIC, Modipuram	4-6 March, 2011
Dr RK Arora	Attended National Symposium on Microbial diversity and bio-prospecting Indian Society of Mycology & Plant Pathology University of Jammu, Jammu	29-30 October, 2010
Dr SP Trehan	Attended National Seminar on Development in Soil Science, 2010 held at Institute of Soil Science, Bhopal	14-17 November, 2010
Dr. Baswaraj, Scientist	Participated in the National symposium on "Perspective in plant health management" organized Indian Phytopathological Society at B.A. College of Agriculture, Anand Agriculture University, Anand, Gujarat	14-16 December, 2010
Dr. Brajesh Singh	Attended the National conference of Plant Physiology held at BHU, Varanasi, India Organised by ISPP, New Delhi	25-27 November, 2010
Dr. Devendra Kumar	Attended the 2 nd India International Expo-2010 at NASC Complex, Pusa New Delhi, Organizers: Indian Chamber of Commerce (ICC)	8-9 July, 2010
Dr. Devendra Kumar	Participated in the Annual Workshop of NAIP component-2 during at UAS, Dharwad and presented the progress report of the sub project "Value chain on potato and potato products" being operated at CPRI	15-16 March, 2011
Dr. Jagesh Kumar Tiwari	International consultation on DNA Barcoding NASC, Pusa, New Delhi	6-7 November, 2010
Dr. Jagesh Kumar Tiwari	Awareness workshop on IPR and Bio-Technology" at Hotel Holiday Home, Shimla	13 December, 2010
Dr. Jai Gopal	Seminar on "GM Free Food-our future concern" organised by Dept. of Environment Science & Technology, Govt. of HP at HP Secretariat, Shimla.	14 May, 2010

Dr. Jai Gopal	Symposium "National Consultation on Agro-Biodiversity" organised by ICAR, New Delhi at NAS Complex, New Delhi	26-27 May, 2010.
Dr. Jai Gopal	ICAR-Industry meet at NAS Complex	28-29 July, 2010.
Dr. Jai Gopal	Workshop on "Review of the conduct of DUS test" at NAARM, Hyderabad	11-12 August, 2010.
Dr. Jai Gopal	Annual review workshop of GTZ sponsored CIP-ICAR project, Ahmadabad	29-30 November, 2010
Dr. Jai Gopal	National Conference on Biotechnology, Dharmapuri, organized by the Society for Applied Biotechnology, presented a paper and chaired the session Genomics and Proteomics	17-18 December, 2010
Dr. Jai Gopal	Xth Agriculture Science Congress at National Bureau of Fish Genetic Resources, Lucknow and presented invited paper on "Role of wild species of potato in Indo-Gangetic plains	10-12 February, 2011
Dr. Jai Gopal	ICAR Zonal Technology Management and Business Planning and Development Meetings-cum-Workshop at IARI, Pusa, New Delhi	17-18 March, 2011
Drs. A. Jeevalatha, SK Chakrabarti, Vinay Sagar	Participated in the national symposium on "Perspective in plant health management" organized Indian Phytopathological Society at B.A. College of Agriculture, Anand Agriculture University, Anand, Gujarat	14-16 December, 2010
Dr. Kamlesh Malik	Participated in Zonal seminar on Physiological and molecular interventions for yield and quality improvement in crop plants" held at Sardar Vallabhbhai Patel University of Ag. & Tech., Meerut (UP)	17-18 September, 2010
Dr. Kamlesh Malik, Dr. R.K. Arora, Dr. S.P. Trehan, Dr. S.K. Singh, Dr. Shambhu Kumar	Attended 28th AICRP meeting on potato at CPRI, Shimla	10-12 September, 2010
Dr. Mehi Lal	Attended training on Application of molecular markers in vegetables and legume breeding at AVRDC, RCSA, & ICRISAT, Hyderabad.	26-31 July, 2010
Dr. N.C. Upadhyay	Delivered lecture on "Scope of summer groundnut production at Meerut – A pilot study at CPRIC, Modipuram. in Rabi-Summer Groundnut Researchers" Group Meeting of AICRP on groundnut, held at BCKB, Mohanpur (W.B.).	18-19, November, 2010

Dr. N.C. Upadhayay	Attended DST Review Meeting of Project, "Towards understanding vermicompost technology: Analysis, Experimentation and Standardization of practices, held at Delhi	13 August, 2010
Dr. N.C. Upadhayay	Attended Second interactive meeting on "National dynamics in Horticultural crops" held at NRCC, Nagpur	27-28 September, 2010
Dr. Name Singh	Attended National Symposium on "Emerging Trends in Agricultural Research" held at PDFSR, Modipuram, Meerut (UP) on	11-12 September, 2010
Dr. NK Pandey	National Workshop on ATIC at NASC	3 July 2010
Dr. R. Ezekiel	Attended international conference on Coconut biodiversity for prosperity" held at CPCRI, Kasaragod, India Organised by CPCRI, Kasaragod	25-28 October, 2010
Dr. R. Ezekiel	Attended National conference of Plant Physiology" held at BHU, Varanasi, India Organised by ISPP, New Delhi	25-27 November, 2010
Dr. R. Ezekiel	National symposium on Emerging Innovative Technologies for Assurance of Quality and Safety in Processed Food held at IIT, Kharagpur during Organised by INAE and IIT, Kharagpur	24-25 February, 2011
Dr. Rajesh Kumar Rana, Sr. Scientist	India International Potato Expo-2010 at NASC	8-9 July, 2010
Dr. Rajesh Kumar Rana, Sr. Scientist	Quantative Modeling Approaches for Economic Policy Analysis in Agriculture at NCAP, New Delhi	12-13 August, 2010
Dr. Rajesh Kumar Rana, Sr. Scientist	Sensitization workshop on "E-Publishing and Knowledge system in Agricultural Research" at NASC	26 March, 2011
Dr. Rajesh Kumar Rana, Sr. Scientist	Participated in the "National Consultation on production of disease free quality planting material propagated through tubers and rhizomes" organized by CPRI at CPRI Campus, Modipuram	4-5 March, 2011
Dr. S. K. Singh (Sr. Scientist)	Discipline wise meeting of Crop Improvement Division held at CPRI, Shimla w.e.f. & also attended Brain storming session on utilization of Potato Genetic Resources	15-17 September, 2010
Dr. S. K. Singh (Sr. Scientist)	Attended discipline wise meeting of crop Production Division held at CPRI Modipuram	1-3 September, 2010
Dr. S. K. Singh (Sr. Scientist)	Attended XIX National Symposium on Resource management approaches towards livelihood security held at UAS, Bengaluru, Karnataka	2-4 December, 2010

Dr. S. K. Singh (Sr. Scientist)	Seminar on "Horticulture Development in Bihar: Issues and Strategies" held at Patna	28-29 January, 2011
Dr. S. K. Singh (Sr. Scientist)	Kishan Mela organised by IIVR, Varanasi at KVK, Kushinagar	27 March, 2011
Dr. S. K. Singh (Sr. Scientist)	Farmers fair organized by Govt. of Bihar on Use of Agriculture Implements in Agriculture held at Patna	04-08 March, 2011
Dr. S. K. Singh (Sr. Scientist)	Regional Farmer's fair organized by ICAR-RCER, Patna held at ICAR-RCER Campus, Patna	08-10 March, 2011
Dr. S. K. Singh (Sr. Scientist)	Workshop on "Post harvest management, processing and contract farming in horticultural crops" to attract Investors in Horticulture Sector organized by APC, Bihar Govt. at Hotel Maurya, Patna	21 August, 2010
Dr. S. V. Singh	Participated in 20 th Meeting of ICAR, Regional committee No. iv at Birsa Agriculture University, Ranchi, Jharkhand.	7-9 October, 2010
Dr. S. V. Singh	Participated in International symposium on Agronomy and Physiology of Potato held in Nevsehir, Turkey	20-24 September, 2010
Dr. Sanjeev Sharma	Participated in the launching workshop on "Developing, commissioning, operating and managing on online examination system for NET/ARS. Preliminary examination for ASRB, ICAR" organized by ASRB	1 July, 2010
Dr. Sanjeev Sharma	Participated in the symposium on "Emerging plant diseases in North India : Status and management strategies "organized by College of Agriculture, HAU, Hissar	28-29 October, 2010
Dr. Shambhu Kumar	Discipline wise meeting of Crop Improvement Division held at CPRI, Shimla & also attended Brain storming session on utilization of Potato Genetic Resources	15-17 September, 2010
Dr. Shambhu Kumar	IRC meeting	26 June, 8-9 October, 2010
Dr. Shambhu Kumar	RAC, at CPRI, Shimla	6-7 October, 2010
Dr. Shambhu Kumar	28 th AICRP on Potato group meeting held at CPRI Shimla	10-12 September, 2010
Dr. Shambhu Kumar	Farmers fair organized by ICAR-RCER Patna, RCER Campus, Patna	8-10 March, 2011
Dr. SK Chakrabarti	Participated in the central steering committee meeting of Technology Mission for Integrated Development of Horticulture in North-Eastern States including Sikkim, J&K, HP and Uttaranchal at Krishi Bhawan, New Delhi	20 April, 2010

Dr. SK Chakrabarti	Participated in the Consultation biotechnology research in ICAR on held at NASC, New Delhi and presented a status report on genomics of horticultural crops	26-27 July, 2010
Dr. SK Chakrabarti	Participated in the workshop on Approved Uses of Pesticides in Agriculture organized by Department of Agriculture & Co-operation (DAC), Ministry of Agriculture at NASC Complex, New Delhi	30 August, 2010
Dr. SK Chakrabarti	participated in the National Consultative Meet on Bioinformatics in Horticulture organized by IISR, Calicut	11-12 October, 2010
Dr. SK Chakrabarti	Participated in the symposium on Emerging plant diseases in North India: status and management strategies organized by College of Agriculture, HAU, Hisar	28-29 October, 2010
Dr. SK Chakrabarti	Participated in the brainstorming session on Making IPM Effective in India organized by NAAS at NASC Complex, New Delhi	29-30 September, 2010
Dr. SK Chakrabarti	Dr. SK Chakrabarti, Head, participated in the national symposium on Perspective in plant health management organized Indian Phytopathological Society at by B.A. College of Agriculture, Anand Agriculture University, Anand, Gujarat	14-16 December, 2010
Dr. SK Chakrabarti	Participated in the Sensitization meeting of Nodal Officers for preparation of Results-Framework Document (RFD) organized by ICAR on at NASC, New Delhi	11-14 March, 2011
Dr. SK Chakrabarti	Participated in the Monitoring and Review Meeting of Foreign-aided Project of the Division of Horticulture, ICAR on	16 November, 2010
Dr. SK Chakrabarti	Dr. SK Chakrabarti, Head, participated in the Interactive Session cum Workshop on Plant Quarantine Activities organized by Directorate of Plant Protection Quarantine and Storage, DAC, Ministry of Agriculture at India Habitat Centre, New Delhi	18 February, 2011
Dr. SK Luthra	Attended National workshop for 2 nd phase of project on FAO project Establishment of the information sharing mechanism for monitoring the implementation of the global plan of action for conservation and sustainable utilization of plant genetic resources for food and agriculture (PGRFA) at NBPGR, New Delhi organized by NBPGR, New Delhi/FAO, Rome	17 April, 2010

Dr. SK Luthra	Attended Crop modelling, templates and tools for the use of trial data in performance prediction and targeting of potato clones and varieties at CPRI, Shimla, HP organized by CIP, Lima and CPRI, Shimla	9-13 August, 2010
Dr. SK Luthra	Attended GTZ project annual meeting at Gandhinagar organized by CIP, SWCA, New Delhi	29-30 November, 2010
Dr. TK Bag	Attended the review meeting of the project CSS on horticulture Mission for North East and Himalayan States at NRC for Orchids, Pakyong Sikkim	21 February, 2011
Dr. TK Bag	Attended interface meeting with Department of Vet. & Animal Husbandry, Agriculture/ Horticulture and Fishery, Govt of Nagaland and Secretary DARE and DG, ICAR at NRC for Mithun, Medziphema, Nagaland	4 February, 2011
Dr. TK Bag	Participated in the 2 nd North East Agri Expo at Dimapur, Nagaland	13-19 December, 2010
Dr. Vinod Kumar	Attended workshop on Crop modelling, templates and tools for the use of trial data in performance prediction and targeting of potato clones and varieties at CPRI, Shimla, HP, Organised by CIP, Lima and CPRI, Shimla	9-13 August, 2010
Drs. TK Bag and SK Yadav	Participated in North Eastern Zone Regional Agri-Fair at ICAR Research Complex for NEH Region, Umiam, Meghalaya	28 Feb. - 2 March, 2011
Er. Sukhwinder Singh	Attended 4 th Indian Horticulture Congress -2010, on Horticulture, Horti-Business and Economic Prosperity, held at New Delhi	18-21 November, 2010
Er. Sukhwinder Singh	and Harvir Singh attended a short training programme on Green house- design and management held at International Horticulture Training and Innovation Center, Jaipur	21-25 March, 2011
Eradasappa, E.	Attended Annual discipline wise meeting and Brain storming session on utilization of potato genetic resources of crop improvement division held at CPRI, Shimla	15-17 September, 2010
डा. एन. सी. उपाध्या	ग्राम कैली, जिला मेरठ में आयोजित किसान गोष्ठी में भाग लिया	20 November, 2010
डा. एन. सी. उपाध्या	सरदार वल्लभ भाई पटेल कृषि एवं प्रौद्योगिकी विश्वविद्यालय, मेरठ के अर्न्तगत कृषि विज्ञान केन्द्र बागपत पर आयोजित किसान गोष्ठी में भाग लिया	18 December, 2010

डा. एन. सी. उपाध्या	इन्डियन पोटाष लिमिटेड बुरगर मिल सकोती टान्डा (मेरठ) में आयोजित किसान गोष्ठी में भाग लिया	28 February, 2011
डा. एन. सी. उपाध्या	मोदीपुरम परिसर में आयोजित किसान गोष्ठी औद्योगिकी फसलों में कार्बनिक खेती का महत्व में आयोजित किसान गोष्ठी में भाग लिया	5-6 मार्च, 2011
Mr. AK Srivastava and Mr. MS Gurjar	Participated in the Udyan Mela at CPRIC, Modipuram, Meerut, Uttar Pradesh	5-6 March, 2011
Mr. AK Srivastava, Dr. SK Yadav and Mr. MS Gurjar	Participated in the ICAR-Industry Meet 2010 organised by ITMU, ICAR Research Complex for NEH region and Zonal Technology Management – Business Planning and Development Unit, NIRJAFT, Kolkata at ICAR Research Complex for NEH Region, Umiam, Meghalaya	18-19 November, 2010
VU Patil	Participated in 3 rd Bangalore Nano 2010 conference held at IISC, Bangalore	8-9 December, 2010

Classified abstract of expenditure in respect of Plan FOR THE YEAR 2010-2011

	<u>Expenditure - Plan</u>
	Expenditure
Capital Works	
A.1 Land	0.00
B.1 Office buildings	20999897.00
B.2 Residential buildings	0.00
B.3 Minor Works	493000.00
Total	21492897.00
Other Capital Expenditure	
C. Equipments	31586787.00
D. Information Technology	3368888.00
E. Library Books and Journals	2453649.00
F. Vehicles and Vessels	0.00
G. Livestock	0.00
H. Furniture & fixtures	0.00
I. Others	0.00
Total	37409324.00
	Total Capital 58902221.00
Revenue	
Establishment Expenses	
A.1 Establishment Charges	0.00
A.2 Wages	0.00
A.3 Overtime Allowance	0.00
Total	0.00
Travelling Allowances	
A. Domestic TA / Transfer TA	2248278.00
B. Foreign TA	0.00
Total	2248278.00
Research and Operational Expenses	
A. Research Expenses	7974668.00
B. Operational Expenses	4308013.00
Total	12282681.00

Administrative Expenses

A. Infrastructure	2524010.00
B. Communication	132847.00
C.1 Repairs/Maintenance - Equipments, Vehicles & Others	502930.00
C.2 Repairs/Maintenance - Office building	0.00
C.3 Repairs/Maintenance - Residential building	0.00
C.4 Repairs/Maintenance - Minor Works	0.00
D. Others (excluding TA)	3402113.00
Total	6561900.00

Miscellaneous Expenses

A. HRD	0.00
B. Other Items (Fellowships, Scholarships etc.)	0.00
C. Publicity & Exhibitions	0.00
D. Guest House - Maintenance	0.00
E. Other Miscellaneous	0.00
Total	0.00
Total	0.00
Total Revenue	21092859.00
Grand Total : Capital +	79995080.00

HEAD OF ACCOUNT (Expenditure)

	Amount
Plan scheme funded for plan budget of Council	42270270.00
'R' Deposits	67736390.00
Revolving Funds	42647772.00

Revenue Receipts

1 Sale of Farms Produce	8466242.00
2 Sale of Fish & Poultry	0.00
3 Sale of Land	0.00
4 Sale of Building	0.00
5 Sale of Vehicle, other Machine Tools	46000.00
6 Sale of Livestocks	0.00
7 Income from Royalty, Sale of Publicatio and	77097.00
8 Licence Fee	882058.00
9 Interest earned on Loans and Advances	810180.00
10 Leave Salary and Pension Contribution	0.00
11 Receipts from Schemes	0.00
12 Analytical and Testing Fee	0.00
13 Pre-shipment Fee	0.00
14 Application fee from candidates	0.00

15 Diploma Charges	0.00
16 Receipts from Services Rendered	0.00
17 Unspent Balance of Grants	0.00
18 Interest earned on short term deposits	884254.00
19 Income generated from Internal Resource	0.00
20 Net profit in Revolving Funds	0.00
21 Recoveries of Loans and Advances	2053452.00
22 Miscellaneous Receipts	7968546.00
Grand Total	21187829.00

Classified abstract of expenditure in respect of Non-Plan FOR THE YEAR 2010-2011

	Expenditure
Capital Works	
A.1 Land	0.00
B.1 Office buildings	0.00
B.2 Residential buildings	0.00
B.3 Minor Works	0.00
Total	0.00
Other Capital Expenditure	
C. Equipments	992561.00
D. Information Technology	128779.00
E. Library Books and Journals	994813.00
F. Vehicles and Vessels	0.00
G. Livestock	2000.00
H. Furniture & fixtures	314858.00
I. Others	0.00
Total	2433011.00
Total Capital	2433011.00
Revenue	
Establishment Expenses	
A.1 Establishment Charges	215430716.00
A.2 Wages	4657973.00
A.3 Overtime Allowance	0.00
B. Pension & Other Retirement Benefits	89999755.00
C. Loans and Advances	1492000.00
Total	311580444.00
Travelling Allowances	
A. Domestic TA / Transfer TA	999237.00
B. Foreign TA	0.00
Total	999237.00
Research and Operational Expenses	
A. Research Expenses	8402933.00
B. Operational Expenses	3067387.00
Total	11470320.00

Administrative Expenses

A. Infrastructure	6699565.00
B. Communication	417148.00
C.1 Repairs/Maintenance - Equipments, Vehicles & Others	2221650.00
C.2 Repairs/Maintenance - Office building	1906136.00
C.3 Repairs/Maintenance - Residential building	711618.00
C.4 Repairs/Maintenance - Minor Works	154960.00
D. Others (excluding TA)	5406014.00
	Expenditure
Total	17517091.00

Miscellaneous Expenses

A. HRD	0.00
B. Other Items (Fellowships, Scholarships etc.)	0.00
C. Publicity & Exhibitions	0.00
D. Guest House – Maintenance	0.00
E. Other Miscellaneous	274846.00
Total	274846.00
	0.00
Total	0.00
Total Revenue	341841938.00
Grand Total : Capital +	344274949.00

Promotions/Retirements/ Transfers/Deaths

Scientific Category

Promotion

1. Dr. (Mrs.) Kamlesh Malik, Sr. Scientist promoted to the post of Principal Scientist with effect from 23.3.2008.

Transfers

2. Dr. Prem Chand Meena, Scientist (Ag. Eco.), CPRIC, Modipuram to NAARM Hyderabad w.e.f. 24.4.2010.
3. Sh. Chandrasekar V. Scientist (Ag. Eco.), CPRI, Shimla to CIFR, Kochi w.e.f. 26.4.2010.
4. Dr. Barsati Lal, Sr. Scientist (Ag.Extn.), CPRS, Patna to CISH, Lucknow w.e.f. 13.5.2010.
5. Dr. Dinesh Kumar, Sr. Scientist (Bio-chemistry), CPRIC, Modipuram relieved w.e.f. 15.6.2010 to join DWR. Karnal to the post of PS.
6. Dr. Parveen Kumar, Sr. Scientist, CPRIC, Modipuram has relieved w.e.f. 30.9.2010 to join his new assignment as PS at CSSRI, Karnal.
7. Dr. Babasaheb Fand Bhasker, Scientist (Ag. Ento.), CPRI, Shimla has relieved w.e.f. 23.10.10 (FN) to join at National Institute of Abiotic Stress Management, Baramati.

3. Dr. TC Kumari Sugitha, Scientist, Microbiology joined at CPRS, Ooty on 5.5.2010 (FN).
4. Dr. Birpal Singh, JD, CPRIC, Modipuram has joined to the post of Director, CPRI, Shimla on 1.7.2010 (FN)
5. Dr. Fand Babasaheb Bhaskar, Scientist (Agricultural Entomology) has joined at CPRI, Shimla on 27.8.2010 (FN).
6. Sh. Dhiraj Kumar Singh, Scientist(Agricultural Extension) has joined at CPRI, Shimla on 28.8.2010 (FN).
7. Dr. AK Somani, PS, CPRS, Gwalior has joined to the post of the Head, CPRS, Gwalior on 28.8.2010 (FN).
8. Dr. JS Minhas, PS, CPRI, Shimla has joined as to the post of the Head, CPRS, Jalandhar on 15.9.2010 (FN).
9. Dr. Sanjay Kumar Yadav, Scientist (Agronomy) has joined on 27.8.2010 at CPRS, Shillong (FN).
10. Dr. (Ms.) Kumari Bandana, Scientist (Bio-chemistry) has joined at CPRIC, Modipuram on 17.9.2010 (FN).
11. Shri Malkhan Singh Gurjar (Plant Pathology) has joined at CPRS, Shillong on 1.9.2010 (FN).
12. Sh. Rahul R Bakade, Scientist(Plant Pathology) has joined at CPRS, Patna on 18.9.2010 (FN).
13. Dr. SK Kaushik, Sr. Scientist, CPRI, Shimla has joined as Joint Director, CPRIC, Modipuram on 28.10.2010 (FN).
14. Dr. TK Bag, PS, ICAR Research complex for NEH Region, Umiam, Barapani has joined as Head, CPRS, Shillong on 1.12.2010 (FN).
15. Dr. S. Sundaresha, Scientist (Plant Pathology) has joined at CPRS, Shimla on 10.1.2011 (FN).

Appointments/Joinings

1. Dr. (Ms.) Pinky, Scientist, Plant Physiology has joined in the Division of Crop Physiology, Bio-chemistry and Post Harvest Technology, CPRI, Shimla in the forenoon of 28.4.2010.
2. Dr. (Mrs.) Ratna Preeti Kaur, Scientist, Genetics has joined at CPRS, Jalandhar in the forenoon of 22.4.2010.

Retirements/Resignations

1. Dr. KM Nagraj, Scientist(Pl. Breeding), CPRS, Shillong resigned w.e.f. 2.6.2007.
2. Dr. SK Pandey, Director, CPRI, Shimla retired on 30.6.2010.
3. Dr. JP Singh, Principal Scientist, CPRS, Jalandhar retired on 31.8.2010.
4. Dr. KR Dhiman, Principal Scientist, CPRS, Kufri retired on 30.9.2010.
5. Dr. Gulab Ram, Principal Scientist, CPRS, Patna retired on 31.10.2010.
6. Dr. YK Sharma, Sr. Scientist, CPRS, Kufri retired on 28.2.2011.
7. Dr. OP Singh, PS, retired on 28.2.2011.
8. Dr. RP Rai, Head, CPRS, Patna retired on 31.3.2011.

Technical

Promotion

1. Dr. Rakesh Mani Sharma, T-6 (TO), CPRI, Shimla promoted to T(7-8).
2. Mrs. Tarvinder Kochhar, T-5 (TO), CPRI, Shimla promoted to T-6.
3. Sh. Rajnish Rajput, T-4, CPRI, Shimla promoted to T-5 (TO).
4. Sh. Chander Mohan Singh Bist, T-4, CPRI, Shimla promoted to T-5 (TO).
5. Smt. Ruma Chakraborty, T-4, CPRI, Shimla Promoted to T-5 (TO).
6. Sh. RS Kapoor, T-4, CPRI, Shimla promoted to T-5 (TO).
7. Smt. Shruti Gupta, T-4, CPRI, Shimla promoted to T-5 (TO).
8. Sh. DP Gautam, T-2 (Projector Operator), CPRI, Shimla promoted to T-3.
9. Sh. Jeet Ram, T-4 (Mason), CPRI, Shimla promoted to T-5 (TO).
10. Smt. Kusum Singh, T-4, CPRIC, Modipuram, Promoted to T-5 (TO).

11. Sh. Vijay Kumar Yadav, T-4, CPRIC, Modipuram, Promoted to T-5 (TO).
12. Sh. Murari Lal, T-4, CPRIC, Modipuram promoted to T-5 (TO).
13. Sh. Omvir Singh, T-4, CPRIC, Modipuram promoted to T-5 (TO).
14. Sh. Dinesh Singh, T-4, CPRIC, Modipuram promoted to T-5 (TO).
15. Sh. Rajdeep Bux, T-4, CPRIC, Modipuram promoted to T-5 (TO).
16. Dr. (Mrs.) Vineet Sharma, T-4, CPRIC, Modipuram promoted to T-5 (TO).
17. Sh. Santosh Kumar, T-4, CPRIC, Modipuram promoted to T-5 (TO).
18. Dr. YP Singh, T-4, CPRS, Gwalior Promoted to T-5 (TO).
19. Sh. Kashi Prasad, T-4, CPRS, Gwalior promoted to T-5 (TO).
20. Sh. Shyam Kumar Gupta, CPRS, Gwalior promoted to T-5 (TO).
21. Sh. UP Paudal, T-2 (Driver), CPRS, Shillong promoted to T-3.
22. Sh. B. Chandran, T-4, CPRS, Muthurai promoted to T-5 (TO).
23. Sh. Rabindra Sharma, T-4, CPRS, Patna promoted to T-5 (TO).

Retirements

1. Sh. VK Awasthy, T-5, CPRI, Shimla on 31.10.2010.
2. Sh. Jeet Ram, T-5, CPRI, Shimla on 30.11.2010.
3. Sh. JS Jassal, T-5, CPRS, Jalandhar on 31.1.2011.

Transfers

1. Sh. Parkash Ram, Tractor Driver transferred from CPRS, Jalandhar to Gwalior.
2. Sh. Prithi Raj, T-2 transferred from CPRIC, Modipuram to CPRI, Shimla.

Administrative

Promotions

1. Sh. Shri Krishan, Skilled Support Staff, CPRS, Gwalior promoted to the post of LDC in the Pay Band of Rs. 5200-20200+ Grade Pay of Rs. 1900 w.e.f. 28.4.2010(AN).
2. Sh. Akhilesh Singh, Skilled Support Staff, CPRS, Patna, promoted to the post of LDC in the Pay Band of Rs. 5200-20200+ Grade Pay of Rs.1900 w.e.f. 28.4.2010(AN).
3. Sh. Kundan Lal, Skilled Support Staff, CPRI, Shimla promoted to the post of LDC in the Pay Band of Rs.5200-20200+ Grade Pay of Rs.1900 w.e.f. 29.4.2010.
4. Sh. Padam Chand, Skilled Support Staff, CPRI, Shimla promoted to the post of LDC in the Pay Band of Rs.5200-20200+ Grade Pay of Rs.1900 w.e.f. 29.4.2010.
5. Sh. Chet Ram Nahata, Sr. Stenographer, CPRI, Shimla promoted to the post of Private Secretary in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4600 w.e.f. 25.10.2010(AN).
6. Sh. Hari Krishan Verma, PA, CPRI, Shimla promoted to the post of Private Secretary in the Pay Band of Rs. 9300-34800+ Grade Pay of Rs.4600 w.e.f. 25.10.2010(AN).
7. Sh. Dharam Dass Kashyap, UDC, CPRI, Shimla promoted to the post of Assistant in the Pay Band of Rs. 9300-34800+ Grade Pay of Rs.4200 w.e.f. 25.11.2010.
8. Smt. Teirina Nongkhaw, UDC, CPRS, Shillong promoted to the post of Assistant in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4200 w.e.f. 25.11.2010.
9. Sh. Devendra Kumar, UDC promoted to the post of Assistant in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4200 w.e.f. 26.11.2010.
10. Smt. Pomilian W. Syiem, UDC, CPRS, Shillong promoted to the post of Assistant in the Pay Band of Rs. 9300-34800+ Grade Pay of Rs.4200 w.e.f. 25.11.2010.
11. Sh. Hare Krishan Sen, Personal Assistant, CPRS, Patna promoted to the post of Private Secretary in the Pay Band of Rs. 9300-34800+ Grade Pay of Rs.4600 w.e.f. 23.12.2010(AN).
12. Mairaj Ul Haque, PA, CPRIC, Modipuram promoted to the post of Asstt. Admn. Officer in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4600 w.e.f. 27.12.2010(AN).
13. Sh. Amar Singh Negi, Asstt. Admn. Officer, CPRI, Shimla promoted to the post of Admn. Officer in the Pay Band of Rs. 15600-39100+ Grade Pay of Rs.5400 w.e.f. 28.3.2011.
14. Sh. NK Gupta, Asstt. CPRIC, Modipuram promoted to the post of Asstt. Admn. Officer in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4600 w.e.f. 9.2.2011(AN).
15. Smt. Roseline, Asstt. CPRI, Shimla promoted to the post of Asstt. Admn. Officer in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4600 w.e.f. 9.2.2011(AN).
16. Sh. Rajesh Kumar, Steno. Grade-III, CPRIC, Modipuram promoted to the post of Personal Assistant in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4200 w.e.f. 19.3.2011(AN).
17. Sh. Suresh Kumar, Steno. Grade-III, CPRI, Shimla promoted to the post of Personal Assistant in the Pay Band of Rs.4200 w.e.f.19.3.2011.
18. Sh. Jeevan Kumar, Asstt. CPRS, Jalandhar promoted to the post of Asstt. Admn. Officer in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4600 w.e.f. 29.3.2011(AN).

Appointments

1. Sh. Chander Prakash, Asstt. Finance & Accounts Officer in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4600 at CPRI, Shimla w.e.f. 24.5.2010.
2. Sh. Ashish Dhangar, Asstt. Finance & Accounts Officer in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4600 at CPRI, Shimla w.e.f. 28.5.2010.
3. Sh. Girish Thakur, Stenographer Grade-III in the Pay Band of Rs.5200-20200+ Grade Pay of Rs.2400 at CPRS, Gwalior w.e.f. 26.6.2010.

Retirements

1. Sh. Vijay Kumar, Asstt. CPRS, Kufri retired on 31st July, 2010 (FN).

2. Sh. RR Das, Asstt. CPRS, Gwalior voluntarily on 1st August, 2010 (FN).
3. Sh. Roshan Lal Chauhan, Finance & Accounts Officer, CPRI, Shimla retired on 31.8.2010 (FN).
4. Sh. Ranvir Singh Mehta, Private Secretary, CPRI, Shimla retired on 30.11.2010.
5. Sh. AS Keprate, Asstt. Admn. Officer, CPRI, Shimla retired on 31st January, 2011.
6. Sh. Didar Singh, Asstt. Admn. Officer, CPRS, Jalandhar retired on 31st January, 2011.
5. Sh. Surjeet Singh, SS Gr. IV (SSS), CPRS, Jalandhar retired on 31.10.2010.
6. Sh. Inder Singh, SS Gr. III (SSS), CPRS, Kufri retired on 30.11.2010.

Untimely Demise

1. Sh. Hari Dass, Skilled Support Staff (SSGr. IV), CPRI, Shimla expired as on 10.09.2010
2. Sh. Ramashish Rai, Skilled Support Staff (SS Gr.I), CPRS, Patna expired as on 25.04.2010

Skilled Supporting Staff

Promotions

1. Sh. Sunil Kumar Singh, SS Grade-II, CPRS, Patna promoted to T-1(FFT) under 33.3% quota w.e.f. 13.4.2010.
2. Sh. Shri Krishan, SS Grade-II, CPRS, Gwalior promoted to Lower Division Clerk under 20% quota w.e.f. 28.04.2010.
3. Sh. Akhilesh Singh, SS Grade-I, CPRS, Patna promoted to Lower Division Clerk under 20% quota w.e.f. 28.04.2010.
4. Sh. Kundan Lal, SS Grade-I, CPRI, Shimla promoted to Lower Division clerk under 20% quota w.e.f. 28.04.2010.
5. Sh. Padam Chand, SS Grade-I, CPRI, Shimla promoted to Lower Division Clerk under 20% quota w.e.f. 28.04.2010.

Retirements

1. Sh. Rampal Singh, SS Gr. III (SSS), CPRIC, Modipuram retired on 30.06.2010.
2. Sh. Sheo Balak Paswan, SS Gr. IV (SSS), CPRS, Patna retired on 31.07.2010.
3. Smt. Sumitra Devi, SS Gr. IV (SSS), CPRIC, Modipuram retired on 31.08.2010.
4. Sh. Lal Singh, SS Gr. IV (SSS), CPRI, Shimla retired on 30.09.2010.

Personnel

Director: Dr. BP Singh

AICPIP Unit

1. Dr. PS Naik, PS & Project Coordinator
2. Dr. MK Jatav, Scientist (SS)

Division of Crop Improvement

1. Dr. Jai Gopal, PS & Head
2. Dr. D. Pattanayak, Sr. Scientist
3. Dr. Vinay Bhardwaj, Sr. Scientist
4. Sh. A.Chanemougasoundaram, Scientist
5. Dr. Virupakshagauda U Patil, Scientist
6. Dr. Jagesh Kumar, Scientist

Division of Seed Technology

1. Dr. KK Pandey, PS & Head
2. Dr. EP Venkatasalam, Scientist (SS)

Division of Crop Production

1. Dr. S.S. Lal, PS & Head
2. Dr. M.C. Sood, PS
3. Dr. PM Govindakrishnan, PS
4. Dr. VK Dua, Sr. Scientist
5. Dr. Manoj Kumar. Sr. Scientist

Division of Social Sciences

1. Dr. NK Pandey, PS & Head
2. Dr. Rajesh Kumar Rana, Sr. Scientist
3. Sh. Dhiraj Kumar Singh, Scientist

Division of Plant Protection

1. Dr. SK Chakrabarti, Head
2. Dr. Sanjeev Sharma, Sr. Scientist
3. Dr. Vinay Sagar, Sr. Scientist
4. Dr. (Ms) Jeevalatha A, Scientist
5. Dr. Baswaraj R., Scientist
6. Dr. Sundersha S, Scientist

Division of Crop Phy. & PHT

1. Dr. R. Ezekiel, PS & Head
2. Dr. Brajesh Singh, Sr. Scientist
3. Dr. (Ms) Pinky, Scientist

ARIS Cell

1. Dr. Shashi Rawat, Sr. Scientist

CPRI Campus, Modipuram

1. Dr. SK Kaushik, Joint Director
2. Dr. NC Upadhyay, PS
3. Dr. Satya Vir Singh, PS
4. Dr. Raj Pal Singh, PS
5. Dr. Devendra Kumar, PS
6. Sh. Rambir, Sr. Scientist
7. Dr. (Mrs.) Kamlesh Malik, PS
8. Dr. SK Luthra, Sr. Scientist
9. Dr. Name Singh, Sr. Scientist
10. Dr. Vinay Singh, Sr. Scientist
11. Dr. RK Verma, Sr. Scientist (Presently working with CITH, RS, Mukteshwar)
12. Dr. MA Khan, Sr. Scientist
13. Er. Sukhwinder Singh, Scientist (SG)

14. Dr. Sanjay Rawal, Sr. Scientist
15. Dr. Dhruv Kumar, Sr. Scientist
16. Dr. Vijai Kishore Gupta, Sr. Scientist
17. Dr. Mehi Lal, Scientist
18. Dr.(Ms) Bandna, Scientist

CPRS, Jalandhar

1. Dr. JS Minhas, Head
2. Dr. RK Arora, PS
3. Dr. (Mrs.) Ashiv Mehta, PS
4. Er. Manjit Singh, PS
5. Dr. SP Trehan, PS
6. Dr. Raj Kumar, Sr. Scientist
7. Er. Sunil Gulati, Scientist (SG)
8. Dr.(Ms) Ratna Preeti Kaur, Scientist

CPRS, Gwalior

1. Dr. AK Somani, PS & Head
2. Dr. Anuj Bhatnagar, Sr. Scientist
3. Dr. Shiv Pratap Singh, Sr. Scientist
4. Dr. Murlidhar J. Sadawarti, Scientist

CPRS, Shillong

1. Dr. TK Bag, Head
2. Dr. AK Srivastava, Scientist
3. Dr. Sanjay Kumar Yadav, Scientist
4. Sh. Malkhan Singh Gurjar, Scientist

CPRS, Muthurai

1. Dr. TA Joseph, PS & Acting Head
2. Dr. (Mrs.) K. Manorama, Sr. Scientist
3. Dr. G. Ravichandran, Sr. Scientist
4. Dr. R. Muthu Raj, Sr. Scientist
5. Dr. Uma Maheshwari, Scientist
6. Dr.(Mrs.) TC Kumari Sangtha, Scientist

CPRS, Kufri

1. Dr. Ashwani Kumar Sharma, Sr. Scientist
2. Dr. Vinod Kumar, Sr. Scientist

CPRS, Patna

1. Dr. Shambhu Kumar, Sr. Scientist
2. Dr. SK Singh, Sr. Scientist
3. Sh. Eradassapa. E, Scientist
4. Sh. Rahul R Bakade, Scientist

Staff Position**Scientific category**

Station-wise Sanctioned/Filled/Vacant position of Scientists as on 31.3.2011

Scientific Category	Shimla		Modi.		Jal.		Patna		Shill.		Gwlr.		Ooty		Kufri		Total	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Director	01	01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	01	01
Prin. Sci.	06	07	02	01	01	01	-	-	-	01	01	01	01	-	-	-	11	11
Sr. Scientist	09	04	04	02	02	-	01	01	01	-	01	01	-	-	01	-	19	08
Scientist	26	17	16	15	14	07	08	03	06	03	03	02	04	06	02	02	79	55
Total	42	29	22	18	17	08	09	04	07	04	05	04	05	06	03	02	110	75

Including RMP

Administrative Category

List of Administrative Category as on 31.3.2011

Name of the Post	Shimla	Modipuram	Jalandhar	Patna	Shillong	Gwalior	Ooty	Kufri	Total
Chief Admn. Officer	01	-	-	-	-	-	-	-	01
Sr. Fin. & A/Cs Officer	-	-	-	-	-	-	-	-	-
AO	01	-	-	-	-	-	-	-	01
Asstt. Admn. Officer	05	02	01	01	-	01	-	-	10
Asstt. Fin. & A/Cs Officer	02	-	-	-	-	-	-	-	02
AD(OL)	01	-	-	-	-	-	-	-	01
Assistant	18	-	01	01	03	-	01	-	24
Upper Division Clerk	14	05	04	-	-	-	01	01	25
Lower Division Clerk	16	03	03	04	-	04	-	01	31
Private Secretary	02	-	01	01	-	-	-	-	04
Personal Assistant	07	01	-	-	-	-	01	-	09
Steno. Grade-III	01	-	-	-	-	01	-	-	02
Total	68	11	10	07	03	06	03	02	110

Technical Category

Staff Position as on 1.4.2011 of Technical Staff

Grade	Shimla	Modipuram	Jalandhar	Patna	Gwalior	Shillong	Ooty	Kufri	Total
TO, T-9	01	01	-	-	-	-	-	-	02
TO, T(7-8)	02	01	01	01	01	-	-	-	06
TO, T-6	02	07	03	02	-	-	-	-	14
TO, T-5	15	18	08	01	02	-	01	02	47
Techn. T-4	04	07	05	04	04	01	02	01	28
Techn. (T-3)/T-1-3	11	05	02	06	-	03	-	01	28
Techn. T-2	21	01	06	05	04	03	02	01	43
Techn. T-1	04	04	-	01	02	01	-	03	15
Total	60	44	25	20	13	08	05	08	183

The position of skilled support staff at CPRI & its regional stations as on 01.4.2011

Grade	Sanctioned	Filled	Vacant
Skilled Support Staff	204	144	60
Canteen Staff*			
Cook	1	1	0
Tea Maker	1	1	0
Wash Boy	1	1	0
Grand Total	207	147	60

* 3 posts of Canteen Staff

Station-wise/ Grade wise list of the skilled support staff

Name of the post	Shimla	Modipuram	Jalandhar	Patna	Shillong	Gwalior	Ooty	Kufri	Total
Skilled Support staff	30	11	24	15	10	33	07	14	144
Canteen Staff	03*								03* = 147

Staff position as on 1.4.2011 of CPRI showing number of SCs, STs, OBCs & Women

Category	Sanctioned	Filled	SC	ST	OBC	Women
Scientific	109	74	07	02	06	09
Administrative	102	109	28	07	06	27
Technical	207	183	39	08	09	11
Supporting	207	144 + 3*	47	08	10	20



हर कदम, हर डगर

किसानों का हमसफर

भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch