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# वार्षिक प्रतिवेदन ANNUAL REPORT 2008-09



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



CPRI Annual Report 2009

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# Preface



The current turmoil in world food supply and demand, and rising inflation of food prices have posed a great challenge to feed the burgeoning population, especially in developing countries. India is also not an exception and has experienced higher inflation of food prices in recent years. With ever increasing pressure on agricultural land on account of rising population (@ 2.1% annually), urbanization and industrialization, India is confronted with the challenge of producing more food per unit area and time. Due to short vegetative cycle combined with high protein: calorie ratio, potato yields more edible energy, protein and dry matter per unit area and time than many other food crops. Potato also offers vast potential for intensifying agriculture in the sub-tropical Indian plains and ensuring food security of the country. Being short duration crop of 80-90 days, it can easily be incorporated into many

prevailing cropping systems, particularly the rice-wheat system of north Indian plains.

Recognising the importance of potato in providing food security and alleviating poverty, the year 2008 was declared as International Year of Potato by the UN General Assembly. Significantly, the year 2008 witnessed India registering a record potato production of 28.5 million tonnes with an average productivity of 183.3 q/ha. There was about 29 per cent increase in potato production in the country over the previous year and potato price in Indian market remained lower as compared to other food commodities during the year. This trend can be attributed to the technological leap in potato production, storage, processing and marketing in the country.

Against this backdrop, the year 2008-09 brought several outstanding achievements in potato research and technology development on the part of CPRI. The national gene bank of potato exceeded 3800 accessions/parental lines and improved early bulking andigena clones developed by pre-breeding. A late blight resistant variety "Kufri Girdhari" was released for cultivation in the hills of India. Similarly, an early bulking variety "Kufri Khyati" was released for north Indian plains. For the first time the Institute released a variety "Kufri Frysona" to fulfill the demand of French fries sector. Two new TPS populations – PT/08-109 and PT/08-112 were found promising in yield. For conferring durable resistance to late blight, six RB-transgenic lines of Kufri Jyoti and four of Kufri Bahar were selected for further evaluation. Thematic maps of areas suitable for growing potatoes for different purposes were prepared. For mechanization of potato production, the fabrication work of rotary tiller with crumbler roller was carried out. Several technological innovations were also made in the area of plant protection, post-harvest technology and seed technology. Field surveys and technology assessment conducted by social science wing revealed the latest scenario of area and production of promising potato varieties and adoption status of potato technologies in the country.

I would like to place on record my appreciation to the entire team of scientists for carrying out the research activities as per plan and bringing out comprehensive report of results obtained. Their devotion and cooperation always infused a new enthusiasm in me. I extend my cordial thanks to Joint Director, CPRIC, Modipuram, Project Coordinator, AICRP (Potato) and all the Heads of Divisions for compilation and timely submission of their respective reports. Special appreciation goes to Drs. AK Somani, JP Singh and SK Chakrabarti for compilation and editing of this report. Finally, I express my deep sense of 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.

A handwritten signature in dark ink, appearing to read 'SK Pandey'.

(SK Pandey)  
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.

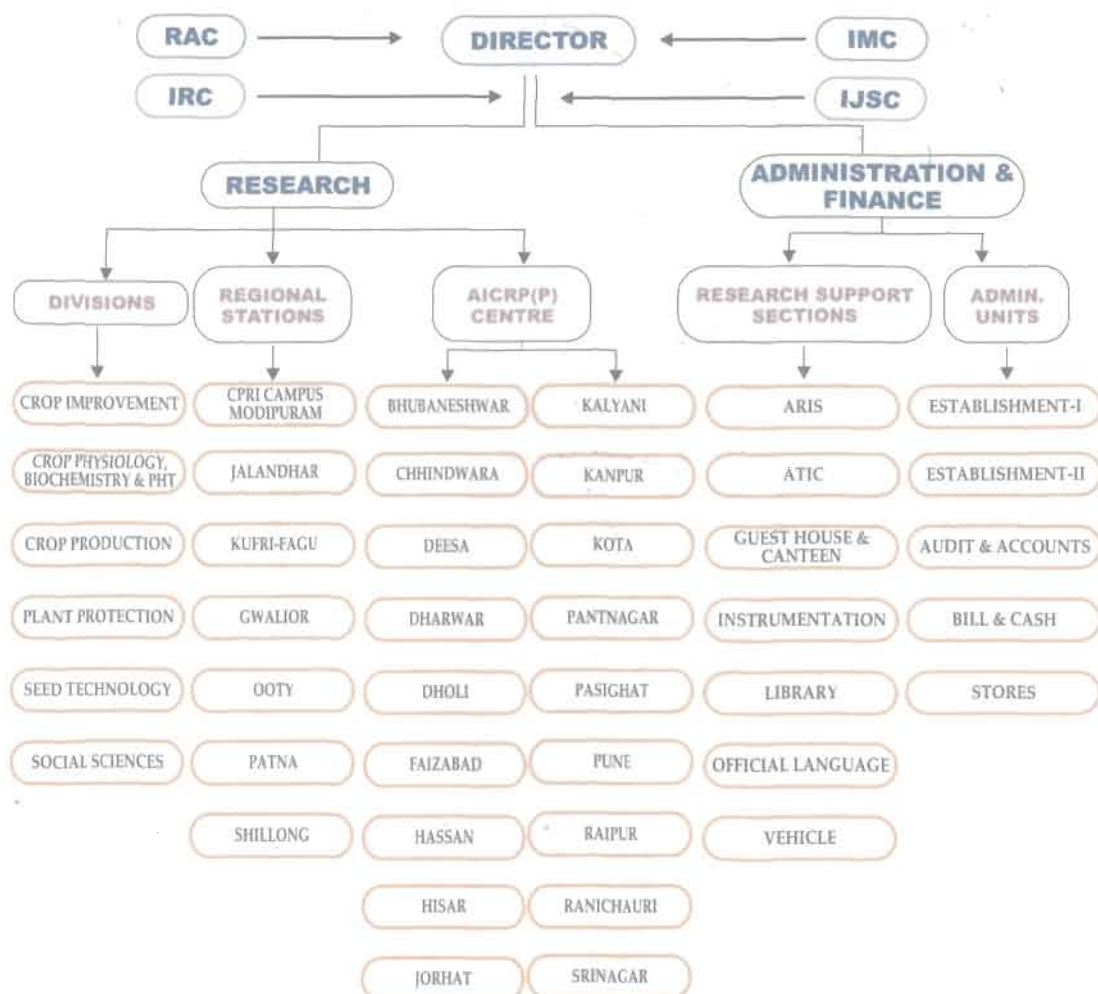
Initially, the institute had 3 research stations at Shimla, Kufri and Bhowali. With the expansion of potato cultivation in major potato growing regions of the country, new stations have been created since its inception in 1949. Presently, it has one campus at Modipuram (Uttar Pradesh) and 6 regional 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.



## CENTRAL POTATO RESEARCH INSTITUTE





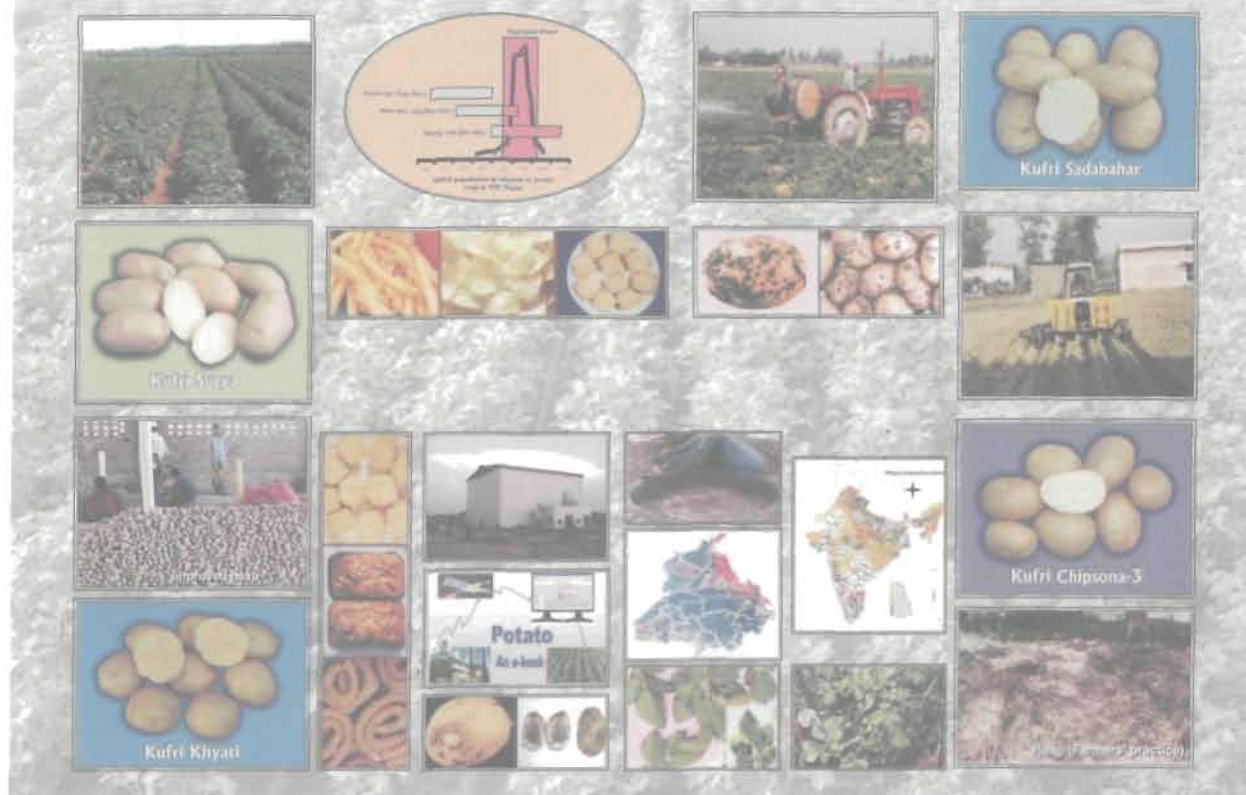


# Mandate

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.

## Achievements of the Institute



- 4



- ❖ 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 and fertilizer and manure application for them.
- ❖ Developed agricultural implements for mechanizing potato cultivation, including an oscillating tray type potato grader, fertilizer applicator-cum-line marker, potato culti-ridger, soil crust brakers, granular insecticide applicator, two/four row automatic potato planter, culti-ridger and potato digger.
- ❖ 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 flavescences; 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 and late blight.
- ❖ Demonstrated that *Azotobacter* strain can partially supplement the nitrogen requirement of the potato crop in the field.
- ❖ Produced transgenic potatoes carrying RB gene for late blight horizontal resistance & hairpin construct of invertase for reduction of cold induced sweetening
- ❖ Created DNA fingerprints of Indian potato cultivars using 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.

## 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 the receipt was 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 generated 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 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 2008-09, in addition to annual report, two issues of newsletter, two folders, nine technical bulletins and one extension folder were brought out by CPRI. CPRI Scientists published thirty seven research papers in referred journals.

## Research achievements highlights during the year

1. The germplasm collection of cultivated and wild species was augmented from CIP, Lima, Potato Gene Bank, USA and SCRI, UK to exceed the count to 3800.
2. Early bulking, white tuber variety Kufri Khyati for plains and medium maturing late blight resistant Kufri Giridhari for hills were released.
3. Hybrid MP98-71 has been released at Institutional level as variety Kufri Frysona for processing into French fries and MP/10-916 has been identified as suitable for processing into chips.
4. 7.4 kgs of TPS of 37 crosses including 92PT-27 was produced.
5. Fifty promising clones from Kufri Jyoti and 22 from Kufri Bahar introgressed with RB-transgenic-Katahdin identified and a molecular map of *Solanum chacoense* with 89 AFLP markers was developed.
6. Different sequential and intercropping systems and their profitable management practices were developed for hills (Shimla and Ooty) and plains (Patna, Jalandhar, Gwalior and Modipuram).
7. The winter potato acreage and production estimated using remote sensing, GIS and crop modeling techniques for states Punjab, UP, Bihar and WB was 74.7, 447.4, 181.7 and 386.7 thousand hectares and 519, 9252, 2010 and 8055 thousand tons, respectively, during 2008-09.
8. A decision support system (DSS) tool "Computer Aided Advisory System for Potato Crop Scheduling was developed for aiding decision on date of planting.
9. Thematic map of potential yield of potato areas suitable for growing potatoes for processing, frost prone areas, plateau area, etc. were prepared.
10. Hybrid JX 567 was identified as most tolerant and efficient to nutrient stress including N, P and K.
11. Kufri Pushkar and Kufri Anand were found highly resistant to russet scab.
12. An integrated tuber treatment of *Bacillus subtilis* together with boric acid exhibited a synergistic effect for control of *Rhizoctonia solani*.
13. Late blight scenario: First appeared in Tarai region of UP during December. However, sudden out burst occurred in last week of January in major part of country causing 15-40% crop loss.
14. Treatment with 0.5%  $MgCl_2$  or  $CaCl_2$  along with blanching at 70°C for 2 minutes decreases the oil content in chips.
15. Starch recovery was found to be related with dry matter content and maximum recovery was found in Kufri Chipsona 3 (12.47% on fresh tuber weight).
16. French fries made from Kufri Surya had firmer texture than that from other processing cultivars.



17. Chips from 26 cultivars were screened for acrylamide content with minimum value in Kufri Chipsona-I, it was found to be related with chip colour.
18. With improved heap storage using CIPC @ 40ml/tonne of potatoes in methanol, farmers could market 6.5% more weight at 35% higher price and processing industry could make better quality of flakes and French fries up to the end of June. This was also effective in sprout inhibition up to 120 days.
19. The bio efficacy of CIPC and other eco-friendly components were tested for potato tuber moth (PTM) and extracts from locally available plants and cattle urine were tested against white grub.
20. During the year a total 26,930.37 q seeds of about 25 varieties were produced from 140.64 ha at Modipuram, Jalandhar, Gwalior, Panta, Kufri and Shimla and 21, 480.92 q was supplied to different agencies. In addition, a total of 10, 160 microtubers and 47,837 *in vitro* plantlets of different commercial cultivars were also produced.
21. Quick survey on potato outlook was conducted in the states of Gujarat, MP and Chhatisgarh revealed the reduction in potato yield by 35, 30 and 25% respectively.
22. The model training course on "Potato improvement production and utilization in current scenario" improved the overall knowledge of the participant by 13%.



## सारांश



### सामाजिक विज्ञान

गुजरात में आलू की विभिन्न किस्मों के अन्तर्गत क्षेत्र एवं उत्पादकता का मूल्यांकन करने के लिए सर्वेक्षण किया गया। राज्य में 48 प्रतिशत आलू उत्पादक क्षेत्र के साथ कुफरी बादशाह किस्म पहले स्थान पर, जबकि 23 प्रतिशत क्षेत्र के साथ कुफरी लवकार दूसरे और 18 प्रतिशत क्षेत्र के साथ कुफरी पुखराज तीसरे स्थान पर रही। पैदावार की दृष्टि से राज्य में 364 किंवटल प्रति हेक्टेयर की दर से कुफरी पुखराज प्रथम, 322 किंवटल प्रति हेक्टेयर की दर से कुफरी बादशाह द्वितीय तथा 284 किंवटल प्रति हेक्टेयर की दर से कुफरी लवकार तीसरे स्थान पर रही। किसानों की प्रतिक्रिया के आधार पर आलू के कुफरी बादशाह और कुफरी पुखराज के क्वालिटी गुणों को जांचने हेतु एक weighted index तैयार किया गया। इसमें कुफरी बादशाह किस्म के सबसे अधिक भारित अंक 88 प्रतिशत प्राप्त हुए, अतः राज्य में किसानों ने कुफरी बादशाह को कुफरी पुखराज (71 प्रतिशत) से अधिक पसन्द किया। गुजरात में बीज प्रतिस्थापन दर बहुत अधिक (लगभग 50 प्रतिशत) पाई गई। यह दर अलग-अलग किस्मों में अलग-अलग थी। इनमें से पंजाब और पश्चिमी उत्तर प्रदेश की किस्मों का योगदान 50 प्रतिशत और 37 प्रतिशत, जबकि शेष 13 प्रतिशत स्थानीय प्रगतिशील किसानों से प्राप्त बीजों का था। मूल्य बेलोचता (price elasticity) 0.32 आंकलित हुई जिससे माल या वस्तु के लिए मूल्य सापेक्षता बेलोच पाई गई। आय बेलोचता नगण्य (-0.21) देखी गई। जबकि आपूर्ति बेलोचता बहुत अधिक (0.84) रही। गुजरात, मध्य प्रदेश और छत्तीसगढ़ में आलू की सम्भावित पैदावार पर सर्वेक्षण किए गए। सर्वेक्षण से गुजरात, छत्तीसगढ़ और मध्य प्रदेश में आलू की पैदावार में क्रमशः 35, 30 और 25 प्रतिशत कमी की जानकारी हुई। पैदावार में कमी का मुख्य कारण उच्च तापमान और पिछेता झुलसा रोग पाए गए। कुफरी सिन्दूरी छत्तीसगढ़ में काफी लोकप्रिय होने के कारण छत्तीसगढ़ के सरगुजा जिले में इसे लगभग 45 प्रतिशत क्षेत्र में उगाया जा रहा है। सामान्य एवं अनुबंध खेती की आर्थिक एवं दक्षता स्तर में तुलना करने के लिए पश्चिम बंगाल के किसानों के खेतों में सर्वेक्षण किए गए। तुलनात्मक अध्ययन के दौरान कुफरी ज्योति की पैदावार अटलांटिक किस्म से अधिक प्राप्त हुई। आर्थिक स्तर पर तुलना करने पर शुद्ध आमद कुफरी ज्योति (20148/- रुपये) की अपेक्षा अटलांटिक किस्म में (30173/- रुपये) अधिक प्राप्त हुई। आलू की चुनिंदा प्रौद्योगिकियों के टेक्नोलॉजी गैप का मूल्यांकन हिमाचल प्रदेश के शिमला व बिहार के मुजफ्फरपुर और वैशाली जिले में किया



गया। कृषि क्रियाओं, कीट प्रबन्धन और स्वस्थ बीज आलू उत्पादन की तकनीकों को अपनाने के संदर्भ में शिमला में टेक्नोलॉजी गैप 45 प्रतिशत तथा मुजफ्फरपुर और वैशाली में 64 प्रतिशत रहा। पटना में जानकारी का सबसे अधिक अभाव 87 प्रतिशत एकीकृत कीट प्रबन्धन के बारे में पाया गया। प्रदर्शन प्लाटों में पिछेता झुलसा का प्रभाव 40 प्रतिशत और सफेद सुण्डी का प्रभाव 0.6 प्रतिशत पाया गया, जबकि किसानों के खेतों में इनका प्रभाव क्रमशः 50 प्रतिशत और 1 प्रतिशत था। वैज्ञानिकों की देखरेख में प्रदर्शनी खेत में उगाई गई आलू की फसल से किसान प्रति हेक्टेयर औसतन 258 क्विंटल पैदावार प्राप्त करने में सफल हुए, जबकि स्वयं के खेत में उन्हें औसतन 115.5 क्विंटल प्रति हेक्टेयर पैदावार प्राप्त हुई। विभिन्न किस्मों की पैदावार के स्तर की तुलना करने पर पैदावार में अधिकतम वृद्धि (33.33 प्रतिशत) कुफरी अशोक में जबकि उसके पश्चात् 30.9 प्रतिशत वृद्धि कुफरी पुष्कर किस्म से प्राप्त हुई। Potato Improvement Production & Utilization In Current Scenario नामक मॉडल प्रशिक्षण पाठ्यक्रम में प्रतिभागियों के आलू उत्पादन ज्ञान में कुल 13 प्रतिशत तक सुधार हुआ।

## बीज प्रौद्योगिकी

वर्ष 2007-08 के दौरान मोदीपुरम, जालन्धर, ग्वालियर, पटना, कुफरी और शिमला में 25 किस्मों के 32216 कन्डों का सूचीकरण किया गया। फसल उत्पादन की विभिन्न अवस्थाओं में 140.564 हेक्टेयर क्षेत्र से कुल 26930.37 क्विंटल आलू का उत्पादन हुआ। जिसमें से 22367.54 क्विंटल वितरित किया गया और 4562.83 क्विंटल संस्थान के विभिन्न केन्द्रों पर बीजाई के लिए रखा गया। ऊटी केन्द्र में 8.72 हेक्टेयर क्षेत्र में आलू की ग्रीष्म एवं पतझड़कालीन फसल उगाकर कुल 570.21 क्विंटल क्वालिटी बीज पैदा हुआ जिसमें से 345.40 क्विंटल विभिन्न विभागों को वितरित किया गया और बाकी बीज आलू की पतझड़ एवं ग्रीष्मकालीन फसलें उगाने के लिए प्रयोग किया गया।

वर्ष 2008-09 के दौरान 22 किस्मों एवं 2 संकर के 32788 सूचीकृत कन्डों की बुआई मोदीपुरम, जालन्धर, ग्वालियर, पटना, कुफरी में की गई तथा शिमला में मणीपुर सरकार के लिए 1440 कन्डों का सूचीकरण किया गया। विभिन्न अवस्थाओं में 133.585 हेक्टेयर क्षेत्र से कुल 26502.67

क्विंटल पैदावार प्राप्त हुई। शीत ऋण्डारों में रखने से पूर्व इसमें से 22848.91 क्विंटल बीज मैदानी क्षेत्रों से तथा 564.49 क्विंटल बीज पहाड़ी क्षेत्रों से वितरित किया गया। केन्द्रीय आलू अनुसंधान केन्द्र, शिलांग में 6.157 हेक्टेयर क्षेत्र से 565.19 क्विंटल क्वालिटी बीज का उत्पादन हुआ जिसमें से 195.17 क्विंटल वितरित किया गया।

संस्थान के मुख्यालय, शिमला एवं परिसर, मोदीपुरम में आलू की विभिन्न किस्मों के कुल 10,162 माइक्रोट्यूबर और 48,277 *इन विट्रो* पौधों का उत्पादन हुआ। माइक्रोप्लांट, माइक्रोट्यूबर, मिनीट्यूबर एवं 3 ग्राम से कम कन्डों के रिसाइक्लिंग द्वारा कुल 868585 कन्ड पैदा हुए। जनरेशन 1 में 5.371 हेक्टेयर से कुल 1127.93 क्विंटल, जबकि जनरेशन 2 में 15.24 हेक्टेयर से कुल 3586.06 क्विंटल पैदावार प्राप्त हुई। शिलांग में कुल 565.19 क्विंटल में से 178.47 क्विंटल क्वालिटी बीज टिशू कल्चर से पैदा हुआ।

वर्ष 2007-08 के दौरान मोदीपुरम, जालन्धर, ग्वालियर, पटना और कुफरी में कन्ड सूचीकरण के समय स्वास्थ्य मानक क्रमशः 97, 98, 96, 97 और 97 प्रतिशत तथा फील्ड अवस्था 1 के दौरान क्रमशः 84, 99, 96, 87 और 79 प्रतिशत था। जबकि वर्ष 2008-09 के दौरान जालन्धर, ग्वालियर, पटना और कुफरी में स्वास्थ्य मानक क्रमशः 95, 98, 97 और 88 प्रतिशत, एवं फील्ड अवस्था 1 के दौरान क्रमशः 90, 98, 97 और 98 प्रतिशत था।

बीज अनुसंधान के अन्तर्गत विभिन्न केन्द्रों पर बीज आलू की बसन्तकालीन फसल से उत्पन्न बीज से पतझड़कालीन फसल उगाने की संभावनाओं का अन्वेषण, मिनी ट्यूबर के गुणन हेतु स्पेसिंग और उर्वरकों का प्रभाव, जैविक और अजैविक खेती का अध्ययन और भण्डारण एवं खेत (फील्ड) में CCC आदि के प्रभावों का अध्ययन किया गया। जैविक खेती के अतिरिक्त अन्य परीक्षणों के परिणाम उत्साहवर्धक पाए गए। कुफरी ज्योति में *इन विट्रो* प्रदर्शन जांचने के लिए परीक्षण किया गया और पाया गया कि सुक्रोज में ऐगर के स्थान पर फाइटाजेल मिलाने से अच्छे परिणाम मिलते हैं।

## फसल उत्पादन

आलू आधारित फसल चक्र प्रणालियों के अन्तर्गत अध्ययनों से ज्ञात हुआ कि शिमला में आलू+फ्रेंच बीन (1:1



अनुपात) की अन्तःफसल प्रणाली में फ्रेंच बीन को 75 प्रतिशत नाइट्रोजन की आवश्यकता पड़ती है। इसी फसल प्रणाली में ऊटी में आलू के सिस्ट सूत्रकृमियों की संख्या में 20 प्रतिशत तक कमी पाई गई। कुल उत्पादकता की दृष्टि से ऊटी में आलू+बाकला (Broad Bean) की (1:1 अनुपात में) अन्तःफसल प्रणाली भी फायदेमंद पाई गई। पटना में आलू+रबी मक्का की अन्तःफसल प्रणाली के अन्तर्गत मक्का तथा आलू की बीजाई एक साथ करना लाभदायक रहा। जालन्धर में आलू+लहसुन-मिंडी का फसल चक्र सबसे अधिक लाभकारी रहा। इसके अलावा आलू-मिंडी, आलू+मटर+मिंडी, आलू+गेहूं तथा आलू+मसूर+मिंडी के फसल चक्र लाभदायी पाए गए। ग्वालियर में आलू+मटर की अन्तःफसल के अन्तर्गत जब आलू की बुआई मेंड़ों पर और मटर की बुआई मेंड़ों के दोनों ओर आड़े-तिरछे की गई तो आलू की पैदावार अधिकतम (29 टन प्रति हेक्टेयर) हुई। ग्वालियर में एक अन्य परीक्षण में 40x10 सें.मी. की दूरी पर 25 ग्राम आकार के बीज कन्दों को लगाने से प्रति हेक्टेयर क्रमशः 10-20 ग्राम के 7.15 लाख और कुल 16.3 लाख कन्द पैदा हुए। मोदीपुरम में 67.5x15 सें.मी. तथा 67.5x20 सें.मी. की दूरी पर बीजाई करने की अपेक्षा 60x15 सें.मी. की दूरी पर बीजाई करने से बीज आकार एवं कुल कन्द पैदावार सर्वाधिक प्राप्त हुई।

आलू बीजाई की सही तिथि, किस्म एवं फसलावधि जानने हेतु कम्प्यूटर सहायी आलू फसल अनुसूची प्रणाली नामक कम्प्यूटरीकृत प्रणाली विकसित की गई। इस प्रणाली में INFOCROP-POTATO मॉडल द्वारा 1047 स्थानों पर आलू की 10 विभिन्न किस्मों को 5 अलग-अलग बीजाई तिथि में 60, 70, 80 एवं 90 दिनों के बाद की पैदावार लेकर डाटाबेस तैयार किया गया। इस डाटाबेस द्वारा पहले राज्य व जिले में, फिर जिले से स्थान विशेष का चयन कर बीजाई का समय मालूम किया जा सकता है।

देश के विभिन्न हिस्सों में आलू के विधायन हेतु अनुकूल किस्में उगाने के लिए उपयुक्त क्षेत्रों, पाला संभावित क्षेत्रों एवं पठारी क्षेत्रों में आलू की संभावित पैदावार के लिए विषयक मानचित्र (Thematic Map) बनाया गया। अनुकूल तापमान, कटाई सूचकांक, अनुमानित कुल पैदावार आदि के आधार पर आलू उत्पादन मौसम का निर्धारण किया गया व विषयक मानचित्र बनाए गए।

वर्ष 2008-2009 के दौरान पंजाब, उत्तर प्रदेश, बिहार एवं पश्चिमी बंगाल राज्यों में शीतकालीन आलू के क्षेत्र और उत्पादन का आंकलन करने के लिए रिमोट सेंसिंग, जी.आई.एस. और क्रॉप मॉडलिंग तकनीक का इस्तेमाल किया गया। इस तकनीक द्वारा उपरोक्त राज्यों में आलू क्षेत्र क्रमशः 74.7, 447.4, 181.7 एवं 386.7 हजार हेक्टेयर जबकि आलू उत्पादन क्रमशः 519, 9252, 2010 एवं 8055 हजार टन आंकलित किया गया। इन चार राज्यों के आंकलित अनुमानों के आधार पर अखिल भारतीय आलू उत्पादक क्षेत्र एवं उत्पादन क्रमशः 1329.3 हजार हेक्टेयर और 23717.5 हजार टन आंकलित किया गया।

जलवायु परिवर्तन के प्राथमिक विश्लेषणों से पता चला कि पंजाब, हरियाणा और पश्चिमी उत्तर प्रदेश में वर्ष 2020 और 2050 में आलू उत्पादकता में क्रमशः 9 प्रतिशत और 11 प्रतिशत वृद्धि होने की संभावना है। जबकि अन्य राज्यों में वर्ष 2020 में उत्पादकता दर में 3 से 19 प्रतिशत तक और वर्ष 2050 में 5 से 44 प्रतिशत तक कमी हो सकती है। परिणामस्वरूप समस्त भारत के आलू उत्पादन में वर्ष 2020 में 9.56 प्रतिशत और वर्ष 2050 में 16.66 प्रतिशत तक कमी हो सकती है।

एकीकृत पोषक एवं जल प्रबन्धन कार्यक्रम के अन्तर्गत किए गए अनुसंधान परिणामों से यह ज्ञात हुआ कि जालन्धर में जेएक्स 576 नामक संकर में नाइट्रोजन, फास्फोरस व पोटेशियम (NPK) के प्रति उच्च स्तर की सहिष्णुता पाई गई। बिना NPK डाले तथा अधिकतम पैदावार के लिए आवश्यक NPK की मात्रा डालने से हुए उत्पादन के आधार पर यह संकर कुफरी पुखराज, कुफरी पुष्कर, कुफरी बादशाह और कुफरी ज्योति की तुलना में NPK उपयोग में अधिक सक्षम था। जिन मृदाओं में NPK की मात्रा कम थी वहां कुफरी सूर्या किस्म के लिए नाइट्रोजन, फास्फोरस व पोटेशियम की अनुकूलतम मात्रा प्रति हेक्टेयर 178 कि.ग्रा. नाइट्रोजन, 104 कि.ग्रा. फास्फोरस और 139 कि.ग्रा. पोटाश रही। ऊटी में कुफरी गिरिराज के बीज आकार (25-75 ग्राम भार) कन्दों की अधिकतम प्राप्ति के लिए अनुकूलतम पोषक तत्वों की मात्रा प्रति हेक्टेयर 75 कि.ग्रा. नाइट्रोजन, 135 कि.ग्रा. फास्फोरस और 75 कि.ग्रा. पोटाश, जबकि

कुफरी स्वर्ण के लिए प्रति हेक्टेयर 60 कि.ग्रा. नाइट्रोजन, 112.5 कि.ग्रा. फास्फोरस और 75 कि.ग्रा. पोटाश रही।

आलू की अधिक पैदावार प्राप्ति के लिए नालियों या कूंडों में 20 मिलीमीटर जल स्तर तक सिंचाई करने पर संचयी कड़ाह वाष्पीकरण, जबकि ड्रिप एवं स्प्रिंकलर सिंचाई के अन्तर्गत जल स्तर CPE 125 प्रतिशत रखना अनुकूलतम पाए गए। तिहरी पंक्तियों वाली ऊंची-ऊंची क्यारियों में आलू की बुआई करके कूंडों या नालियां बनाकर सिंचाई करने की अपेक्षा उसमें ड्रिप और स्प्रिंकलर (टपका और फव्वारे) विधि से सिंचाई करने से पैदावार अधिक हुई, साथ ही इससे 40-50 प्रतिशत तक सिंचाई जल की बचत भी हुई।

मोदीपुरम में लम्बी अवधि के खादों/उर्वरकों के परीक्षणों में आलू समतुल्य पैदावार (PEY) के संबंध में फसल उत्पादकता चक्र के अन्तर्गत मक्का-आलू-प्याज (76.5 टन/हेक्टेयर) में सबसे अधिक पैदावार, जबकि इसके पश्चात् चावल-आलू-गेहूं (54.7 टन/हेक्टेयर) के फसल चक्र में प्राप्त हुई। आलू समतुल्य पैदावार सबसे कम तिल-आलू-मूंग के फसल चक्र में (36.5 टन/हेक्टेयर) दर्ज की गई। जैविक उपचारों की अपेक्षा अजैविक उपचारों में चक्र प्रणाली उत्पादकता में 25-51 प्रतिशत वृद्धि दर्ज हुई।

खेत में फसल के अवशेषों को मिलाने एवं जैविक खादों को डालने से कार्बनिक कार्बन एवं नाइट्रोजन खनिजों में सुधार हुआ। शतप्रतिशत कार्बनिक स्रोतों से पोषण करने से शुष्क पदार्थ की मात्रा में वृद्धि हुई। फसल अवशेषों को खेत में मिलाने से अवकारक और गैर अवकारक शर्करा में मामूली कमी आई। जैविक खाद को खेत में डालने से मिट्टी के कार्बनिक कार्बन, उपलब्ध नाइट्रोजन, फास्फोरस एवं पोटेशियम जैसे गुणों में तो सुधार हुआ परन्तु इससे आमासी घनत्व (bulk density) में कमी हुई।

आलू उत्पादन के यन्त्रीकरण में क्रम्बलर रोलर सहित रोटेरी टिल्लर का निर्माण किया गया। रोटेरी-टिल्लर द्वारा एक घण्टे में 0.26 हेक्टेयर क्षेत्र में जुताई की जा सकती है। इस प्रकार इसकी गति प्रति घण्टे 2.0 से 3.5 किलोमीटर रही। मानवीय श्रम एवं इंजन चालित निरन्त (endless) सक्रीन टाइप पोटेटो ग्रेडर का निर्माण किया गया। इस मशीन को फ्लाई

व्हील लगाकर श्रमिक द्वारा चलाने से एक घण्टे में औसतन 2.5 टन आलुओं का वर्गीकरण हुआ। लेकिन जब इसे 3.5 अश्वशक्ति इंजन से चलाया गया तो इससे प्रति घण्टा 45 विंटल आलुओं का वर्गीकरण हुआ और वह भी बहुत ही कम या बिना खर्च के।

आलुओं को छीलने वाले विभिन्न प्रकार के अपघर्षकों में आधार प्लेट परफोरेटेड शीट से बनाने और साथ लगते हिस्से को इसी प्रकार के अन्य तत्वों से बनाने पर अपघर्षक या छीलने का यन्त्र बेहतर पाया गया और इसकी पहचान कम लागत में विकसित आलू छीलने वाले यन्त्र के रूप में हुई।

बीज आलू उत्पादन और प्रदर्शन के लिए एक मिनी एरोपोनिक प्रोटोटाइप का डिजाइन (खाका) और निर्माण किया गया। ब्रीडर सीड-II उत्पादन के लिए आलू डिगर में और सुधार किया गया और इसके कार्य निष्पादन की तुलना रुढ़िवादी पुराने पोटेटो डिगर से की गई।

## फसल दैहिकी, जीव रसायन एवं फसलोत्तर प्रौद्योगिकी

लोगों की स्वास्थ्य के प्रति बढ़ती जागरूकता को ध्यान में रखते हुए आलू चिप्सों में तेल की मात्रा कम करना आवश्यक हो गया है। 0.5 प्रतिशत कैल्शियम क्लोराइड अथवा 0.5 प्रतिशत मैगनीशियम क्लोराइड के साथ उपचार करने के साथ-साथ चिप्सों को 70 डिग्री सेल्सियस तापमान पर 2 मिनट तक ब्लांच करके तलने से चिप्सों में तेल की मात्रा कम पाई गई। मेघालय में लगने वाली आलू की पांच स्थानीय किस्मों में से 'लाह सौ खासी' के स्टार्च में एमाइलोज के अंश कम जबकि विस्कोसिटी एवं फूलने की क्षमता अधिक पाई गई। मोदीपुरम में भी आलू की मुख्य फसल के कन्दों से प्राप्त स्टार्च में विस्कोसिटी एवं फूलने की क्षमता अधिक पाई गई, जबकि जल्दी निकाली गई फसल के स्टार्च के घोल की पारदर्शिता अधिक पाई गई। आलू की 13 किस्मों/संकर किस्मों से स्टार्च निकाला गया। स्टार्च की प्राप्ति कन्दों के शुष्क पदार्थ के अनुसार ही पाई गई। 23 प्रतिशत शुष्क पदार्थ वाली कुफरी चिप्सोना-3 किस्म के ताजे खोदे आलुओं से 12.47 प्रतिशत स्टार्च की प्राप्ति हुई। आलुओं के 100 दिनों तक गड्ढों में भण्डारण के उपरान्त उनसे तैयार फ्रोजन फ्रेंच

फ्राइज की संरचना का मूल्यांकन करने पर यह ज्ञात हुआ कि कुफरी सूर्या से तैयार फ्रेंच फ्राइज की संरचना अधिक कठोर (1076 जी फोर्स) जबकि कुफरी चिप्सोना-1 (811 जी फोर्स) एवं कुफरी चिप्सोना-3 (907 जी फोर्स) की संरचना कम कठोर पाई गई। उद्योगों एवं घरों में आलू के उत्पादों को बनाते समय पोषक तत्वों में होने वाले ह्रास का अध्ययन किया गया।

अध्ययन से ज्ञात हुआ कि जिस ढंग से फ्लैक्स और चिप्स तैयार किए जाते हैं, उससे अवकारक शर्करा, सुक्रोज, फ्री एमिनो एसिड, टोटल फीनोल और घुलनशील प्रोटीन का काफी ह्रास हो जाता है। आलुओं को प्रेशर कुकर और माइक्रोवेव द्वारा पकाने पर घुलनशील प्रोटीन और टोटल केरोटिन में तो वृद्धि पाई गई, परन्तु इससे सुक्रोज, फ्री एमिनो एसिड, टोटल फीनोल और एस्कार्बिक एसिड में कमी हुई। मनुष्य के लिए एक्रिलामाइड विषाक्त या टॉक्सिस हो सकती है, इस रिपोर्ट को ध्यान में रखते हुए आलू की 26 भारतीय किस्मों से तैयार चिप्सों में एक्रिलामाइड की मात्रा को निकाला गया। एक्रिलामाइड की सबसे कम मात्रा कुफरी चिप्सोना-1 (65 म्यूग्राम/कि.ग्रा.) एवं कुफरी चिप्सोना-2 में (82 म्यूग्राम/कि.ग्रा.) पाई गई, जबकि सबसे अधिक कुफरी कंचन (1177 म्यूग्राम/कि.ग्रा.) एवं कुफरी आनन्द में (1096 म्यूग्राम/कि.ग्रा.) पाई गई। एक्रिलामाइड अंशों का सीधा संबंध चिप्स की रंगत के साथ ( $r=0.52$ ) पाया गया।

CIPC के उपयोग द्वारा आलुओं को ढेर लगाकर भण्डारित करने की सुधरी तकनीक (जिसमें प्रति टन आलुओं को 40 मिलीलीटर CIPC के घोल से उपचारित किया जाता है) का पंजाब के चार गांवों में सफलतापूर्वक प्रदर्शन किया गया जिससे भोज्य एवं विधायन के लिए उपयुक्त आलुओं को अल्पावधि के लिए भण्डारित किया गया। ऐसा करने से किसानों को अनुपचारित आलुओं की अपेक्षा कुफरी पुखराज किस्म का 6.5 प्रतिशत अधिक वजन प्राप्त हुआ व उन्हें 35 प्रतिशत अधिक लाभ की प्राप्ति हुई, साथ ही अंकुरण को हटाने हेतु लगने वाले श्रम की लागत भी बच गई। सतनाम एग्री प्रॉडक्ट्स लिमिटेड, जालन्धर की प्रोसेसिंग इन्डस्ट्री के सहयोग से कुफरी चिप्सोना-1 को 45 दिनों तक भण्डारित करने पर अवकारक शर्करा की मात्रा में कमी व चिप्स की रंगत

में सार्थक सुधार पाया गया। जून माह के अन्त तक भण्डारित आलुओं से बढ़िया किस्म के फ्लैक्स एवं फ्रेंच फ्राइज बनाए जा सके। मिथानोल में अंकुर रोधक (CIPC) ऊर्जा (Oorja) को घोल कर उपचारित करने से कम सान्द्रता (10-40 मिलीलीटर/टन) पर भी 120 दिनों तक आलू अंकुरण रहित पाए गए, जबकि इसको पानी में मिलाकर छिड़काव करना अधिक प्रभावकारी साबित नहीं हुआ। साथ ही कन्दों में गलन बढ़ गई व ढेर एवं गड्ढों में भण्डारित कुफरी पुष्कर किस्म के आलुओं में अंकुरण भी हो गया। सात महीनों तक 12 डिग्री सेल्सियस तापमान पर भण्डारित आलुओं से तैयार चिप्सों में सबसे अधिक हंटर स्कोर कुफरी चिप्सोना-2 किस्म के चिप्सों में पाया गया जो कि सर्वाधिक स्वीकार्य रहा जबकि कुफरी हिमसोना और कुफरी सूर्या किस्म से तैयार चिप्सों में हंटर स्कोर इससे कम पाया गया। 90 दिनों के भण्डारण के उपरान्त सबसे अधिक कुल भार ह्रास एमपी/03-396 (12.9 प्रतिशत) में व इसके पश्चात् एमपी/आरके-516 (13.1 प्रतिशत) एवं एमपी/01-916 (15.4 प्रतिशत) में दर्ज किया गया। आलू की चार किस्मों को 8, 10 व 12 डिग्री सेल्सियस तापमान पर 90 दिनों तक भण्डारित करने के पश्चात् किसी भी किस्म से स्वीकार्य गुणवत्ता वाले चिप्स नहीं प्राप्त हुए। प्राकृतिक रूप से तैयार होने वाले डायफेनेलायाइन नामक रसायन के उपचार द्वारा बिना किसी गलन वृद्धि के 90 दिनों तक आलुओं में अंकुरण को रोका जा सका।

कांच घर में ऊष्मा सहनशीलता परखने के लिए चार संकरों का मूल्यांकन कर 187 पुंजकों का चयन किया गया। मोदीपुरम के खेतों में एफ<sub>1</sub>सी<sub>1</sub> अवस्था में 567, एफ<sub>1</sub>सी<sub>2</sub> अवस्था में 30, एफ<sub>1</sub>सी<sub>3</sub> अवस्था में 45 और एफ<sub>1</sub>सी<sub>4</sub> अवस्था में 21 पुंजकों का चयन आगामी मूल्यांकन हेतु किया गया। जल के तनाव (वाटर स्ट्रेस) का मूल्यांकन करने के लिए 42 संकरों में से आगामी मूल्यांकन हेतु 34 संकरों का चयन किया गया। कुफरी सूर्या किस्म की अनुकूलतम पैदावार प्राप्ति हेतु उर्वरकों की मात्रा का प्रति हेक्टेयर के हिसाब से निर्धारण किया गया जो कि जालन्धर में 178 कि.ग्रा. नाइट्रोजन, 104 कि.ग्रा. फास्फोरस और 139 कि.ग्रा. पोटाश रही जबकि मोदीपुरम में यह मात्रा 300 कि.ग्रा. नाइट्रोजन, 80 कि.ग्रा. फास्फोरस और 100 कि.ग्रा. पोटाश प्रति हेक्टेयर रही।



## फसल सुधार

अन्तर्राष्ट्रीय आलू केन्द्र, लीमा पेरू, आलू जीनकोष, संयुक्त राज्य अमेरिका और स्कॉटिश फसल अनुसंधान संस्थान, ब्रिटेन से कृषि योग्य व जंगली प्रजातियों के वांछित जननद्रव्य प्राप्तियों/पैतृक जातियों को मंगवाकर जनन द्रव्य (जर्मप्लाज्म) संग्रहण में वृद्धि की गई। इस प्रकार आलू के राष्ट्रीय जीनकोष में जननद्रव्य प्राप्तियों की संख्या 3800 से अधिक हो गई है, जिन्हें ऊतक संवर्धन विधि, खेतों में एवं सत्य बीज के रूप में सम्प्रेषित किया जा रहा है। कई जननद्रव्य प्राप्तियों का ऊतक संवर्धन विधि से कन्दों में रूपान्तरण किया गया और उन्हें विषाणुओं से मुक्त किया गया ताकि उन्हें प्रजनन कार्यक्रमों में इस्तेमाल किया जा सके। आलू की कई जंगली किस्मों सहित जननद्रव्य प्राप्तियों की एक बड़ी संख्या का कई महत्वपूर्ण गुणों जैसे शीत-प्रेरित मिठास, शाकाणु मुरझान, स्टेम नेक्रोसिस, विषाणुओं, कन्द शलम कीट इत्यादि की प्रतिरोधिता एवं पिछेता झुलसा के प्रति प्रतिरोधिता के लिए मूल्यांकन किया गया। आलू प्रजनन द्वारा अल्पावधि में पककर तैयार होने योग्य एण्डीजीना पुंजकों का विकास किया गया। ट्यूबरोसम, एण्डीजीना और जंगली प्रजातियों के कम्प्यूटर डाटाबेस का अद्यतन किया गया।

भारतीय मैदानों के लिए कुफरी ख्याति किस्म जारी की गई। अल्पावधि में पककर तैयार होने वाली, इस किस्म के कन्द सफेद, अण्डाकार और अंखुए उथले होते हैं। इसके अलावा यह किस्म पिछेता झुलसा की कुछ प्रतिरोधी भी है। भारत के पहाड़ी इलाकों के लिए कुफरी गिरधारी किस्म को जारी किया गया। मध्यावधि में तैयार होने वाली इस किस्म में पिछेता झुलसा प्रतिरोधिता उच्च स्तर की है। उथले अंखुओं सहित इसके कन्द सफेद, अण्डाकार-लम्बे होते हैं। कई वर्षों तक अच्छे प्रदर्शन के आधार पर केन्द्रीय आलू

अनुसंधान केन्द्र, जालन्धर से दो, केन्द्रीय आलू अनुसंधान संस्थान परिसर, मोदीपुरम से एक एवं केन्द्रीय आलू अनुसंधान केन्द्र, पटना से तीन संकरों (अग्रवर्ती संकरों) को अखिल भारतीय समन्वित अनुसंधान परियोजना (आलू) में शामिल करने के लिए प्रस्ताव प्राप्त हुए।

संस्थानीय स्तर पर फ्रेंच फ्राइज़ विधायन युक्त संकर एमपी/98-71 को कुफरी फ्राइसोना के नाम से जारी किया गया।

सफेद, लम्बाकार कन्दों एवं उथले अंखुओं वाली इस किस्म में शुष्क पदार्थ की मात्रा अधिक एवं अवकारक शर्करा कम होती है। एमपी/01-916 नामक एक अन्य संकर को चिप्स बनाने के लिए उपयुक्त पाया गया क्योंकि इसमें शुष्क पदार्थ अधिक, अवकारक शर्करा कम एवं एक समान बड़े आकार के कन्दों की पैदावार अधिक होती है।

पूर्वी भारत में सत्य आलू बीज की बढ़ती मांग को ध्यान में रखते हुए 92 पीटी-27 सन्तति (4.00 कि.ग्रा. सत्य आलू बीज) सहित कुल 37 संकरों का 7.40 कि.ग्रा. सत्य आलू बीज पैदा किया गया। सत्य आलू बीज की कई नई विकसित सन्ततियों में से पीटी/08-109 और पीटी/08-112 की पैदावार विद्यमान कन्ट्रोल किस्मों की पैदावार से अधिक प्राप्त हुई। गत वर्षों के अनुसंधान अध्ययनों के परिणामों से यह सुनिश्चित हुआ कि सत्य आलू बीज को 40 डिग्री सेल्सियस तापमान पर 3-4 माह तक भण्डारण करने से अंकुरण निर्गमन एवं अंकुरण सूचकांक में वृद्धि होती है। इसी प्रकार गत वर्ष के अनुसंधान से यह पाया गया कि पौध वृद्धि अवरोधक पेक्लोब्युट्रजोल (25 ppm) के इस्तेमाल से प्ररोह की ऊंचाई एवं जड़ की लम्बाई में कमी होती है, अतः पनीरी की रोपाई के पश्चात् इसकी जीविता दर में सुधार लाने के लिए इसे प्रयोग किया जा सकता है।

पिछेता झुलसा रोग प्रतिरोधी किस्मों के विकास हेतु, जंगली प्रजाति *एस. बलबोकास्टानम* से लिए गए RB जीन को कुफरी बहार व कुफरी ज्योति किस्मों में RB ट्रांसजेनिक कताहदिन से संकरण द्वारा स्थानान्तरित किया गया। इस प्रकार कुफरी ज्योति के 50 और कुफरी बहार के 22 प्रतिरोधक पुंजकों का चयन किया गया। RB जीन से सीधे कुफरी ज्योति व कुफरी बहार किस्मों को परिवर्तित किया गया तथा कुफरी ज्योति के 6 और कुफरी बहार के 4 पुंजकों का चयन किया गया। विधायन के लिए उपयुक्त किस्म कुफरी चिप्सोना-1 के Invertase RNAi gene construct द्वारा बनाए गए ट्रांसजेनिक पुंजकों को 4 डिग्री सेल्सियस पर 45 दिनों तक भण्डारण करने के बाद, चिप्स बनाने पर 6 पुंजकों को आशाजनक पाया गया और उनका चयन किया गया। कुफरी चिप्सोना-1, कुफरी चिप्सोना-3 और कुफरी सूर्या किस्मों को ami RNA जीन के साथ रूपान्तरित किया गया जिससे

UDP-glucose Pyrophosphorylase और vacuolar acid invertase genes को निष्क्रिय करना अपेक्षित है।

शाकाणु मुरझान प्रतिरोधिता के लिए कुफरी गिरिराज किस्म के 20 अपेक्षित पुंजकों का चयन किया गया। ये पुंजक आत्र B-defensin जीन द्वारा रूपान्तरित हैं। कुफरी बादशाह को आलू की शीर्ष पत्ती मुड़न विषाणु की प्रतिरोधिता प्रदान करने वाले replicase gene द्वारा रूपान्तरित कर, 12 सुनिश्चित ट्रांसजेनिक पुंजकों की पहचान की गई। आलू को PVY प्रतिरोधिता देने वाले RYadg जीन से सहलग्नित SCAR चिह्नक का प्रयोग करके एक पैतृक पुंजक की पहचान की गई जिसमें यह जीन त्रिविध रूप में उपलब्ध है।

## पौध संरक्षण

सात जननद्रव्य एकसैशनों से प्राप्त 192 पुंजकों को PSTVd मुक्तता के लिए जांच की गई जिनमें से CP-1391 के 20, CP-1574 के 12 एवं CP-3083 के एक पुंजक (मेरीक्लोन) के अतिरिक्त शेष सभी पुंजक PSTVd से ग्रसित पाए गए। अन्तर्राष्ट्रीय आलू केन्द्र, लीमा, पेरू से आयातित जननद्रव्यों के 57 एकसैशन PSTVd से मुक्त पाए गए। IEM परीक्षण में K-22 के तीन, J-93-86 के समस्त (8) एवं गुलमर्ग स्पैशल का एक जननद्रव्य विषाणु मुक्त पाए गए। 23 जननद्रव्य एकसैशनों के 33 पुंजकों और कुफरी स्वर्ण के 2 पुंजकों का परीक्षण किया गया जिनमें से जननद्रव्यों के पुंजक तो विषाणु मुक्त पाए गए, परन्तु कुफरी स्वर्ण में अभी तक PVS का ग्रसन पाया गया। 10 जननद्रव्य पुंजकों (CP-1829, 2217, 2307, 3146, 3165, 3533, 3756, 3762, 3764 और 3765) में PVX और PVY की स्थिर प्रतिरोधिता दूसरे वर्ष भी लगातार पाई गई। Endophytes की उपस्थिति जांचने के लिए 21 किस्मों के *इन विट्रो* स्टॉक की जांच की गई। सभी में समान कल्चरल और जैव रसायनिक गुणों सहित ग्राम ऋणात्मक बेसीलाई (gram negative bacilli) पाए गए, परन्तु इनमें से किसी में भी कोई फफूंद या पेक्टोलाइटिक जीवाणु नहीं थे। स्थानीय मण्डी से प्राप्त (न कि के.आ.अ.सं. द्वारा उत्पादित मिनी कन्दों) आलू कन्दों में पेक्टोलाइटिक बैक्टीरियम (*पेक्टोबैक्टीरियम एट्रोसेप्टिका*) पाया गया। PVA और PVS को जांचने के लिए RT-PCR के परिणामों को IEM एवं das-ELISA के

परिणामों से तुलना कर वैध बनाया गया; RT-PCR की विश्वसनीयता IEM के बराबर, लेकिन जहां कहीं कुछ मिथ्या या अयथार्थ घनात्मक परिणाम प्राप्त हुए वहां यह das-ELISA से भी अधिक विश्वसनीय पाई गई। PVX<sub>MS</sub>, PVX<sub>HB</sub> और PVS<sup>A</sup> के लेपित प्रोटीन जीन को क्रमबद्ध किया गया और PVS<sup>A</sup> (FJ 643622) और PVX<sup>0</sup> (FJ 643623) के क्रम को NCBI जीन बैंक के पास विचारार्थ भेजा गया।

खरीफ मौसम के दौरान कर्नाटक राज्य के हासन और चिकमंगलूर जिलों में पिछेता झुलसा रोग से लगभग 66.8 प्रतिशत आलू फसल का नुकसान हुआ। रबी मौसम में पिछेता झुलसा रोग का प्रभाव सर्वप्रथम उत्तर प्रदेश के तराई के इलाकों में दिसम्बर के प्रथम सप्ताह में देखा गया जो बाद में पश्चिमी उत्तर प्रदेश के अन्य हिस्सों में फैल गया। जनवरी के अन्तिम सप्ताह में अचानक पिछेता झुलसा रोग फैलने से 15-40 प्रतिशत फसल का नुकसान हुआ। ऐसी ही स्थिति पश्चिम बंगाल और बिहार में भी हुई लेकिन पंजाब राज्य अपेक्षाकृत रोग मुक्त रहा। बायोलॉजिकल मार्कर, जैसे कि मेटिंग टाइप, मेटालेक्सल रसिस्टेंस और फिजियोलॉजिकल रिसज के संदर्भ में *पी.इन्फेस्टांस* के पैटर्न लगभग पिछले वर्ष के समान ही रहे। फफूंदनाशकों की आवश्यकतानुसार मूलभूत मात्रा के इस्तेमाल एवं फसल हास मूल्यांकन के मॉडल अच्छे पाए गए और इन्हें पिछेता झुलसा प्रबन्धन के लिए DSS के साथ एकीकृत किया जा सकता है। पिछेता झुलसा रोग पर नियन्त्रण पाने के लिए एक प्रभावकारी वानस्पतिक इथाइल एसिटेक अंश का अपरिष्कृत (कच्चा) और प्रवण (ग्रेडिंट) सत्त (extract) बहुत ही प्रभावकारी पाया गया। एजोक्सीस्ट्रोबिन 23SC, फेनामिडोन 10 प्रतिशत+मेंकोजेब 50 प्रतिशत, साईमोक्सानिल 8 प्रतिशत+मेंकोजेब 64 प्रतिशत नामक नए फफूंदनाशक पिछेता झुलसा पर नियन्त्रण पाने के लिए अधिक प्रभावकारी पाए गए। इस वर्ष के दौरान F<sub>1</sub>C<sub>1</sub> से F<sub>1</sub>C<sub>4</sub> की पॉपुलेशन से 600 से अधिक सीडलिंग और 128 जीन प्रकारों का चयन किया गया, जिनसे पिछेता झुलसा रोग नियन्त्रण हेतु आगामी अनुसंधान/अध्ययन किए जा सकें। जांच के दौरान पहाड़ी संकर SM/00-42 उपोष्ण के मैदानी इलाकों में उगाने के लिए सबसे अधिक उपयुक्त पाई गई। 64 AFLP प्राइमर कम्बीनेशन विधि का प्रयोग करके *सोलेनम स्पेगाजिन्नी* और *सोलेनम*



चैकॉइंस के मैपिंग पॉपुलेशन के बहुरूपियों के प्रभावों का अध्ययन किया गया। कुल 4002 Loci का विस्तार किया गया जिसमें से 67 प्रतिशत (अर्थात् 2698) बहुरूपी पाए गए। त्रिविध और चतुर्विध अवस्था में PVY की चरम प्रतिरोधिता युक्त पैतृक वंशजों को विकसित करने के प्रयास किए गए जिसके अन्तर्गत बहुविध पुंजकों और PVY सुग्राही किस्मों/संकर (शून्य विध) के बीच पांच परीक्षण क्रॉस बनाए गए। YY-6/3-C11 त्रिविध की तरह पाई गई और इसे PVY के चरम प्रतिरोधक किस्मों को विकसित करने के लिए इस्तेमाल किया जाएगा।

कुफरी पुष्कर और कुफरी आनन्द किस्मों में 'रसैट स्कैब' के प्रति उच्च प्रतिरोधिता पाई गई। इसके अलावा 1187, 1243, 1349, 1388, 1418 तथा 1476 नामक छः एक्सैशनों में भी प्रतिरोधिता उच्च स्तर की पाई गई। रसैट स्कैब पर नियन्त्रण पाने के लिए मध्य मई से मध्य जून माह तक खेत को धूप में 'सूर्यभिवर्तन' करना बेहतर पाया गया। कन्ट्रोल की अपेक्षा स्ट्रेप्टोसाइक्लीन (0.05 प्रतिशत) और औरीओफन्जीन (0.02 प्रतिशत) एवं खेत में ब्लीचिंग पॉउडर के साथ उपचार करने से रसैट स्कैब में क्रमशः 9.4, 16.7 एवं 24.1 प्रतिशत अधिक नियन्त्रण हुआ।

राइजोक्टोनिया सोलानी के नियन्त्रण हेतु बैसिलस सबटिलिस को बोरिक एसिड के साथ एकीकृत कन्द उपचार योगवाही (Synergistic) पाया गया। काली रूसी रोग पर नियन्त्रण पाने के लिए विन्का रोसिया (*Vinca rosea*), ऑसिमम केनम (*Ocimum canum*) और विथानिया सोमनीफेरा (*Withania somnifera*) नामक वनस्पतियों (1:3 W/V अनुपात) से कन्दों को उपचारित करना प्रभावकारी पाया गया। खुदाई के पश्चात् गड़बों में 1 माह तक भण्डारित जिन कन्दों में शुष्क गलन (dry rot) का संक्रमण हो गया था, बोरिक एसिड द्वारा उपचार करने पर उनमें किसी प्रकार की कमी नहीं आई।

राइजोक्टोनिया सोलानी के 30 वियुक्तों को आगामी अध्ययन के लिए एकत्रित किया गया। बैसिलस सबटिलिस B<sub>5</sub> को धान की फसल में डालने से चावल की पूसा सुगन्धा और पूसा बासमती-1 की पैदावार (कन्ट्रोल की पैदावार की अपेक्षा) प्रति

हेक्टेयर 36 क्विंटल से बढ़कर क्रमशः 46.0 क्विंटल और 42.8 क्विंटल प्राप्त हुई।

हिमाचल की कांगड़ा घाटी के भण्डारों में CIPC और अन्य प्रदूषण मुक्त संघटकों के जैविक प्रभावोत्पादकता की जांच की गई। कन्दों को सात सप्ताह तक भण्डारण करने के उपरान्त जिन कन्दों को CIPC से उपचारित करके भण्डारित किया था, उनमें कन्द शलम कीट (PTM) के ग्रसन का प्रभाव 0 से 8 प्रतिशत, जबकि भण्डारित कन्दों में ग्रसन का प्रभाव 5.0 से 25.0 प्रतिशत के बीच (14 भण्डारों में 10 प्रतिशत से भी अधिक) पाया गया। केन्द्रीय आलू अनुसंधान संस्थान की लोअर लैब में 5 जून से 22 जुलाई तक 157 भृंग (बीटल) एकत्रित किए गए। इसी प्रकार फागू से दो प्रकाश प्रपंचों तथा एकान्तर परपोषी वृक्षों से 1680 भृंगों को एकत्रित किया गया। बीटल का आगमन 25 जुलाई, 2008 को हुआ तथा 25 जून (500 बीटल) और 11 जुलाई (450) को इनकी चरम संख्या देखी गई। आलू के आसपास के खेतों से सफेद सुण्डियों को पकड़ने से इनकी संख्या में अप्रत्यक्षतः कमी आई। सफेद सुण्डियों पर नियन्त्रण पाने के लिए स्थानीय क्षेत्रों में उपलब्ध सात पौधों एवं उनके सत्त को गाय के गोत्र में मिलाकर जांच की गई। इनमें से नीम के बीज की गिरी और जेट्रोपा की गिरी का सत्त (5 मि.ली./ली.) प्रभावकारी पाए गए। स्टीइनेर्नेमा कार्पोकेपसी और हेट्रोशाब्दिटिस इन्डिका द्वारा सफेद सुण्डियों की संख्या में 80 प्रतिशत तक कमी आई। इससे कन्दों के ह्रास में 55 प्रतिशत से भी अधिक कमी हुई। बीजाई के समय खेत में कारटेप हाइड्रोक्लोराइड डालने और उसके पश्चात् एसिटेमीप्रिड या थियामेथोक्साम का पर्णाय छिड़काव करने से सफेद मक्खी, पर्ण फुदका और माहू पर तो पर्याप्त नियन्त्रण हुआ परन्तु इससे बड़ी कटुकी (broad mites) पर नियन्त्रण नहीं हुआ। नीम

आधारित उत्पादों को इस्तेमाल करने से पौधों पर थ्रिप्स कीट की संख्या में (1.05-2.92/पौधा) एवं स्टेम नैक्रोसिस की तीव्रता में कन्ट्रोल (32.73 प्रतिशत) की अपेक्षा 22.75 प्रतिशत तक कमी हुई। लाल चींटी और कर्तक कीट के नियन्त्रण हेतु क्रमशः बिएवेरिया बैसिआना (*Beauveria bassiana*) और एच. इन्डिका अधिक प्रभावकारी पाए गए।

पिछेता झुलसा और आलू के कवचधारी सूत्रकृमियों की



प्रतिरोधक के चुनिंदा वंशजों वाले 23 द्वि-पैतृक संकरों से कुल 67,400 TPS हाइब्रिड पैदा किए गए। प्रारम्भिक पीढ़ी के मूल्यांकन एवं चयन में खेत स्तर में पिछेता झुलसा की प्रतिरोधिता, कवचधारी प्रतिरोधिता, पैदावार एवं आर्थिक दृष्टि से अन्य महत्वपूर्ण गुणों के आधार पर 1501 जीन प्रकारों का चयन किया गया। एडवांस जनरेशन मूल्यांकन में 32 जीन प्रकारों का चयन किया। आलू के कवचधारी सूत्रकृमि और पिछेता झुलसा प्रतिरोधक आशाजनक हाइब्रिड (OS/93-D-204) को नीलगिरि में बहुक्षेत्रीय परीक्षणों हेतु अखिल भारतीय समन्वित सुधार परियोजना (आलू) को प्रस्तुत किया गया।

कवचधारी सूत्रकृमियों की रोकथाम एवं आलू की पैदावार में सुधार लाने के लिए फोरेट की अपेक्षा कार्बोफ्यूथ्रान अधिक प्रभावी पाई गई। नीम की खली को टी. विरडी के साथ

मिलाकर प्रयोग करने से पैदावार में अधिकतम वृद्धि एवं कवचधारी सूत्रकृमियों की बढ़वार में कमी सबसे अधिक और इसके पश्चात् खुम्ब की पुरानी इस्तेमाल की हुई कम्पोस्ट और यूक्लेप्टस के खली को टी. विरडी के साथ मिलाकर प्रयोग करने से हुई। पी. फ्लोरसेन्स से कवचधारी सूत्रकृमियों (PCN) की बढ़वार में अधिकतम कमी होने के परिणामस्वरूप फसल पैदावार में वृद्धि हुई। जिन खेतों में गर्मियों में आलू+फ्रेंचबीन की अन्तःफसल चक्र और पतझड़ में आलू+बन्दगोभी के फसल चक्र को अपनाया गया, वहां पर PCN की संख्या में 20 प्रतिशत कमी हुई। दो साल में कम से कम एक बार खेत में बन्दगोभी और PCN प्रतिरोधक आलू की किस्में उगाने से सूत्रकृमियों की संख्या में काफी कमी हो सकती है।



# Executive Summary



## Crop Improvement

The germplasm collection of cultivated as well as wild species was augmented by importing the desired accessions/parental lines from International Potato Centre, Lima, Peru, Potato Genebank, USA and Scottish Crop Research Institute, UK. The total collection in the national genebank of potato now exceeds 3,800 accessions/parental lines, which are maintained as *in vitro* repository, field genebanks as well in true seeds. A number of accessions were converted from *in vitro* to tuber form and also cleaned of viruses for their ready use in the breeding programmes. A large number of accessions were evaluated for all important characters including the screening of wild species for resistance to cold-induced sweetening, bacterial wilt, stem necrosis, other viruses, PTM etc. and horizontal resistance to late blight. Improved early bulking andigena clones were developed by pre-breeding. Computer databases for all the three groups of collection i.e. Tuberosum, Andigena and wild species were updated.

For the plains of India, variety Kufri Khyati was released. This early bulking variety has oval, white tubers with shallow eyes and also some resistance to late blight. Whereas for the hills of India, variety Kufri Girdhari has been released. This medium maturing variety has high level of resistance to late blight. Its tubers are white, oval-oblong with shallow eyes. Based on consistently good performance over the years, two hybrids from CPRS Jalandhar, one from CPRIC Modipuram and 3 hybrids from CPRS Patna have been proposed for inclusion in All India Coordinated Research Project on Potato (AICRP Potato).

For processing into French fries, hybrid MP98-71 has been released at institutional level as variety Kufri Frysona. This variety with white, oblong tubers having shallow eyes has high dry matter and low reducing sugar. Another advanced hybrid MP/01-916 has been identified as suitable for processing into chips because it has high dry matter, low reducing sugars and high yield of uniformly large tubers.

Keeping in view the increasing demand of TPS in eastern parts of India, a total of 7.40 kg true seeds of 37 crosses including the released population 92PT-27 (4.00 kg) was produced. Among a large number of new TPS populations developed, populations PT/08-109 and PT/08-112 yielded

significantly higher than the existing controls. Studies confirmed the previous year's results that storage of TPS at 40°C for 3-4 months improved germination and germination index. Similarly, it was found that the application of plant growth retardant, paclobutrazole (25 ppm) significantly reduced the shoot height and root length, and thus can be used for improving transplant survival.

For conferring durable resistance to late blight, the *RB* gene of *Solanum bulbocastanum* was previously introgressed by crossing popular Indian potato cultivars Kufri Bahar and Kufri Jyoti with *RB*-transgenic Katahdin. Fifty promising clones from the cross of Kufri Jyoti and 22 from Kufri Bahar were identified. Six *RB*-transgenic lines of Kufri Jyoti and 4 of Kufri Bahar have also been selected. Six promising transgenic lines of processing variety Kufri Chipsona 1 transformed with the RNAi construct of the vacuolar invertase gene were identified as promising for production of chips from tuber stored for 45 days at 4°C. Three Indian potato cultivars, viz. Kufri Chipsona 1, Kufri Chipsona 3 and Kufri Surya were transformed with amiRNA gene constructs targeted towards silencing of UDP-glucose pyrophosphorylase and vacuolar acid invertase genes. For bacterial wilt resistance, 20 promising lines of cultivar Kufri Giriraj transformed with the enteric  $\beta$ -defensin gene have been identified. Twelve positive transgenic lines of Kufri Badshah transformed with the replicase gene of potato apical leaf curl virus were identified. A molecular map of *Solanum chacoense* with 89 AFLP markers was developed. A parental line with *Ryadg* gene in triplex/quadruplex state was identified using tightly linked SCAR marker.

## Crop Production

Under the programme on potato based cropping systems, studies revealed that French bean required 75% N in potato+French bean (1:1 proportion) intercropping system at Shimla. This system at Ooty also reduced potato cyst nematode population by 20%. At Ooty, potato + Broad bean (*Vicia faba*) intercropping at 1:1 proportion was also found beneficial in terms of total productivity. At Patna, under potato+*rabi* maize intercropping, the sowing of maize simultaneously with potato planting was found beneficial. At Jalandhar, potato+garlic-okra

cropping system was highly remunerative followed by potato-okra, potato+vegetable peas-okra, potato+wheat and potato+lentil-okra. At Gwalior under potato+peas intercropping, the higher yield of potato (29 t/ha) was recorded when potato was planted on the ridges and peas on both sides of the ridge in zigzag planting pattern. In another experiment at Gwalior, planting 25 g seed-sized tubers at 40 cm × 10 cm recorded 7.15 lacs and 16.3 lacs tubers of 10-20 g and total tuber numbers/ha, respectively. At Modipuram, the total and net tuber yield as well as seed sized tuber yields were higher at 60 × 15 cm spacing with 1,11, 111 plants/ha followed by the yields at 67.5 × 15 cm spacing (98,765 plants/ha) in comparison to 60 × 20 and 67.5 × 20 cm spacings with 83,333 and 74,074 plants population/ha.

A decision support system (DSS) tool "Computer Aided Advisory System for Potato Crop Scheduling" for aiding decisions on date of planting, variety and crop duration was developed. This tool consists of a database of yield derived from INFOCROP-POTATO model for 10 varieties at 5 dates of planting and at 60, 70, 80 and 90 days after planting for 1047 locations. The database is accessed by selecting the state, then the district and location and finally the date of planting through an interface developed in visual basic.

The thematic maps of potential yield of potato areas suitable for growing potatoes for processing, areas prone to frost, plateau area etc. in different parts of the country were prepared. Characterization of potato growing season in terms of thermally suitable growing period, harvest index, expected total biomass yield etc. were also carried out and thematic maps prepared.

The winter potato acreage and production were estimated using remote sensing, GIS and crop modeling techniques during 2008-09 for Punjab, Uttar Pradesh, Bihar and West Bengal states which was 74.7, 447.4, 181.7 and 386.7 thousand hectares, respectively with corresponding production of 519, 9252, 2010 and 8055 thousand tons. All India winter potato area and production extrapolated on the basis of these four states were estimated to be 1329.3 thousand ha and 23717.5 thousand tons, respectively.



Preliminary analysis of impact of climate change showed that potato productivity is likely to increase in Punjab, Haryana and Western Uttar Pradesh by 9% and 11 % in the year 2020 and 2050, respectively. In other states productivity is likely to decrease by 3 to 19% and 5 to 44 % in the year 2020 and 2050, respectively leading to all India estimated decline in production by 9.56% and 16.06 % in year 2020 and 2050, respectively.

Under the integrated nutrient and water management programme, results showed that the hybrid JX576 possesses high tolerance to nutrients (N, P and K) stress at Jalandhar. This hybrid was more N, P and K efficient than Kufri Pukhraj, Kufri Pushkar, Kufri Badshah and Kufri Jyoti based on tuber yield without N, P and K application and on dose of NPK required to produce maximum achievable fixed yield. The optimum doses of N, P and K for Kufri Surya in soil having low amounts of available NPK were 178 kg N, 104 kg  $P_2O_5$  and 139 kg  $K_2O$  /ha. At Ooty, Kufri Giriraj required 75, 135 and 75 kg per hectare of N,  $P_2O_5$  and  $K_2O$ /ha to produce higher number of seed sized (25-75 g) tubers, whereas, Kufri Swarna required only 60, 112.5 and 75 kg of N,  $P_2O_5$  and  $K_2O$ /ha.

Irrigations at 20 mm cumulative pan evaporation (CPE) water level under furrow irrigation and 125% CPE water level under drip and sprinkler irrigation were found optimal for higher potato yields. Raised bed, triple row planting under drip and sprinkler fertigation gave higher potato yield over furrow irrigation besides saving of 40-50% irrigation water.

In long term manurial/fertilizer experiment at Modipuram the system productivity in term of potato equivalent yield (PEY) was higher in maize – potato – onion (76.5 t/ha) followed by rice–potato–wheat (54.7 t/ha) crop sequence. The lowest PEY was recorded in sesamum–potato–green gram crop sequence (36.5 t/ha). The system productivity in inorganic treatments was 25-51% higher than organic treatments.

The dry matter content was higher in treatment receiving 100% nutrients through organic source and incorporation of crop residue/use of organic manure improved the organic carbon and mineral N content in soil. Incorporation of crop residues slightly decreased the reducing and non reducing sugar contents. The soil properties viz.,

organic carbon, available nitrogen, phosphorus and potassium improved, while bulk density decreased, by application of organic manure.

For mechanization of potato production, the fabrication work of rotary tiller with crumbler roller was carried out. Rotary tiller was found to till an area of 0.26 hectares in an hour. The speed of operation was observed to be 2.0-3.5 km/hr. The fabrication work of the manually/ engine operated endless screen type of potato grader was completed. This grader when operated manually with a person using a flywheel arrangement can handle on an average around 2.5 t of potatoes in an hour. However, on being operated with a 3-5 hp diesel engine, this prototype can grade 45 quintals of potatoes per hour, into three grades with negligible bruising.

Among the different types of abrasive materials for peeling of potato, the base plate made of perforated sheet and with sides made of the same type of material was found better for peeling and was identified to be used with advantage to develop low cost prototype peeling machine.

A mini aeroponics prototype was designed and fabricated for seed potato production and trials were initiated. Potato digger for stage II of breeder seed production was further refined and its performance was compared with the traditional potato digger.

## Plant Protection

One hundred ninety two mericlones obtained from seven germplasm accessions infected with PSTVd and maintained at 6°C for 5 to 10 months were tested for PSTVd freedom. Except 20 mericlones of CP-1391, 12 of CP-1574 and one of CP-3083 rest were still infected with PSTVd. Fifty seven accessions of potato germplasm imported from CIP, Lima, Peru were found free from PSTVd. Three of K-22, all the 8 of J-93-86 and one of Gulmarg Special were found free from viruses in IEM examination. Thirty three mericlones of 23 germplasm accessions and two of Kufri Swarna revealed that germplasm mericlones were free from viruses but not of Kufri Swarna which was still infected with PVS. Nine germplasm accessions showed resistance to both PVX and PVY consistently and consecutively for the 2<sup>nd</sup> year.

They were: CP-1829, 2217, 2307, 3146, 3165, 3533, 3756, 3762, 3764 and 3765. *In vitro* stocks of 21 potato varieties were tested for the presence of endophytes; all carried Gram negative bacilli having similar cultural and biochemical characteristics; none carried any fungus and pectolytic bacteria. Pectolytic bacterium (*Pectobacterium atroseptica*) was isolated from potato tubers taken from local market but not from CPRI produced minitubers. RT-PCR detection of PVA and PVS was validated by comparing with the results of IEM and das-ELISA; reliability of RT-PCR matched with that of IEM and it was higher than that of das-ELISA where some false positive results were observed. Coat protein genes of PVX<sub>MS</sub>, PVX<sub>HB</sub> and PVS<sup>A</sup> were sequenced and sequences of PVS<sup>A</sup> (FJ643622) and PVX<sup>o</sup> (FJ643623) were submitted to NCBI GenBank.

During the *Kharif* season, average crop loss of 66.8 % was recorded due to late blight in Hasan and Chikmagalore districts of Karnataka. During the *Rabi* season, late blight was first recorded in the first week of December in *Tarai* region of Uttar Pradesh which subsequently spread to other parts of Western U.P. A sudden burst of late blight was recorded in the last week of January leading to 15-40% crop loss. Similar situation was recorded in West Bengal and Bihar. Punjab state comparatively remained disease free. The pattern of *P. infestans* profile with regard to biological markers, like mating type, metalaxyl resistance and physiological races was almost similar to that of last year. The models for applying need based application of fungicides and yield loss assessment were found robust and can be integrated with DSS for late blight management. The ethyl acetate fraction, crude and gradient extracts of one of the effective botanicals were highly effective in controlling late blight. The newly released fungicides, namely azoxystrobin 23 SC, fenamidone 10 % + mancozeb 50 %, cymoxanil 8 % + mancozeb 64 % were found effective in managing late blight. During the current year, over 600 seedlings and 128 genotypes were selected from F<sub>1</sub>C<sub>1</sub>- F<sub>1</sub>C<sub>4</sub> population against late blight for further studies. Hill hybrid SM/00-42 was found to be the best when tested for its suitability under subtropical plains. The extent of polymorphism of the two parents *Solanum spegazzinii* and *S. chacoense* of the mapping population was studied using 64 AFLP primer

combinations. A total of 4,002 loci were amplified out of which 2,698 (67 %) were polymorphic. In an effort to develop parental lines having PVY extreme resistance in triplex/ quadruplex conditions, five test crosses were attempted between multiplex clones and PVY susceptible commercial cultivars / hybrid (nulliplex). YY-6/3-C11 appeared to be a putative triplex and would be exploited for developing varieties having extreme resistance to PVY.

Kufri Pushkar and Kufri Anand were found highly resistant to russet scab. Six germplasm accessions viz. 1187, 1243, 1349, 1388, 1418 and 1476 were also highly resistant. Soil solarization from mid-May to mid-June was the best to control russet scab. Streptocycline @ 0.05% and aureofungin @ 0.02% and soil application of bleaching powder also reduced russet scab by 9.4, 16.7 and 24.1 % over the control.

An integrated tuber treatment of *Bacillus subtilis* together with boric acid exhibited a synergistic effect for control of *Rhizoctonia solani*. Botanicals namely *Vinca rosea*, *Ocimum canum* and *Withania somnifera* as tuber treatment @ 1:3 W/V reduced black scurf disease effectively. Boric acid did not control dry rot infections that have already been established during storage in heaps a month after the harvest. Thirty isolates of *R. solani* were collected for further studies. *Bacillus subtilis* B5 applied to paddy crop as seedling dip increased yield from 36 q/ha in untreated control to 46.0 q/ha in variety Pusa Sugandha and 42.8 q/ha in variety Pusa Basmati -1.

The bio-efficacy of CIPC and other eco-friendly components were tested in stores at Kangra valley of Himachal Pradesh. After 7 weeks of storage, PTM infestation was 0-8% in CIPC treated tubers as compared to 5.0-25.0% (>10% in 14 stores) tubers showed massive tuber infestation. A total of 157 beetles were collected from CPRI, Lower Lab, Shimla during 5<sup>th</sup> June to 22<sup>nd</sup> July. Similarly, 1680 beetles were collected from two traps and alternate hosts from Fagu. Beetles started appearing on 25<sup>th</sup> May 2008 and the peak population was observed on 25<sup>th</sup> June (500 beetles) and 11<sup>th</sup> July (450 beetles). Total catches indirectly reduced white grubs population in the surrounding potato fields. Seven locally available plants and their extracts in cattle urine were tested against white grubs. Of these, *Neem*

seed kernel & *Jatropha* kernel extracts @ 5 ml/L were found very effective. There was >80% reduction in grub population due to *Steinernema carpocapsae* and *Heterorhabditis indica*. Percent reduction in tuber damage was >55 %. Soil treatment with Cartap hydrochloride at planting followed by foliar sprays of acetamiprid or thiamethoxam resulted in good control of whitefly, leaf hopper and aphids, but could not control broad mite. Four sprays with neem based products reduced the thrips population (1.05-2.92/plant) and stem necrosis intensity (22.75%) against 32.73% in control. Microbial agents *Beauveria bassiana* and *H. indica* were most effective against red ant and cutworm, respectively.

In all, 67,400 hybrid TPS were produced from 23 bi-parental crosses involving selected late blight and potato cyst nematode resistant parents. In the early generation evaluation and selection, 1,501 genotypes were selected on the basis of field resistance to late blight, cyst nematode resistance, yield and other traits of economic importance. In advance generation evaluation 32 hybrids were selected. The promising hybrid OS/93-D-204 possessing combined resistance to both species of PCN and late blight was introduced in All India Coordinated Research Project (Potato) trials. Carbofuran is more effective than Phorate in suppressing PCN and improving potato yield. Neem cake in combination with *T. viride* recorded maximum increase in yield and reduction in PCN multiplication followed by spent mushroom compost and eucalyptus cake in combination with *T. viride*. *P. fluorescens* gave maximum reduction in PCN multiplication and improvement in potato yield. PCN population was reduced by 20% in the fields where potato + French beans intercropping in summer and cabbage crop in autumn season was followed. Growing cabbage and PCN resistant potato varieties at least once in two years could bring down the nematode population substantially.

## Crop Physiology, Biochemistry & Post Harvest Technology

Because of increasing health concerns, it is desirable to decrease the oil content of potato chips. Treatment with 0.5% magnesium chloride or 0.5% calcium chloride along with blanching at

70°C for 2 minutes resulted in decreased oil content of chips. Among the five local cultivars of Meghalaya, Lah Sow Khasi had low amylose content but the starch viscosity and swelling volume were higher. Starch separated from tubers harvested from the main crop grown at Modipuram showed higher viscosity and swelling volume but the clarity of starch was better in the early crop. Starch was extracted from 13 varieties/hybrids and the starch recovery was related to tuber dry matter content. Kufri Chipsona-3 with a dry matter of 23% gave maximum starch yield (12.47% on fresh tuber wt). Analysis of texture of frozen French fries made from potatoes after 100 days of storage in heap revealed that fries made from Kufri Surya were firmer in texture (1076 g force) in comparison to Kufri Chipsona-1 (811g force) and Kufri Chipsona-3 (907 g force). The influence of industrial and home processing on nutritional composition of products was studied and it was observed that steps involved in the processing of flakes and chips caused considerable loss in reducing sugars, sucrose, free amino acids, total phenols and soluble protein. Pressure cooking and microwave cooking increased the contents of soluble protein, and total carotenes and decreased the contents of sucrose, free amino acids, total phenols and ascorbic acid. In view of the report that acrylamide can be toxic to humans, the acrylamide content was determined in chips prepared from 26 Indian potato varieties. Minimum acrylamide was observed in Kufri Chipsona-1 (65 µg/kg) and Kufri Chipsona-2 (82 µg/kg) and maximum acrylamide was observed in Kufri Kanchan (1177 µg/kg) and Kufri Anand (1096 µg/kg). Acrylamide content showed a significant positive correlation with chip colour score ( $r=0.52^{**}$ ). Improved heap storage technology with the use of CIPC @ 40 ml/ tonne of potatoes in methanol was successfully demonstrated and validated in four villages of Punjab for short-term storage of table and processing potatoes. The farmer could market 6.5% more weight of potatoes of cv. Kufri Pukhraj and fetch 35% higher price than the control tubers, besides saving on desprouting labour cost. In cv. Kufri Chipsona-1 stored in collaboration with the processing industry (Satnam Agri Products Ltd, Jalandhar), reducing sugar concentrations decreased and chip colour improved significantly after 45 days of storage. Stored potatoes were successfully used in making good quality flakes and french fries up



to the end of June. Sprout inhibition treatment with CIPC (Oorja) spray in methanol remained effective up to 120 days in heaps even at lower rates (10-40 ml/tonne), whereas application in water remained less effective, increased rottage in two cultivars and induced internal sprouting in cv. Kufri Pushkar under heap and pit storage. Kufri Chipsona-2 maintained the highest Hunter colour (dL) values denoting more acceptable chip colour followed by Kufri Himsona and Kufri Surya up to 7 months of storage at 12°C. Minimum total weight loss was recorded in MP/03-796 (12.9%) followed by MP/2K-516 (13.1%) and MP/01-916 (15.4%) up to 90 days of storage. None of the four cultivars produced chips of acceptable quality after 150 days of storage at 8, 10 and 12°C. Diphenylamine, a naturally occurring compound recorded significant sprout suppression up to 90 days without any increase in rottage of tubers.

Out of 4 crosses screened for heat tolerance in the glass house, 187 were selected. In the field selection at Modipuram, 567 clones at  $F_1C_1$ , 30 clones at  $F_1C_2$ , 45 clones at  $F_1C_3$ , 21 clones at  $F_1C_4$  stage were selected for further evaluation. Out of 42 hybrids evaluated for water stress, 34 were selected for further evaluation. Fertilizers for optimum yield during early planting of Kufri Surya were worked out at Jalandhar to be 178 kg N, 104 kg  $P_2O_5$  and 139 kg  $K_2O$ . At Modipuram, it was 300 kg N, 80 kg  $P_2O_5$  and 100 kg  $K_2O$  per ha.

## Seed Technology

During the year 2007-08 indexing of 32, 216 tubers of 25 varieties was done at Modipuram, Jalandhar, Gwalior, Patna, Kufri and Shimla. A total production of 26,930.37 q was achieved in an area of 140.564 ha in different stages and 22367.54 q was supplied and 4562.83 q was used for own planting. At CPRS, Ooty a total of 570.21q quality seed was produced in an area of 8.72 ha during summer and autumn and out of which 345.40 q was supplied and the remaining quantity was used for raising the autumn and summer seed crop.

During the year 2008-09, planting of 32,788 indexed tubers of 22 varieties and two hybrids was done at Modipuram, Jalandhar, Gwalior, Patna, Kufri and Shimla. 1,440 tubers were also indexed for Manipur Govt. A total production of

26502.67 q was achieved in an area of 133.585 ha in different stages and 22848.91 q was supplied before cold store from plains and 564.49 q from hills. At CPRS, Shillong, a total of 565.19 q quality seed was produced in an area of 6.157ha out of which 195.179 q was supplied.

A total of 10,162 microtubers and 48,277 *in vitro* plantlets of different commercial potato cultivars were produced at CPRI, Shimla and CPRIC, Modipuram. A total of 8,68,585 tubers were produced from microplants, microtubers, minitubers and recycling of <3 g tubers. In generation 1 and 2 a total of 1127.93q in 5.371 ha and 3586.06q in 15.24 ha respectively was achieved. 178.47q quality seed was produced at Shillong through tissue culture out of 565.19 q i.e. total produce.

During 2007-08, health standard at Modipuram, Jalandhar, Gwalior, Patna and Kufri at the time of tuber indexing was 97, 98, 96, 97 and 97%, respectively and in field stage-I, it was 84, 99, 96, 87 and 79% respectively.

During 2008-09, health standard at Jalandhar, Gwalior, Patna and Kufri at the time of tuber indexing was 95, 98, 97 and 88% respectively while in field stage-I, it was 90, 98, 97 and 98%, respectively.

Under seed research, different experiments were conducted at different stations viz. exploring possibility of producing seed potato during spring season for use in autumn, effect of spacing and fertilization on minituber multiplication, studies on organic and inorganic farming and studies on effect of CCC in storage and field. The experiments were conducted successfully and results were encouraging except in organic farming. An experiment on *in vitro* performance of Kufri Jyoti was conducted in which this variety performed better in sucrose with phytigel.

## Social Sciences

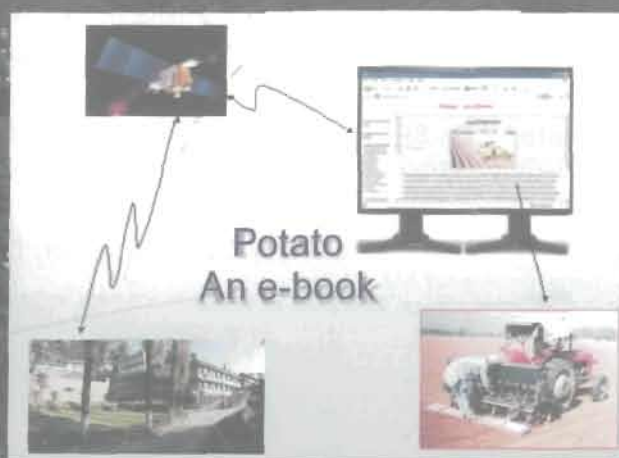
Survey was conducted to assess the area and productivity of different potato varieties in Gujarat. Kufri Badshah was identified as the leading potato variety covering 48% of potato area followed by Kufri Laukar (23%) and Kufri Pukhraj (18%) in the state. Kufri Pukhraj was the most productive variety in the state with an average yield of 364 q/ha followed by Kufri Badshah (322 q/ha) and Kufri Laukar (284 q/ha).

Weighted index of farmers' response on quality attributes on Kufri Badshah and Kufri Pukhraj was designed to evaluate the quality attributes of potato. The percent weighted score was estimated 88 for Kufri Badshah hence preferred more over Kufri Pukhraj (71%) by the farmers' in the state. The seed replacement rate in Gujarat was found to be very high (50%) and it varied from variety to variety. Out of this, 50% & 37% was contributed by Punjab and Western UP seed while the remaining 13% contributed by the local progressive farmers. Price elasticity was estimated 0.32 indicating relatively inelastic price elasticity for the commodity. Income elasticity was observed negative (-0.21). Supply elasticity was found very high at 0.84. Quick survey on potato outlook was conducted in the states of Gujarat, MP and Chattisgarh. The survey revealed that reduction in potato yield by 35%, 30% and 25% in Gujarat, Chattisgarh and MP. This is due to high temperature and severe late blight infection. Kufri Sindhuri was predominant variety and occupied about 45% area in Sarguja district in Chattisgarh. To compare the economics and efficiency level under ordinary and contract farming, a farmers' field survey was conducted. The comparison shows that the yield

of Atlantic was poor as compared to variety Kufri Jyoti. On the comparison of economics, the net return was more in case of Atlantic variety i.e. Rs. 30,173/- than of Kufri Jyoti i.e. 20,148/-. Technological gap for selected potato technology was assessed at Shimla, Muzaffarpur & Vaishali. The survey indicated that there was 45% gap in adoption of potato technologies in Shimla and 64% in Muzaffarpur & Vaishali with respect to cultural practices, pest management and healthy seed potato production. Maximum knowledge gap (87%) was found in case of integrated pest management at Patna. 50% & 1% incidence of late blight and white grub was observed in farmers' plot as compared to 40% and 0.6% in the demonstration plots. The demonstration also indicated that the farmers were able to harvest on an average 258 q/ha yield from demonstration plot as against the yield of 115.5 q/ha at farmers own plot. On the comparison of yield level of different varieties it was found that the maximum increase in yield was observed in case of Kufri Ashoka (33.33%) followed by Kufri Pushkar (30.9%). Overall knowledge of the participants of the Model training course on "Potato improvement production and utilization in current scenario" improved by 13%.



# Research Achievements 2008-09



Potato E-book identifies the best cultivation practices in different agro-climatic zones in the country

Most of the Institutes research programmes are of multidisciplinary nature and have been identified as per mandate set by the Council and priorities identified in the Research Advisory Committee (RAC) and Institute Research Council (IRC) meetings held every year. At present, potato research is being carried out under the following 19 programmes. For convenience - research achievements under these programmes during 2008-09 are presented under different disciplines.

## Research Programmes Year 2008-09

### Research Programmes & Institute Code No.

### Programme Leader and Co-Investigator

Potato genetic resources P1-2004/1-IPR-F30/0210

Dr. Jai Gopal **Co-Investigator:** Drs. Vinod Kumar, SK Luthra, Raj Kumar, Vinay Bhardwaj, ID Garg, PH Singh, VK Chandla, AK Somani, Ashiv Mehta, RS Marwaha, TA Joseph, Shambhu Kumar, Rajpal Singh, Kamlesh Malik, AK Srivastava and Uma Maheshwari

Development of varieties and technology for potato processing P1-2004/3-IPR-F30/0210

Dr. SV Singh **Co-Investigator:** Drs. SK Pandey, RS Marwaha, Dinesh Kumar, Parveen Kumar and Vinay Bhardwaj.

Breeding potato cultivars for Indo Gangetic plains P1-2004/5-IPR-F30/0210

Dr. GS Kang **Co-Investigator:** Drs. BP Singh, Raj Kumar, SK Luthra, Shambhu Kumar, VK Gupta and Eradasappa E.

Biotechnology in potato improvement P1-2004/6-IPR-F30/0210

Dr. SK Chakrabarti **Co-Investigator:** Drs. PS Naik, SK Kaushik and D Pattanayak.



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|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TPS technology for potato production P1-2004/11-IPR-F30/0210                                                          | Dr. Shambhu Kumar <b>Co-Investigator:</b> Drs. SV Singh, S Ramani, Devender Kumar and Eradasappa E.                                                                                                                                                                                                                                           |
| Develop sustainable potato based cropping systems P1-2004/7-IPR-F27/0210                                              | Dr. SS Lal <b>Co-Investigator:</b> Drs. JP Singh, PM Govindakrishnan, VS Kushwah, RK Arora, SK Singh, VK Dua, SP Singh, Sanay Rawal, Manoj Kumar, K Manorama, Shashi Rawat, MK Jatav and Islam Ahmed.                                                                                                                                         |
| Integrated nutrient and water management in potato P1-2004/9-IPR-F25/0210                                             | Dr. SP Trehan <b>Co-Investigator:</b> Drs. NC Upadhyay, MC Sood, Name Singh, Manoj Kumar, Parveen Kumar, K Manorama, MA Khan and MK Jatav.                                                                                                                                                                                                    |
| Studies on long term manurial/fertilizer application and organic farming in potato production P1-2004/20-IPR-F25/0210 | Dr. NC Upadhyay <b>Co-Investigator:</b> Drs. OP Singh, MC Sood and MA Khan.                                                                                                                                                                                                                                                                   |
| Mechanization of potato cultivation P1-2004/10-IPR-N20/0210                                                           | Er. Manjit Singh <b>Co-Investigator:</b> Ers. Sunil Gulati and Sukhwinder Singh.                                                                                                                                                                                                                                                              |
| Management of late blight in potato P1-2004/2-IPR-H20/0210                                                            | Dr. BP Singh <b>Co-Investigator:</b> Drs. PH Singh, RK Arora, SK Chakrabarti, M Narayan Bhat, SK Kaushik and Shashi Rawat.                                                                                                                                                                                                                    |
| Diagnostics and detection of pathogens in potato P1-2004/12-IPR-H20/0210                                              | Dr. ID Garg <b>Co-Investigator:</b> Dr. JK Tiwari                                                                                                                                                                                                                                                                                             |
| Integrated disease management in potato P1-2004/13-IPR-H20/0210                                                       | Dr. RK Arora <b>Co-Investigator:</b> Drs. AK Somani and Narayan M Bhatt.                                                                                                                                                                                                                                                                      |
| Integrated pest management in potato P1-2004/14-IPR-H10/0210                                                          | Dr. VK Chandla <b>Co-Investigator:</b> Drs. S Ramani, Gulab Ram, Anuj Bhatnagar and K Malik.                                                                                                                                                                                                                                                  |
| Management of potato cyst nematodes P1-2004/15-IPR-H10/0210                                                           | Dr. TA Joseph <b>Co-Investigator:</b> Drs. Uma Maheshwari and K Manorama.                                                                                                                                                                                                                                                                     |
| Physiological response of potato plants to heat stress P1-2004/4-IPR-F60/0210                                         | Dr. JS Minhas <b>Co-Investigator:</b> Drs. Devendra Kumar, Brajesh Singh, Kamlesh Malik, Sanjay Rawal, Vinay Bhardwaj and VK Gupta.                                                                                                                                                                                                           |
| Storage behaviour and processing quality of potatoes P1-2004/16-IPR-F60/0210                                          | Dr. Ashiv Mehta <b>Co-Investigator:</b> Drs. R Ezekiel, RS Marwaha, SV Singh, RK Arora, Brajesh Singh and Dinesh Kumar.                                                                                                                                                                                                                       |
| Diversified utilization of potatoes P1-2004/17-IPR-Q10/0210                                                           | Dr. R Ezekiel <b>Co-Investigator:</b> Drs. RS Marwaha, Dinesh Kumar and Brajesh Singh.                                                                                                                                                                                                                                                        |
| Development and production of nucleus and breeder seed of potato P1-2004/18-IPR-F00/0210                              | Dr. PH Singh <b>Co-Investigator:</b> Drs. BP Singh, VS Kushwah, GS Kang, RP Rai, AK Somani, Gulab Ram, Rajpal Singh, Vinay Singh, Ashwani Sharma, SP Singh, Vinod Kumar, R Muthu Raj, SK Singh, Dhruv Kumar, Anuj Bhatnagar, G Ravichandran, EP Venkatasalam, RK Verma, AMR Sanwale, Kapil Kumar Sharma, SK Awasthy, P Jassal and Brij Mohan. |
| Impact of potato technologies developed by the Institute P1-2004/19-IPR-COO/0210                                      | Dr. NK Pandey <b>Co-Investigator:</b> Drs. Rambir, RK Rana, Anil Kumar and Barsati Lal.                                                                                                                                                                                                                                                       |



## *Division of Crop Improvement*





# Potato Genetic Resources



This programme is aimed at conserving and providing diverse genetic material to the potato researchers. The collection is evaluated, characterized and documented, and improved upon through pre-breeding. The collection besides being kept in tuber form for immediate use is also conserved *in-vitro* as a safe repository, which is routinely checked for virus freedom. The important work undertaken under three projects of this programme in the last one year is summarized below.

## Collection, conservation, evaluation and documentation of potato germplasm and development of parental lines

### Collection

Efforts were continued to augment the potato germplasm collection at CPRI, which is the designated National Repository for potato germplasm. During the year under report, - 33 accessions obtained from CIP, Lima, Peru, and 3 varieties developed by CPRI were added to the collection. One PVY resistant clone, imported from UK in tuber form, and 41 parental lines in *in vitro* form and 50 accessions of wild species in TPS form, important from USA were tested for quarantine diseases and pests. The present germplasm collection consists of more than

3,800 accessions of cultivated and wild species from 30 countries (Table 1).

### Conservation

One thousand three hundred twenty seven *Tuberosum* accessions, 770 *Andigena* accessions and 69 indigenous samples were maintained in fields at Jalandhar. Nearly 1200 *Tuberosum* accessions, 90 indigenous samples and 15 VDS lines were maintained in fields at Kufri. Seven hundred fifty four *Andigena* accessions were maintained in fields at Patna. Five hundred and thirty two clones of 110 accessions of 38 species were maintained in tuber form in glasshouse/polyhouse at Shimla and 125 clones in fields at Modipuram. Ten dihaploids of Indian commercial varieties were maintained in glasshouse at Shimla. With a view to evaluate different wild species, at Shimla, 20 accessions belonging to 11 species were

Table 1. Potato germplasm holding at CPRI, Shimla

| Material                                         | No. of accessions   |          |                      |                       | No. of donor countries |
|--------------------------------------------------|---------------------|----------|----------------------|-----------------------|------------------------|
|                                                  | Tuber               | In vitro | True seed            | Total                 |                        |
| <b>a) Tuberosum (Cultivars / parental lines)</b> |                     |          |                      |                       |                        |
| <i>Indian</i>                                    |                     |          |                      |                       |                        |
| Cultivars bred at CPRI                           | 44                  | 44       |                      | 44                    |                        |
| Advanced hybrids                                 | 86                  | 17       | -                    | 86                    |                        |
| Indigenous varieties                             | 51                  | 22       | -                    | 51                    |                        |
| Indigenous samples                               | 97                  | 43       |                      | 97                    |                        |
| <i>Exotic</i>                                    | 1445                | 1450     | -                    | 1700                  | 30                     |
| <b>b) Andigena</b>                               | 770                 | -        | -                    | 770                   | 5                      |
| <b>c) Wild/ semi-cultivated sps.</b>             | 110<br>(38 species) | -        | 972<br>(104 species) | 1082<br>(118 species) | 5                      |
| <b>Total germplasm</b>                           |                     |          |                      | <b>3830</b>           |                        |

converted into tuber form and seventy- three clones were obtained, whereas 191 clones of 19 accessions were obtained at Modipuram. A total of 4,010 true seeds of 9 clones of 6 accessions pertaining to 4 wild species were produced through sib-mating at Shimla.

Nearly 1,450 Tuberosum accessions were maintained in *in vitro* form. Minutubers of 159 accessions from *in-vitro* repository were produced and added to the germplasm collection maintained under field conditions. Twenty-seven *in vitro* accessions including K-22, Gulmarg Special, Kufri Pushkar and Kufri Khyati were made free from all viruses through meristem tip culture.

### Evaluation

A large number of accessions were evaluated for various biotic and abiotic stresses and also for adaptability and physico-biochemical qualities. Promising accessions identified in these evaluations are listed in Table 2.

### Combining ability for late blight resistance

In order to identify good parents for breeding programme, crosses were attempted to complete Line x Tester (13 x 9) design for studying the combining ability of parents. However, berries were obtained in 21 crosses only. Remaining crosses will be attempted again.

Combining ability study based on 75 progenies from 25 x 3 (L x T) mating, evaluated in second clonal generation at Kufri, showed that female parents namely CP 1160, CP 2390, CP 3203 and D/79-56 were good general combiner for tuber yield. Accessions CP 1160, CP 2390 and CP 3203 were promising during last year also. Female parents namely CP Nos. 1243, 2137, 3072, 3203, 3210, 3316 and 3331 were found to be good/average combiner for late blight. Among these accessions namely CP 3072, 3203 and 3316 were good combiner during last year also.

### Documentation

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

### Development of Andigena parental lines

Improvement of Andigena (2<sup>nd</sup> cycle of recurrent selection):

Crosses were made among improved Andigena hybrids from first cycle, and between improved Andigena and original Andigena clones. In total 3,791 seeds of 9 crosses were obtained. A total of 2,580 seedlings were transplanted in field and

Table 2. Evaluation of potato germplasm

| Character             | Location         | No. of accessions evaluated | Promising accessions                                                                                                  |
|-----------------------|------------------|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Adapatability         | Kufri            |                             |                                                                                                                       |
|                       | Replicated       | 30                          | None                                                                                                                  |
|                       | Row Trial        | 131                         | CP nos. 3761, 3762, 3768, 3775 and 3787                                                                               |
|                       | Jalandhar        |                             |                                                                                                                       |
|                       | Spring           | 100                         | CP nos. 3147, 3185, 3194, 3195 and 3198                                                                               |
|                       | Modipuram        |                             |                                                                                                                       |
| Late blight           | Autumn (early)   | 105                         | CP nos. 2292, 2337, 2340, 2351, 2369, 2378 and 2994                                                                   |
|                       | Autumn (Main)    | 107                         | CP nos. 3080, 3090, 3098, 3099, 3100, 3127, 3157, 3164, 3165, 3167, and 3170                                          |
|                       | Kufri (field)    | 206                         | 25-HR; 10-R; 18-MR                                                                                                    |
|                       | Foliage          |                             |                                                                                                                       |
|                       | Ooty (field)     | 37                          | 11-R; 8-MR                                                                                                            |
|                       | Shillong (field) | 63                          | 5-R (CP nos. 2018, 2068, 2132, 2163 and 3276)                                                                         |
| Tuber                 | Shimla(Lab)      | 46                          | 11-HR; 15-R, 19-MR                                                                                                    |
|                       | Shimla(Lab)      | 95                          | 2-MR (CP nos. 3467 & 3574)                                                                                            |
| Bacterial wilt        | Bhowali          | 53                          | 15 accessions showed wilting                                                                                          |
|                       | Shillong         | 159                         | 40 accessions showed wilt incidence                                                                                   |
| Stem necrosis         | Gwalior          | 110 (4 <sup>th</sup> time)  | 13-HR; 16-R; 21-MR                                                                                                    |
|                       |                  | 29 (3 <sup>rd</sup> time)   | 1-HR; 4-R; 6-MR                                                                                                       |
|                       |                  | 59 (2 <sup>nd</sup> time)   | 15-HR; 2-R; 19-MR                                                                                                     |
|                       |                  | 72 (1 <sup>st</sup> time)   | 45 had stem necrosis                                                                                                  |
| Viruses<br>PVX & PVY  | Shimla           | 70 (1 <sup>st</sup> time)   | 8 resistant to PVX; 27 to PVY                                                                                         |
|                       |                  | 26 (2 <sup>nd</sup> time)   | 9 resistant to both PVX and PVY                                                                                       |
| PALCV                 | Jalandhar        | 30                          | 10 found infected with PALCV                                                                                          |
| Leaf hopper and Mites | Modipuram        | 202                         | 4 resistant to leafhopper. 143 had less than 10% mite damage.                                                         |
| PTM                   | Shimla (Lab)     | 86                          | None                                                                                                                  |
| Cyst nematodes        | Ooty             | 51                          | 3 resistant to both species of cyst nematodes; 3 resistant to <i>G. rostochiensis</i> only                            |
| Keeping quality       | Jalandhar        | 88                          | 14- best keepers; 40-good keepers and 22-average keepers.(On the basis of two consecutive years, 7 were best keepers) |
| Chipping              | Jalandhar        | 75                          | 3 for cold chipping.                                                                                                  |

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

1,880 selections were made on the basis of tuber characters such as colour, shape, eye depth etc.

In first and third clonal generations clones from andigena × andigena hybrids, and backcrosses were evaluated. In first clonal generation 92 clones were selected out of 817 evaluated. In third clonal generation 5 clones were selected

from 38 clones evaluated. The selection was made for improvement in tuber colour, shape, size etc. The yield range of the selected clones was 580 to 810 g/plant as compared to control Kufri Pushkar (560 g/plant).

No hybrid (among 30) was significantly higher yielding at 90 days than the controls Kufri Pukhraj and Kufri Pushkar.



## Pre-breeding of wild species

### Screening for late blight resistance

In order to diversify the sources of resistance to late blight in potato breeding programmes, 72 clones of 27 wild species were screened for late blight resistance under natural epiphytotic conditions. Forty one clones were highly resistant (AUDPC <100) and seven were moderately resistant (AUDPC =101-300). Among species the highest proportion of highly resistant clones was obtained in *S. demissum* (10 clones) followed by *S. spagazzinii* (9 clones) and *S. sparsipilum* (4 clones).

### Screening for bacterial wilt

One hundred six clones of wild species were planted at Bhowali for field screening against bacterial wilt. Out of these, 15 clones did not

germinate and only 17 clones showed wilt symptoms.

### Glucose estimation

The glucose estimation was done in 94 clones of wild species by analyzing the potato tuber juice through Biochemistry analyzer before cold storage and after cold storage. Accessions namely SS 1652-9 (*S. jamesi*), SS 1732, SS 1735-2, SS 1846 (*S. demissum*), SS 1763-6 (*S. albicans*), SS 1780-3 (*S. berthaultii*) and SS 2044-5 (*S. tuberosum* ssp. *andigena*) were found promising (glucose content < 50 mg/100 gram fresh tuber weight) before and after cold storage based on pooled data of two years. These cultures produced light coloured chips even after five months of cold storage (Fig. 1 and 2)

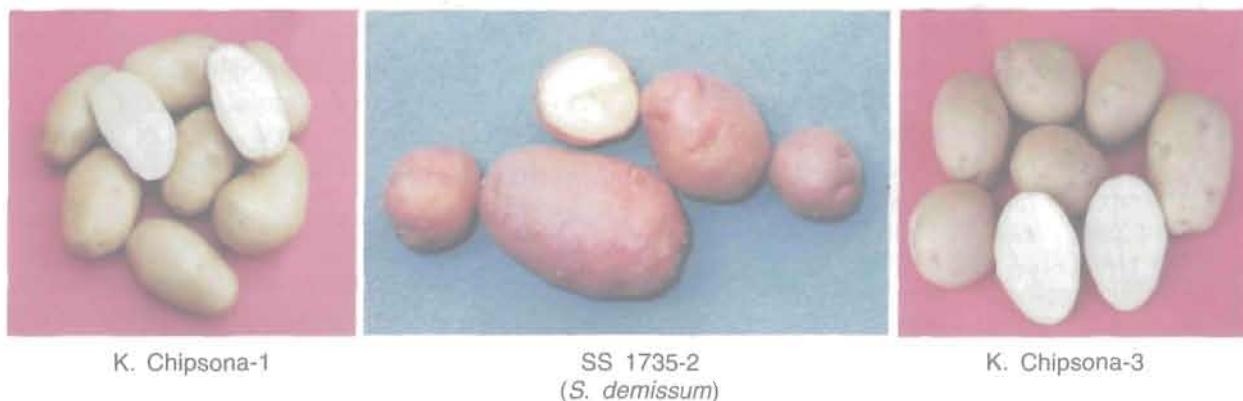


Fig. 1. Tubers of SS 1735-2 and processing varieties



Fig. 2. Chips from tubers of SS 1735-02 and processing varieties after 5 months of cold-storage

# Breeding potato cultivars for Indo-Gangetic plains



**I**ndo-Gangetic plains are the major potato producing area in India. Early and medium maturing varieties are preferred in plains. Early maturing varieties fit well in intensive cropping system. Late blight resistance and good keeping quality are preferred in medium maturing varieties. The major work undertaken during the last one-year is reported below.

## Release of Kufri Khyati

J93-86 recommended for the release by the 26<sup>th</sup> Group Meeting of potato workers was released as variety Kufri Khyati (Fig. 3). This early bulking hybrid with white oval tuber and shallow eyes is also moderately resistant to late blight. It is suitable for cultivation in the plains of India.

## Hybridization & seedling raising

A total of about 2,63,000 botanical seeds were obtained from 104 crosses. About 1,02,000 seedlings were raised and 6,923 single plant selections were retained based on tuber characters such as shape, skin color and eye depth.

## Evaluation in early clonal generations

In early clonal generations ( $F_1C_1$ ,  $F_1C_2$ ,  $F_1C_3$ ) 11,124 cultures were evaluated at 75/80 days harvest and 1,635 cultures were retained based on tuber characters.

## Replicated yield trials

### Jalandhar

*Early (September) planting conditions:* None of the 4 hybrids tested out-yielded controls Kufri Ashoka, Kufri Pukhraj and Kufri Surya at 60 and 75 days harvest.





**Fig. 3. Newly released variety Kufri Khyati**

*Normal (October) planting conditions preliminary trials:* Out of the 21 hybrids evaluated in three preliminary yield trials of 65 days 4 were selected. Selected hybrids were: J.3-121, J.3-125, J.3-41 and J.3-239. Among these, J.3-125 significantly out-yielded the controls.

*Confirmatory trials:* In all 22 hybrids were evaluated in three confirmatory yield trials. Hybrids in the most advance trial were evaluated at 60 and 75 days harvest and three hybrids viz., J.100-152, J.1-155 and J.1-390 were selected. Among these, J.100-152 significantly out-yielded controls both at 60 and 75 days harvest. J.1-390 significantly out-yielded controls at 60 days harvest only. Hybrids in other two confirmatory yield trials were evaluated at 65 days harvest only. Hybrids J.2-13, J.2-14, J.2-17, J.2-27, J.2-69, J.2-75, J.2-80 and J.2-97 were selected. Among these, J.2-14, J.2-27, J.2-75 and J.2-80 significantly out-yielded the controls.

## Modipuram

*Preliminary trials:* In preliminary trials MS/5-32, MS/5-284, MS/5-1181, MS/5-1396, MS/5-1543 and MS/5-2272 were selected on the basis of yield at 80 days harvest. MS/5-284, MS/5-1181, MS/5-1396, MS/5-1543 and MS/5-2272 out-yielded controls.

*Confirmatory trials:* Hybrids MS/4-292, MS/4-2261 and MS/3-2164 were selected based on tuber characters and yield in confirmatory yield trials. Hybrids MS/4-2261 out-yielded controls at 80 days harvest.

## Patna

*Preliminary trials:* In a preliminary trial five hybrids were selected on the basis of yield at 75 days harvest. Four hybrids with white tubers namely, 2004P18, 2004P42, 2004P61 and 2004P67 yielded significantly higher than control Kufri Khyati (255 q/ha). While one hybrid 2004P22 with red tubers had significantly higher marketable and total tuber yield than control Kufri Arun.

*Confirmatory trials:* In three confirmatory yield trials, hybrids 2003P2, 2003P4, 2002 P26, 2001 P26, 2001P67, 2003P21, 2002P13, 2002P14 and 2001P55 were selected on the basis of yield at 75 days harvest. Among these four hybrids namely 2003P4, 2002P26, 2001P26 and 2001P67 have white tubers and five namely 2003P2, 2003P21, 2002P13, 2002 P14 and 2001 P55 have red tubers. Hybrids 2003P4, 2002P26, 2001P26 and 2001P67 out-yielded white tuber control Kufri Khyati. Hybrids 2003P2, 2003P21, 2002P13, 2002P14 and 2001P55 out-yielded red tuber control Kufri Arun.

## Introduction of hybrids in AICRP (Potato)

Based on consistently good performance over years, two hybrids from CPRS, Jalandhar, one hybrid from CPRIC, Modipuram and 3 hybrids



from CPRS, Patna are proposed for inclusion in All India Coordinated Research Project on Potato (AICRP Potato).

#### Jalandhar

It was proposed that early maturing white tuber hybrids J.100-152 and J.1-390 should be introduced in AICRP (Potato) on the basis of average yield over 3 years. J.100-152 gave 9.4% and 15.1% higher yield over control Kufri Ashoka at 60 and 75 days harvest, respectively. Hybrid J.1-390 gave 15.7% and 14.3% higher yield over control Kufri Ashoka at 60 and 75 days harvest, respectively (Table 3).

#### Modipuram

Hybrid MS/3-2164 possessing high yield and moderate resistance to late blight is proposed for inclusion in AICRP Potato (Table 4). At 90 days harvest MS/3-2164 produced 21%, 8.1% and 9.9% higher tuber yield than Kufri Bahar, Kufri Sadabahar and Kufri Pukhraj, respectively.

#### Patna

Hybrids 2001P-26, 2001P-55 & 2001P-67 possessing high yield and moderate resistance to late blight are proposed for inclusion in AICRP Potato (Table 5).

**Table 3. Cultures proposed to be initiated in AICRP Potato from the project "Breeding early bulking varieties for northern plains" (Location: Jalandhar)**

| S. No. | Hybrid/control | Yield (q/ha) |         |         |         |         |         |         |         |
|--------|----------------|--------------|---------|---------|---------|---------|---------|---------|---------|
|        |                | 2006-07      |         | 2007-08 |         | 2008-09 |         | Average |         |
|        |                | 60 days      | 75 days | 60 days | 75 days | 60 days | 75 days | 60 days | 75 days |
| 1.     | J.100-152*     | 217          | 319     | 244     | 382     | 305     | 464     | 255     | 388     |
|        | Kufri Ashoka   | 194          | 275     | 244     | 361     | 260     | 374     | 233     | 337     |
|        | CD (0.05)      | 12.3         | 32.0    | 20.3    | 23.4    | 22.2    | 30.2    |         |         |
| 2.     | J.1-390**      | 225          | 342     | 296     | 442     | 297     | 436     | 273     | 407     |
|        | Kufri Ashoka   | 198          | 314     | 249     | 379     | 262     | 374     | 236     | 356     |
|        | CD (0.05)      | 20.6         | 45.7    | 23.8    | 29.5    | 22.2    | 30.2    |         |         |

\*Creamy skin, oval, shallow eyes and creamy flesh

\*\* Creamy skin, oval, shallow eyes and creamy flesh

**Table 4. Culture proposed to be initiated in AICRP Potato from the project "Development of late blight resistant medium maturing varieties" (Location; Modipuram)**

| Hybrid          | Yield (q/ha) during the year |         |           |         |           |         |         |         |
|-----------------|------------------------------|---------|-----------|---------|-----------|---------|---------|---------|
|                 | 2006-2007                    |         | 2007-2008 |         | 2008-2009 |         | Average |         |
|                 | 75 days                      | 90 days | 75 days   | 90 days | 75 days   | 90 days | 75 days | 90 days |
| MS/3-2164*      | 267                          | 289     | 254       | 362     | 343       | 349     | 288     | 333     |
| Kufri Pukhraj   | 258                          | 269     | 253       | 313     | 325       | 328     | 279     | 303     |
| Kufri Bahar     | 197                          | 214     | 179       | 355     | 256       | 257     | 210     | 276     |
| Kufri Sadabahar | -                            | -       | -         | -       | 291       | 306     | 291     | 306     |
| CD (0.05)       | 15.6                         | 12.3    | 10.1      | 19.1    | 19.4      | 21.6    |         |         |

\*White, oval, fleet eyes, white flesh, 18% dry matter and field resistance to late blight at Modipuram

**Table 5. Cultures proposed to be initiated in AICRP (Potato) from the project "Breeding improved potato varieties for eastern plains" (Location Patna)**

| Hybrid          | Yield (q/ha) at 75 days during the year |           |           |           | Average |
|-----------------|-----------------------------------------|-----------|-----------|-----------|---------|
|                 | 2005-06                                 | 2006-2007 | 2007-2008 | 2008-2009 |         |
| 2001P-26 (W)*   | 409                                     | 332       | 366       | 276       | 346     |
| 2001P-55 (R)**  | 373                                     | 357       | 314       | 267       | 328     |
| 2001P-67 (W)*** | 373                                     | 319       | 291       | 266       | 312     |
| Kufri Khyati    | -                                       | -         | 332       | 241       | 287     |
| Kufri Pukhraj   | 363                                     | 331       | 328       | -         | 340     |
| Kufri Ashoka    | 347                                     | -         | -         | -         | 347     |
| Kufri Arun      | -                                       | 238       | 280       | 239       | 252     |
| CD (0.05)       | NS                                      | 17        | 31.9      | 25.1      | -       |

\*White, round tubers, medium deep eyes, creamy flesh

\*\*Light red, round tubers, medium deep eyes, light yellow flesh

\*\*\*White, oval tubers, fleet eyes and white flesh



# Development of potato varieties and technology for processing



Potato processing is increasing at a very fast pace in India. Currently, the country processes about 6% of its potato produce which is more than 6 times of late nineties. Potato processing industry is expected to grow by 10% by the year 2015. Quality raw material is required to fulfill the requirement of this sector. This programme aims at development of varieties and technologies which are suitable for chip, French fry and flake making.

## Release of Kufri Frysona

The processing hybrid MP98-71 has been released at the Institute level by the CPRI as variety Kufri Frysona (Fig. 4). This medium maturing variety with white-oblong tubers having shallow eyes and creamy flesh is also resistant to late blight. It has high tuber dry matter and low reducing sugars, and is suitable for processing into French fry.

## Hybridization and seedlings evaluation

A total of 96,000 hybrid seeds from 68 crosses were produced at CPRS, Kufri and seedlings were raised at CPRIC, Modipuram (Meerut). In all 2,120 seedlings were selected on the basis of tuber characters.

## Early clonal generations

A total of 1,045 clones of  $F_1C_1$  to  $F_1C_2$  generations were evaluated and 42 clones were retained on the basis of tuber characters and chip colour. In  $F_1C_3$ , a total of seven genotypes were evaluated and on the basis of tuber yield, processing and biochemical quality parameters, five hybrids were selected.

## Advance clonal generations

In  $F_1C_4$ , two cultures namely MP/04-578 and MP/04-816 were selected out of six tested. In  $F_1C_5$  stage, again two cultures (MP/02-32 and MP/03-626) were selected out of three evaluated. The following trials were conducted with most advanced hybrids

Five processing hybrids and controls, Kufri Chipsona-1, Kufri Chipsona-3 and Atlantic, were





**Fig. 4. Newly released variety Kufri Frysona**

tested at Modipuram and based on chip colour, tuber dry matter, reducing sugars and other biochemical parameters, hybrid MP/01-916 was selected being better than/at par with control Atlantic at 75 and 90 DAP in total and processing grade yield along with quality (Table 6 & 7). This hybrid was also tested at Agra (U.P.), Indore (M.P.), Burdwan (W.B.), Hassan and Chikmangloor (Karnataka), and Manchar (Maharashtra). It had superior performance at all the locations.

Hybrids MP/98-71 and MP/02-204 were tested against controls Kufri Chipsona-1, Kufri Surya and Kennebec. Hybrid MP/98-71, which has been released by the Institute as Kufri Frysona, was tested at six locations in U. P. and had superior performance at all the locations (Table 8 & 9).

In the industrial testing at M/s Satnam Agrotech, Jalandhar, Kufri Frysona produced best quality French fries. After deep frying the texture was very good, no oil soaking, breaks into two, no sogginess was observed up to three minutes.

### Screening of germplasm for processing traits

In order to diversify the parents for processing traits, one hundred and twenty germplasm accessions including controls were evaluated at CPRI Campus, Modipuram for processing traits i.e. dry matter (%) and chip colour. Three accessions viz., CP 3180, CP 3079 and CP 3151, had high tuber dry matter (>22%) and acceptable chip colour (<3.5).

Evaluation of chipping quality of Indian and exotic cultivars at different dates of harvest at Modipuram

Among the early maturity group, Atlantic yielded the most acceptable colour chips (score <3.0) at all three stages of harvest. The mean dry matter content was also highest in Atlantic followed by Kufri Chandermukhi. Among the medium/late maturing varieties, Lady Rosetta gave acceptable chip colour right from 80 DAP till 110 DAP. The variety Kufri Himsona yielded acceptable chip colour at 90, 100 & 110 days.

Dry matter content increased with crop maturity till 90 DAP, after that the increase was not appreciable. Highest mean dry matter content was obtained in Kufri Himsona. Reducing sugar content decreased with crop maturity except a rise at 90 DAP, the lowest values of reducing sugars were obtained in Lady Rosetta. Sucrose content increased at 80 DAP and then decreased at 90 DAP and remained the same at later stages. The lowest value for this parameter was also obtained for Lady Rosetta. Phenol content had a zigzag pattern of change with crop maturation and cultivars Kufri Himsona and Lady Rosetta registered minimum mean values. Total free amino acids increased at 80 DAP, decreased till 100 DAP and then increased at 110 DAP.

Effect of tuber size on the processing and nutritional qualities

Tubers of six processing varieties were graded into four sizes viz., 20-40, 40-60, 60-80 and >80 mm diameter. It was concluded that 60-80 mm tuber size would be the most suitable for chipping industries as these contained maximum dry matter/specific gravity, minimum levels of reducing sugars, sucrose and produced chips of lightest colour with higher chip yield and low peeling loss. Large size tubers (>80 mm) generally showed hollow heart ranging between 33-100% in different varieties.

Identification of antioxidant rich purple pigmented *Andigena* accessions

In order to provide antioxidant rich processed products to the Indian consumers, six

anthocyanin rich purple pigmented *andigena* cultures were identified and evaluated for chips. All the six cultures produced chips in different colour and shades. Tubers of JEX/A 911 showed maximum dry matter content (24.8%) and contained 41.0 mg reducing sugars, 259.3 mg sucrose, 86.6 mg total phenols and 415.2 mg free amino acids per 100 g fresh wt and produced most attractive chips having deep yellow colour with purple shade.

Identification of accessions ideal for cold chipping

Four *andigena* accessions viz., JEX/A-663, JEX/A-695, JEX/A-785 and JEX/A-798, produced nearly acceptable chips (score 3.0-3.5) as compared to the best control Kufri Chipsona-1 (score 7) after cold storage. However, when chip colour was considered in conjunction with dry matter content, only three accessions viz., JEX/A-663, JEX/A-695 and JEX/A-785, having dry matter content of 21.3, 22.3 and 22.8%, respectively, were identified as the most suitable for cold chipping.

Yield, processing and nutritional qualities of varieties/hybrids grown at two locations in Punjab during spring, 2008

Fourteen potato varieties/hybrids were evaluated for yield and processing quality after 100 days of harvest at Hoshiarpur, while four varieties were grown and evaluated at Jalandhar.

At both the locations, Kufri Pukhraj, a table variety produced maximum total and chipping grade yield. Among processing varieties, Kufri Chipsona-1 gave maximum tuber yield, while Kufri Chipsona-3 produced maximum chipping grade tuber yield at both the locations. At Hoshiarpur, Kufri Anand produced the lowest dry matter (16.9%), while maximum dry matter (23.2%) was in Kufri Himsona. Kufri Chipsona-1 produced excellent quality chips, while acceptable chips were produced from Kufri Chipsona-3, Kufri Himsona, Kufri Surya and Atlantic. Kufri Chipsona-3 produced maximum chip yield, while chips made from Kufri Chipsona-2 were the most crispy, although its chip colour was unacceptable. Among the varieties producing acceptable coloured chips, maximum crispness (46 peaks) was observed in

Kufri Chipsona-1. Kufri Surya contained minimum reducing sugars, while MP/98-178 had maximum sucrose content. Out of four varieties grown at Jalandhar, highest tuber dry matter (24.5%) and specific gravity (1.092) was observed in Kufri Chipsona-3. All the processing varieties produced acceptable chips. Kufri Chipsona-1 produced maximum chip yield, while chips made from Kufri Chipsona-2 were the most crispy (72 peaks). Kufri Chipsona-1 contained minimum amount of reducing sugars and total phenols, while Kufri Pukhraj had maximum sucrose content. Based on processing grade tuber yield, chip colour, dry matter and chip yield, it was concluded that Kufri Chipsona-1 and Kufri Chipsona-3 grown at both the locations in spring season would provide suitable raw material for the processing industries.

Changes in processing quality of spring grown potatoes during short term storage at ambient temperature

Spring harvested potatoes of 14 varieties/hybrids from Hoshiarpur (Punjab) after six weeks of storage at ambient temperature showed a reduction of 13% in total weight with an improvement in chip colour. The contents of dry matter, reducing sugars, free amino acids and total phenols increased by 6.0, 16.9, 18.1 and 42.1%, respectively, while chip yield, sucrose, true protein, ascorbic acid and enzymic discoloration fell by 14.5, 27.8, 6.0, 32.3 and 16.9%, respectively after six weeks of storage at ambient temperature.

Spring harvested potatoes of four varieties from Jalandhar after six weeks of storage at ambient temperature showed a reduction of 9.1% in total weight, slight deterioration in chip colour with non-significant reduction in reducing sugars. Dry matter and total phenols content increased by

3.3 and 2.7%, respectively, while sucrose, true protein, free amino acids, ascorbic acid and enzymic discoloration fell by 46.3, 10.7, 23.7, 42.1 and 57.6%, respectively after six weeks of storage at ambient temperature.

Optimizing fertilizer requirements of potato cv. Kufri Chipsona-3 for chipping

Based upon the three years study, N should be applied in two soil splits in Kufri Chipsona-3 (50% at planting and 50% at earthing up).

Optimizing crop geometry and plant density for higher processing grade tuber production in cv. Kufri Himsona

Total and processing grade tuber yield was maximum when 65,800 plants/ha were planted at  $67.5 \times 22.5$  cm crop geometry but it did not differ significantly with other treatments. However, net tuber yield was maximum at 53,800 plants/ha planted at  $67.5 \times 27.5$  cm. Further decrease in the plant density led to decrease in net tuber yield too. Processing quality traits like chip colour and specific gravity did not differ significantly with crop geometry/plant density treatments.

Optimizing fertilizer requirements of variety Kufri Frysona

At Patna, the trial with respect to optimization of fertilizer requirement of Kufri Frysona conducted for second year indicated that fertilizer dose already recommended for other processing varieties i.e. 270 Kg N + 80 Kg  $P_2O_5$  and 150 Kg  $K_2O$ /ha is also optimum for Kufri Frysona. At this dose 46.6% FFG was obtained along with 48.1% chip grade. The total processable produce was 92.7% of total produce.





Table 6. Processing grade &amp; total yield (t/ha) of hybrid MP/01-916 and control variety at different locations.

| Sl. No. | Variety/hybrid   | Meerut (U.P.) |      | Agra (U.P.) |       | Hasan (Karnataka) |       | Chikmangloor (Karnataka) |       | Manchar (Maharashtra) |       | Indore (M.P.) |       | Bardwan (WB) |       | Mean        |
|---------|------------------|---------------|------|-------------|-------|-------------------|-------|--------------------------|-------|-----------------------|-------|---------------|-------|--------------|-------|-------------|
|         |                  | PGY           | TTY  | PGY         | TTY   | PGY               | TTY   | PGY                      | TTY   | PGY                   | TTY   | PGY           | TTY   | PGY          | TTY   |             |
| 1       | MP/01-916        | 33.8          | 36.7 | 21.0        | 29.4  | 26.6              | 30.1  | 23.1                     | 28.0  | 24.9                  | 32.5  | 27.9          | 37.0  | 21.8         | 28.4  | 22.39 27.76 |
| 2       | Kufri Chipsona-1 | 31.3          | 37.0 | 15.5        | 29.4  | 19.3              | 24.5  | 15.7                     | 20.1  | 12.9                  | 24.4  | 24.3          | 29.0  | 16.3         | 23.2  | 16.91 23.45 |
| 3       | Kufri Chipsona-3 | 35.2          | 39.9 | 18.8        | 33.5  | 21.1              | 25.3  | 13.2                     | 17.7  | 20.7                  | 28.4  | 24.1          | 34.5  | 17.2         | 25.9  | 18.79 25.65 |
| 4       | Atlantic         | 27.2          | 29.3 | 18.7        | 24.5  | 25.2              | 27.2  | 26.9                     | 28.9  | 25.1                  | 29.6  | 20.9          | 26.3  | 21.5         | 25.3  | 20.69 23.89 |
| 5       | Kufri Surya      | -             | -    | 18.81       | 33.81 | 31.41             | 33.11 | 36.45                    | 39.84 | 30.43                 | 33.02 | 23.13         | 31.64 | 21.66        | 26.45 | 23.13 28.27 |

Table 7. Processing quality of hybrid MP/01-916 and control variety at different locations.

| Sl. No. | Variety/hybrid   | Meerut (U.P.)   |        | Agra (U.P.)     |        | Hasan (Karnataka) |        | Chikmangloor (Karnataka) |        | Manchar (Maharashtra) |        | Indore (M.P.)   |        | Bardwan (WB)    |        | Mean       |
|---------|------------------|-----------------|--------|-----------------|--------|-------------------|--------|--------------------------|--------|-----------------------|--------|-----------------|--------|-----------------|--------|------------|
|         |                  | Chip colour (%) | DM (%) | Chip colour (%) | DM (%) | Chip colour (%)   | DM (%) | Chip colour (%)          | DM (%) | Chip colour (%)       | DM (%) | Chip colour (%) | DM (%) | Chip colour (%) | DM (%) |            |
| 1       | MP/01-916        | 2.4             | 19.65  | -               | -      | 1.7               | 22.4   | 1.0                      | 20.8   | 3.4                   | 22.3   | 1.0             | 19.32  | 2.0             | 24.50  | 1.64 18.42 |
| 2       | Kufri Chipsona-1 | 2.3             | 20.92  | 1.0             | 21.66  | 3.1               | 20.4   | 1.0                      | 19.7   | 3.4                   | 19.8   | 1.0             | 19.11  | 1.20            | 19.18  | 1.63 17.60 |
| 3       | Kufri Chipsona-3 | 4.0             | 21.56  | 1.9             | 22.61  | 2.3               | 23.5   | 1.0                      | 19.9   | 3.5                   | 21.4   | 1.0             | 21.79  | 1.20            | 22.87  | 1.86 19.20 |
| 4       | Atlantic         | 2.40            | 20.33  | 1.2             | 20.77  | 1.9               | 22.1   | 1.5                      | 19     | 3.3                   | 22.6   | 1.20            | 20.90  | 1.10            | 22.03  | 1.58 18.47 |
| 5       | Kufri Surya      | -               | -      | 1.0             | 19.92  | 4.1               | 21.10  | 2.8                      | 13.93  | 4.1                   | 19.0   | 1.0             | 18.31  | 1.70            | 23.83  | 2.10 16.58 |

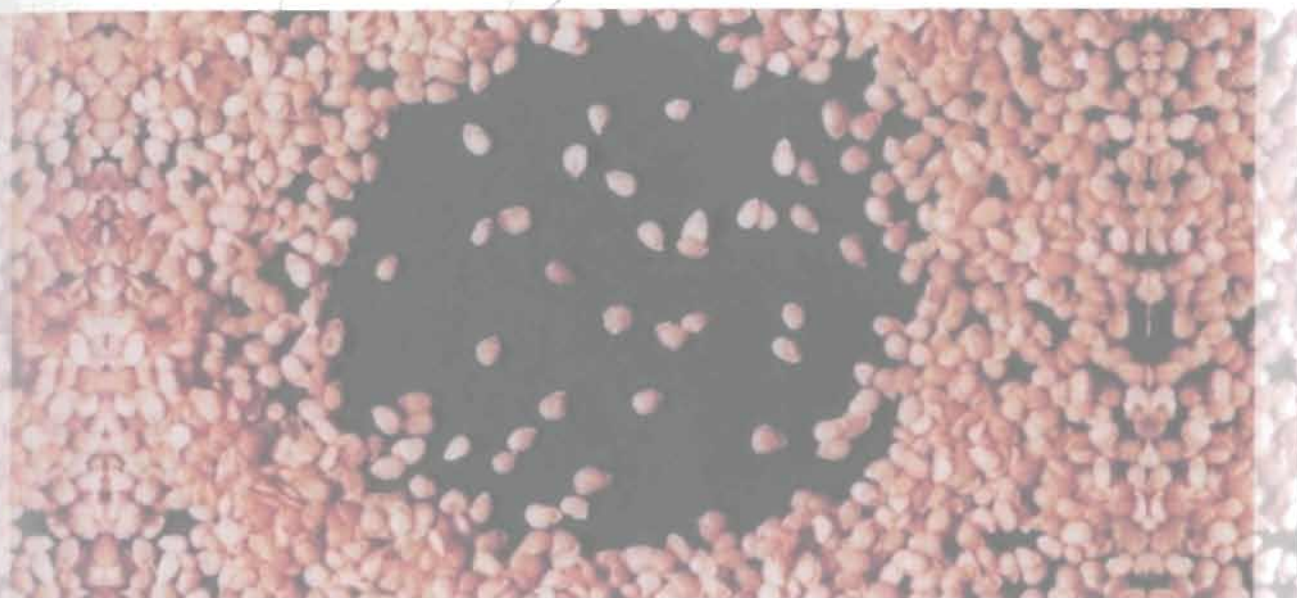
Table 8. French fry grade &amp; total yield (t/ha) of Kufri Frysona and control variety at different locations in Uttar Pradesh.

| Sl. No. | Variety/hybrid   | CPRIC, MDP Meerut (U.P.) |       | BVBPUAT, Meerut (U.P.) |       | GHAZIABAD (Babugarh) |       | Badaun (Bisoli) |       | Farrukhabad (Timarva) |       | Agra (Sadabad) |       |
|---------|------------------|--------------------------|-------|------------------------|-------|----------------------|-------|-----------------|-------|-----------------------|-------|----------------|-------|
|         |                  | FFGY                     | TTY   | FFGY                   | TTY   | FFGY                 | TTY   | FFGY            | TTY   | FFGY                  | TTY   | FFGY           | TTY   |
| 1       | MP/98-71         | 13.87                    | 43.91 | 12.56                  | 28.72 | 20.00                | 47.46 | 8.83            | 54.04 | 13.75                 | 45.33 | 5.72           | 39.00 |
| 2       | Kufri Chipsona-1 | 7.75                     | 42.21 | 7.87                   | 25.1  | 8.83                 | 43.66 | 6.81            | 54.29 | 8.12                  | 40.41 | 3.81           | 29.43 |
| 3       | Kufri Chipsona-3 | 9.0                      | 45.7  | 15.0                   | 35.71 | 11.29                | 38.54 | 11.51           | 48.63 | 12.5                  | 34.12 | 4.79           | 33.81 |
| 4       | Kufri Surya      | 17.2                     | 42.05 | 9.2                    | 25.48 | 11.25                | 41.87 | 7.07            | 48.23 | 8.75                  | 40.41 | 0.00           | 33.47 |
| 5       | Kennebec         | 9.28                     | 30.67 | 8.20                   | 16.67 | -                    | -     | -               | -     | -                     | -     | -              | -     |

Table 9. Processing quality of Kufri Frysona (MP/98-71) and control variety at different locations in Uttar Pradesh.

| Sl. No. | Variety/hybrid   | CPRIC, MDP Meerut (U.P.) |            | BVBPUAT, Meerut (U.P.) |            | GHAZIABAD (Babugarh) |            | Badaun (Bisoli) |            | Farrukhabad (Timarva) |            | Agra (Sadabad) |            |
|---------|------------------|--------------------------|------------|------------------------|------------|----------------------|------------|-----------------|------------|-----------------------|------------|----------------|------------|
|         |                  | Fry colour               | Dry matter | Fry colour             | Dry matter | Fry colour           | Dry matter | Fry colour      | Dry matter | Fry colour            | Dry matter | Fry colour     | Dry matter |
| 1       | MP/98-71         | 1.50                     | 21.53      | 1.50                   | 22.27      | 2.2                  | 24.38      | 1.00            | 24.88      | 1.00                  | 22.07      | 1.00           | 21.78      |
| 2       | Kufri Chipsona-1 | 1.50                     | 22.25      | 2.30                   | 22.65      | 3.0                  | 24.67      | 1.00            | 24.56      | 1.20                  | 21.74      | 1.00           | 21.66      |
| 3       | Kufri Chipsona-3 | 1.20                     | 22.78      | 2.50                   | 20.52      | 2.0                  | 23.17      | 1.40            | 20.62      | 1.00                  | 24.05      | 1.90           | 22.61      |
| 4       | Kufri Surya      | 1.80                     | 21.18      | 1.20                   | 20.50      | 2.3                  | 22.04      | 1.10            | 18.74      | 1.00                  | 21.93      | 1.00           | 19.92      |
| 6       | Kennebec         | 3.50                     | 21.86      | 3.00                   | 18.19      | -                    | -          | -               | -          | -                     | -          | -              | -          |

# TPS Technology for potato improvement



Raising of commercial crop through true potato seed is being followed to some extent in north-eastern parts of India. TPS population 92-PT-27 developed by the CPRI and released for commercial adoption is becoming popular. In order to further promote this technology, the work on development of early bulking and hardy TPS populations is one of the objectives of the breeding programmes of the CPRI. The major output of the work done in the last one year is given below.

## Development of early bulking and hardy TPS populations

### TPS production

During the year, a total of 7.40 kg TPS of 37 crosses including of the recommended population, 92PT-27 (4.0 kg) was produced at Patna.

### Development of early bulking parents

Seedlings of 35 bi-parental crosses were evaluated at Patna, and 60 early bulking clones with desirable tuber attributes were selected. Sixty-nine clones from 11 populations of  $F_1C_1$  were also selected.

### Seedling transplant crop

Out of 51 populations evaluated at Patna in 4 replicated trials, eight populations viz. PT/08-04, PT/08-14, PT/08-109, PT/08-104, PT/08-105, PT/08-108, PT/08-111 and PT/08-112 gave significantly higher yield than the control 92-PT-27 at 90 days. Population PT/08-109 and PT/08-112 had the highest yield among the white  $\times$  white and red  $\times$  red crosses, respectively (Table 10). However, none of the 35 TPS populations evaluated at CPRS, Shillong yielded higher than the controls 92-PT-27 and TPS/C-3.

### Seedling tubers crop

In all, 11 populations were evaluated with controls 92-PT-27 and Kufri Kanchan. At 90 days harvest, one population PT/07-124 yielded



significantly higher than the control 92-PT-27 (Table 11).

## Development of techniques for seedling establishment and vigour

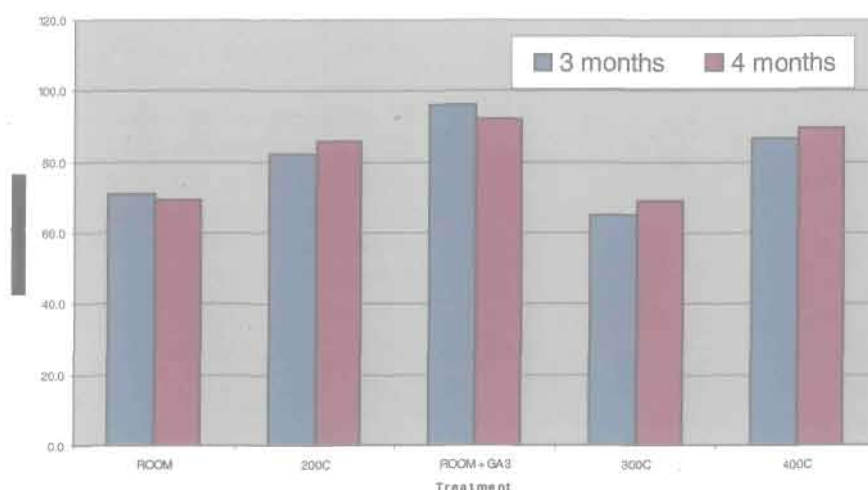
*High temperature priming to enhance seed germination and seedling vigour on TPS: Seeds*

of two TPS populations HPS I/13 and TPS/C-3 were kept for 4 months in BOD incubator storage at 40°C for 3-4 months improved germinations and it was at par with those kept at room temperature (43°C) and treated with 1500 ppm GA<sub>3</sub>. HPS-I/13 responded better than TPS/C-3 (Fig. 5).

*Effect of PGR formulations on transplant survival, seedling vigour and productivity in 90 days winter crop: One month old seedlings of*

**Table 10. Performance of selected populations as transplanted crop at 90 days**

| Trial No. | No. of Populations tested | Selected Populations | Yield (q/ha) |       |
|-----------|---------------------------|----------------------|--------------|-------|
|           |                           |                      | Marketable   | Total |
| 1.        | 11 + 1                    | Nil                  | —            | —     |
| 2.        | 11 + 1                    | PT/08-04             | 68.8         | 95.7  |
|           |                           | PT/08-14             | 73.8         | 99.1  |
|           |                           | 92PT-27              | 52.7         | 78.4  |
|           |                           | CD (0.05)            | 10.8         | 17.5  |
| 3.        | 11 + 1                    | PT/08-109            | 86.51        | 129.3 |
|           |                           | 92PT-27              | 50.2         | 78.2  |
|           |                           | CD (0.05)            | 7.6          | 13.5  |
| 4.        | 17 + 1                    | PT/08-104            | 85.0         | 121.6 |
|           |                           | PT/08-105            | 88.8         | 115.3 |
|           |                           | PT/08-108            | 74.6         | 112.6 |
|           |                           | PT/08-111            | 78.3         | 109.7 |
|           |                           | PT/08-112            | 75.2         | 112.8 |
|           |                           | 92PT-27              | 61.1         | 94.3  |
|           |                           | TPS/D-150            | 50.1         | 84.2  |
|           |                           | CD (0.05)            | 10.4         | 14.7  |



**Fig. 5. Effect of 3 and 4 months temperature priming during storage on germination (%) in TPS**

Table 11. Performance of seedling tubers progenies at Patna at 90 days

| Population/Control | Yield (q/ha) |       |
|--------------------|--------------|-------|
|                    | Marketable   | Total |
| PT/07-124          | 91.0         | 103.0 |
| PT/07-126          | 83.2         | 94.9  |
| PT/07-132          | 49.0         | 56.9  |
| PT/07-138          | 30.7         | 37.5  |
| PT/07-139          | 69.6         | 78.9  |
| PT/07-128          | 65.0         | 73.2  |
| PT/07-130          | 72.9         | 82.0  |
| PT/07-134          | 67.6         | 75.6  |
| PT/07-123          | 71.6         | 79.9  |
| D-150 (Self)       | 77.7         | 83.0  |
| 92PT-27            | 78.4         | 85.7  |
| Kufri Kanchan      | 116.1        | 126.9 |
| CD(0.05)           | 11.9         | 13.3  |

HPS I/13, TPS/C-3 and 92PT-27 raised in nursery bed.

The application of plant growth retardant paclobutrazole (25ppm) significantly reduced the shoot height and root length. The reduction in shoot height was also noticed in seedlings treated with botanical (*badchi*-3.5%) but attained

higher root length. The reduction in seedling height was also accompanied by decrease in fresh weight. The shoot/root ratio also reduced and seedlings turned shorter but more compact due to the foliar spray of paclobutrazole and botanical. The transplant survival was >90% in all the treatments.



# Biotechnology in potato improvement



The programme aims at development of potato transgenic cultivars with durable resistance to late blight, low accumulation of reducing sugars in tubers during cold storage, tolerance to bacterial wilt and major viruses. Besides, the programme also covers the area of marker-assisted selection for resistance to late blight and PVY. Recently, potato genome sequencing has become a major objective of this programme. Major achievements in the above research areas during the year 2008-09 are described below.

## Development of potato transgenics

### Late blight resistance

The *RB* gene known to be effective against all known races of *P. infestans* is being used for development of late blight resistant varieties both by introgression breeding and genetic transformation.

**Introgression of *RB* gene by crossing with *RB*-transgenic Katahdin:** The potato cultivar Kufri Bahar was crossed with *RB*-transgenic Katahdin during 2005-06. Twenty-two selected  $F_1C_3$  clones from that cross were evaluated under controlled environment chamber at Shimla and under contained field condition at Modipuram. All the selected lines performed better than the maternal parent Kufri Bahar in terms of late blight field resistance both at Shimla and Modipuram. Based on performance at both the

locations, 11 clones (KP/SP-951-9, KP/SP-951-26, KP/SP-904-12, KP/SP-904-22, KP/SP-904-23, KP/SP-904-46, KP/SP-904-50, KP/SP-904-56, KP/SP-904-62, KP/SP-904-66, KP/SP-904-77) have been selected.

**Hybrids of Kufri Jyoti/Kufri Bahar X SP951:** One hundred three  $F_1C_1$  clones of the cross Kufri Jyoti X SP951 (*RB*-transgenic Katahdin) that tested positive for *RB* gene, were screened for late blight resistance under controlled environment chamber. All the clones except three (KJ 15, KJ 52, and KJ 54) showed higher resistance than the maternal parent Kufri Jyoti. Fifty-four clones having sufficient tubers were screened at CPRI Campus, Modipuram. All had higher resistance than controls. Fifty clones that performed better both at Shimla and Modipuram have been selected. Similarly, 55  $F_1C_1$  clones obtained from the cross Kufri Bahar x SP951 and positive for *RB* gene were screened under controlled environment chamber at Shimla. Though most of the clones showed resistance to





**Fig. 6. Late blight infection in non-transgenic Kufri Jyoti and RB-transgenic Kufri Jyoti line KJRBE-58.**

late blight, the degree of field resistance in most of the clones was not desirable. Twenty-four clones were screened at CPRI Campus, Modipuram. Based on performance of the clones at both the locations, 11 promising clones (KB-23, 24 27 28, 29, 30, 31, 32, 37, 38, and 45) have been selected.

**Development of RB-transgenic Kufri Bahar and Kufri Jyoti by direct transformation:** The potato cultivars Kufri Bahar and Kufri Jyoti were transformed with the *RB* gene by *Agrobacterium*-mediated genetic transformation. Eight putative transgenic lines of Kufri Jyoti positive for the *RB* gene were screened under controlled environment chamber. All the eight transgenic lines showed higher resistance than that of non-transgenic Kufri Jyoti. Late blight resistance of the clone KJRBE-58 after screening under controlled environment chamber is shown in the Fig. 6. Similarly, 10 putative *RB*-transgenic lines of Kufri Bahar were screened under controlled environment chamber. Although, seven lines showed late blight resistance better than non-transgenic control, the degree of field resistance was not desirable in most of the clones. Four of them, i.e. KB-RBL-23, KBRBL-12, KBRBL-22, and KBRBE-23 have been selected for further evaluation.

## Bacterial wilt resistance

Forty-seven putative EBD transgenic lines of Kufri Giriraj were screened against bacterial wilt (*Ralstonia solanacearum*) under controlled environment chamber. Twenty putative transgenic lines did not show any wilt symptom during the period of 84 days after planting. These lines have been selected for further evaluation.

## Transgenics for virus resistance

The replication-associated protein gene (AC1) of the potato apical leaf curl virus is being used to develop transgenic potato resistant to the virus. The internodal stem segments of Kufri Badshah microplants were used for explants and co-cultivated with EHA105 harboring the binary vector pGTLC1 (containing replicase gene in antisense orientation). One hundred sixty nine putative transgenic shoots were regenerated. Eight lines were positive for integration of the replicase gene in antisense orientation. The variety Kufri Badshah was also transformed with the replicase gene as hairpin loop to confer resistance by post transcriptional gene silencing. Four positive lines have been identified. The early variety Kufri Pukhraj was transformed with the antisense construct of the replicase gene and 3 lines have been identified with positive gene integration.

## Molecular Markers

### QTL mapping of late blight horizontal resistance

A mapping population consisting of 126 progenies from the cross *S. spegazzinii* x *S. chacoense* had been genotyped previously. The extent of polymorphism between the two parents was studied using 64 AFLP selective primer combinations. A total of 4,002 loci were amplified out of which 2,698 (67%) were polymorphic. The population was characterized by 12 AFLP selective primer pairs and 268 loci were amplified from male parent *S. chacoense* that were absent in *S. spegazzinii*. The expected segregation ratio of 1:1 was tested for all these loci in the population by Chi-square analysis using JoinMap 0.4 software and only 89 (33%) loci segregated as per the expected ratio. A

molecular linkage map of *S. chacoense* has been prepared using those 89 markers (Fig. 7).

### Marker assisted selection of PVY extreme resistance

A SCAR marker validated earlier was used to develop parental lines having PVY extreme resistance gene (*Ryadg*) in triplex/quadruplex state. Test crosses were attempted using five putative multiplex clones and PVY susceptible commercial cultivars/hybrid (nulliplex). The progeny thus obtained was analyzed for presence of the SCAR marker. One clone i.e. YY-6/3 C11

appeared to be a putative triplex clones as the segregation ratio in its progeny was 30:1, quite close to the expected segregation ratio of 27:1 in the progeny of a nulliplex x triplex cross following random chromatid assortment. To confirm its triplex status, a larger progeny having 151 individuals was raised from the cross (QB/A 9-120 x YY-6/3 C11) and checked for presence of the marker. A segregation ratio of 25:1 was obtained in the progeny of this cross thus confirming triplex status of the clone YY-6/3 C11. The clone was challenge inoculated by PVY and confirmed to have extreme resistance to the virus by ELISA and IEM.

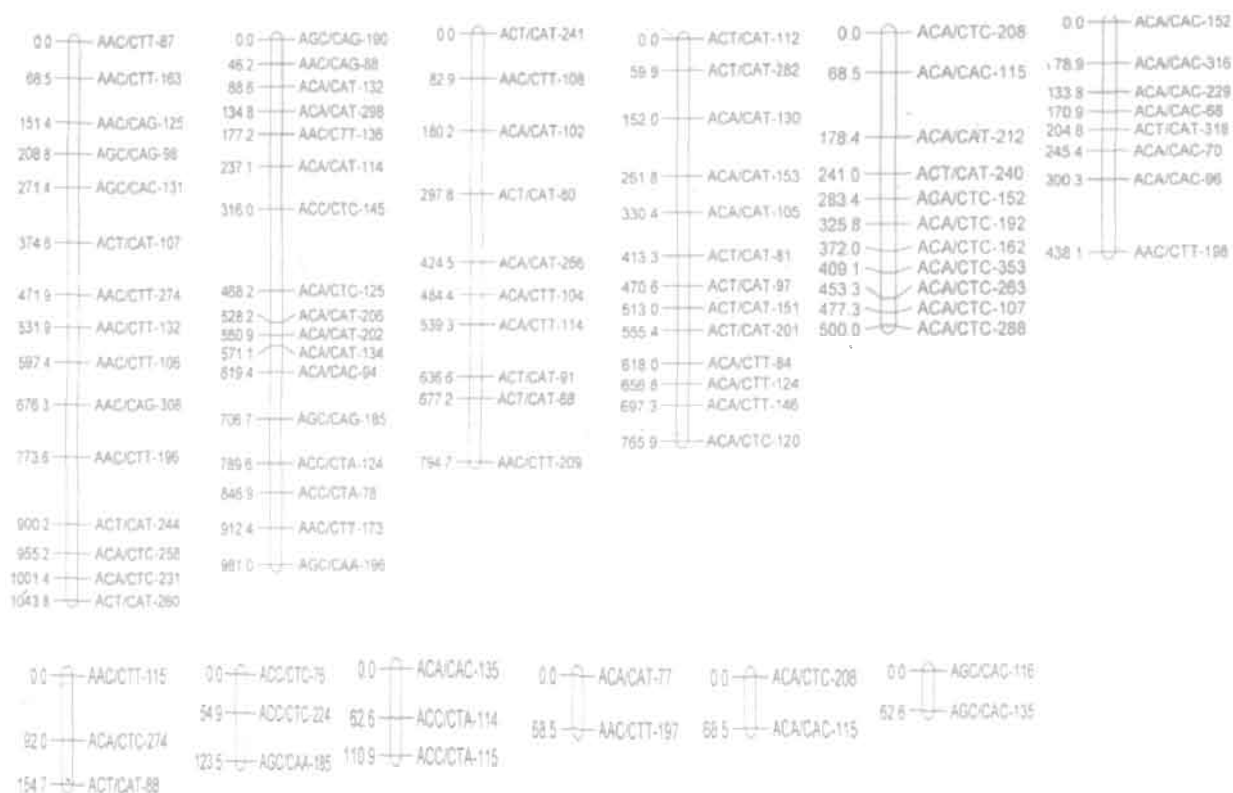


Fig. 7. Linkage map of *Solanum chacoense*



## *Division of Crop Production*





# Develop Sustainable Potato Based Cropping Systems



Potato being a short duration crop fits well in different multiple and intercropping systems. However, adjustments are needed in production technology to make potato based cropping systems profitable. Keeping this in view, the programme aims to standardize/workout resource management strategies for important potato based cropping systems. The programme also aims to develop decision support systems for potato production and standardize the methodology for acreage and production estimation of potato using remote sensing, geographical information system and crop simulation techniques.

## Resource management strategies in cropping systems

### Evaluation of planting methods for intercropping of potato in north-western plains

At Jalandhar, a field experiment was conducted on innovative potato based intercropping systems with the objective of providing insurance against possible crop losses due to late blight and frost. The cropping systems were potato-okra, potato + vegetable peas-okra, potato + lentil-okra, potato + garlic-okra and potato + wheat (Table 12). Two rows of vegetable peas and lentil intercrops were sown between two rows of potato by FIRB (Furrow irrigation in

raised bed) method, while one row of garlic and two rows of wheat intercrop were sown between normally planted potato crop. Okra was planted after harvesting of potato except where the intercrop was wheat. Results revealed that potato + garlic - okra cropping system was highly remunerative with net returns of Rs. 1,52,090/ha followed by potato-okra, potato + vegetable peas - okra, potato + wheat and potato + lentil - okra. All the cropping systems were highly profitable with benefit: cost ratios ranging from 2.4 to 3.1.

At Modipuram, a field experiment was conducted with the objective of including short duration crop between rows of potato crop. Treatments were combination of 3 planting methods (bed planting, modified bed planting and conventional method of planting) and 4 potato cultivars (Kufri Pukhraj,

**Table 12. Productivity and profitability of some potato based intercropping systems in North-Western plains of India at Jalandhar**

| Cropping systems         | Treatments                         |        | Yield of crops (t/ha) |      |      | Net returns (Rs/ha) | B:C ratio |
|--------------------------|------------------------------------|--------|-----------------------|------|------|---------------------|-----------|
|                          | Intercropping planting density (%) | Potato | Inter-crops           | Okra | REY  |                     |           |
| Potato-okra              |                                    | 34.5   | Nil                   | 6.65 | 25.5 | 125485              | 2.9       |
| (Potato + Veg. Pea)-okra | 100:25                             | 30.8   | 1.01                  | 6.74 | 25.0 | 117528              | 2.7       |
| (Potato + lentil)-okra   | 100:38                             | 30.4   | 0.64                  | 5.57 | 22.4 | 98332               | 2.4       |
| (Potato + garlic)-okra   | 100:25                             | 34.9   | 1.82                  | 6.24 | 30.1 | 152090              | 3.1       |
| (Potato + wheat)         | 100:66                             | 35.2   | 5.42                  | Nil  | 26.0 | 112017              | 2.4       |
| CD (P = 0.05)            |                                    | 1.6    |                       | 0.6  |      |                     |           |

REY - Rice equivalent yield

Kufri Anand, Kufri Sutlej and Kufri Chipsona-1). The graded and total tuber number did not differ significantly due to planting methods. However, marketable and total tuber yields improved significantly in bed planting (35.7 and 37.2 t/ha) and modified bed planting (39 and 40.2 t/ha) over conventional ridge furrow system (32.2 and 33.6 t/ha). Among cultivars, maximum productivity was recorded with Kufri Pukhraj (41.8 t/ha) followed by Kufri Anand, Kufri Sutlej and Kufri Chipsona-1. In another field experiment at Modipuram, intercropping of potato+lentil and potato+*methi* proved beneficial for potato yield with potato variety Kufri Pukhraj and Kufri Surya, respectively.

To evaluate planting density of recent potato cultivars for intercropping, a field experiment was conducted at Modipuram. The total tuber numbers were reduced significantly by 10.7 and 29.2% at planting densities of 75 and 50%, respectively, compared to the control (100% planting density). Corresponding reduction in total tuber yield was 11.1 and 22.0%. Kufri Pukhraj gave maximum yield (40.3 t/ha) followed by Kufri Anand (38.3 t/ha) and Kufri Sutlej (34.7 t/ha) across the treatments.

Potato+rabi maize intercropping studies in north-eastern Indo-Gangetic plains

Rabi maize is popular in north Indo-Gangetic plains particularly in Bihar. An experiment was conducted at Patna to evaluate the effect of planting geometry on production and economics

of rabi maize + potato intercropping system. The treatments consisted of combination of two methods of potato + maize intercropping (maize sown on one side of potato ridge and maize sown in the furrow between potato ridges) and three dates of maize sowing (D1: maize sown on the same day as of potato planting, D2: maize sown 10 days after potato planting and D3: maize sown after earthing up of potato). The sole crop treatments of potato and maize were included as control.

Potato yield was similar under all the intercropping patterns, but lower than sole crop (Table 13). The sole maize crop sown on the same day as of potato gave highest grain yield. Delaying planting of maize intercrop after earthing up of potato reduced grain yield most severely. There was no significant effect of the method of maize sowing on maize yield. The total potato equivalent yield was significantly higher in all the intercropping systems irrespective of date and method of maize sowing than the respective sole component crop stands. The highest total potato equivalent yield (PEY) was recorded when maize was sown in farm, 10 days after with potato planting. Intercropping of maize in potato was highly remunerative giving net return in the range of Rs. 69098 to 73058 per hectare as compared to Rs.59998/ha from sole crop of potato.

Three legume crops i.e. vegetable pea, gram and lentil were evaluated for intercropping with potato in raised bed. The treatments consisted



**Table 13. Yield and total potato equivalent yield (PEY) under different treatments in potato+ *rabi* maize intercropping system at Patna**

| Treatments                                                      | Potato yield (t/ha) | Intercrop yield (t/ha) |       | Total PEY (t/ha) | Net return (Rs./ha) | Return per rupee investment |
|-----------------------------------------------------------------|---------------------|------------------------|-------|------------------|---------------------|-----------------------------|
|                                                                 |                     | Maize grain yield      | PEY   |                  |                     |                             |
| Intercropping pattern                                           |                     |                        |       |                  |                     |                             |
| Sole potato                                                     | 32.7                |                        |       | 32.7             | 52998               | 1.18                        |
| Sole maize D <sub>1</sub>                                       |                     | 6.46                   | 15.08 | 15.1             | 24548               | 0.94                        |
| Sole maize D <sub>2</sub>                                       |                     | 6.06                   | 14.14 | 14.1             | 21420               | 0.82                        |
| Sole maize D <sub>3</sub>                                       |                     | 5.03                   | 11.74 | 11.7             | 14031               | 0.54                        |
| Potato+ maize sown on potato ridge on one side, D <sub>1</sub>  | 28.1                | 6.03                   | 14.06 | 42.2             | 71608               | 1.19                        |
| Potato+ maize sown on potato ridge on one side, D <sub>2</sub>  | 29.1                | 5.70                   | 13.30 | 42.4             | 72153               | 1.20                        |
| Potato+ maize sown on potato ridge on one side, D <sub>3</sub>  | 31.0                | 4.99                   | 11.65 | 42.6             | 71210               | 1.16                        |
| Potato+ maize sown in the furrow of potato ridge D <sub>1</sub> | 28.3                | 6.04                   | 14.10 | 42.4             | 72333               | 1.21                        |
| Potato+ maize sown in the furrow of potato ridge D <sub>2</sub> | 29.2                | 5.79                   | 13.51 | 42.7             | 73058               | 1.22                        |
| Potato+ maize sown in the furrow of potato ridge D <sub>3</sub> | 30.7                | 4.81                   | 11.22 | 41.9             | 69098               | 1.13                        |
| CD( P=0.05)                                                     | 1.7                 | 0.61                   | 0.61  | 1.9              | -                   | -                           |
| <b>Row Spacing</b>                                              |                     |                        |       |                  |                     |                             |
| 60 cm                                                           | 29.3                | 5.65                   | 13.19 | 42.5             | 72549               | 1.21                        |
| 67.5 cm                                                         | 29.5                | 5.47                   | 12.76 | 42.2             | 71538               | 1.19                        |
| CD (P=0.05)                                                     | NS                  | NS                     | NS    | NS               | NS                  | NS                          |

D1: Maize sown on the same day as of potato planting

D2: Maize sown 10 days after potato planting

D3: Maize sown after potato earthing up

of potato (ridge and furrow), potato (FIRB), potato FIRB + pea/gram/lentil (2:1). FIRB method of potato planting reduced tuber yield by 6.3% compared to ridge and furrow.

Intercropping legumes with potato reduced potato tuber yield, but the decrease was well compensated with additional yield of intercrops. The decrease in potato yield due to intercropping was least when intercropped with pea. The total potato equivalent yield was higher in potato+pea intercropping (24.2 t/ha) followed by potato+ gram (23.6 t/ha). The economics of the treatments showed that intercropping of legumes in potato was economical and feasible as the net return on per rupee investment was higher with pea (0.67) and gram (0.62) as

compared to sole potato (0.51).

### Cropping system studies in the north-central plains

An experiment was conducted to evaluate low input technology for potato production in various potato based cropping systems at Gwalior. The highest cost of cultivation was recorded in *bajra*-potato sequence (Rs.53,500/ha). This system also gave the maximum gross return of Rs.99,224/ha and net return of Rs.45,724/ha, followed by fallow-potato and *bajra*-wheat sequence (Rs.39,500/ha). However, benefit: cost ratio was higher with fallow-mustard (3.11) followed by *bajra*-wheat sequence (2.13).

In another experiment at Gwalior, pea was intercropped with potato in additive series. The highest potato tuber yield of 29 t/ha was recorded when potato was planted on ridge and pea on both sides of the ridge in zigzag planting pattern. Pod yield of 2.27 t/ha was also higher in this intercropping system as compared to other systems i.e. sowing of pea on the ridges between tubers or in the channel between two rows of potato.

At Gwalior, experiment was conducted to economize the cost of seed by maximizing small seed tuber (10-20g) production. Planting 25 g seed size tubers at 40 x 10 cm spacing maximized 10-20 gm tubers in the produce, net return (Rs.78,837/ha) and the benefit: cost ratio (2.8) compared to planting of 50, 75 and 100 g tubers. The total and 10-20 gm tubers in the produce were 16.3 lacs and 7.15 lacs/ha, respectively. Haulm killing at 65-70 days after planting enhanced the proportion of 10-20 g tubers in the produce.

#### Intercropping studies in the north-western hills

In an intercropping experiment conducted at Shimla, potato + French bean were planted in 1:1 row ratio with 50 and 75% of respective sole crop population. French bean was applied nitrogen @ 0, 25, 50, 75 and 100% of recommended on population basis and potato was raised with 100% recommended N. Results confirmed last years finding and showed that French bean required only 75% N in potato + French bean (1:1) intercropping. All the intercropping treatments gave land equivalent ratio (LER) of more than unity, thus showing that the intercropping of potato + French bean was always beneficial irrespective of N dose to French bean.

#### Intercropping studies in the Nilgiri hills

At Ooty a study was initiated during summer season to evaluate recommended technologies in comparison with the farmers' practice. The treatments were; growing potato as monocrop, potato (summer)-cabbage (autumn) rotation (Farmers' practice), potato (summer)-cabbage (autumn) rotation by applying FYM @ 20 t/ha to potato crop and potato + French bean intercropping-cabbage rotation (recommended

practice). No significant difference in yield of potato during summer season was observed among treatments. There was a significant increase in potato cyst nematode (PCN) population when potato cultivar Kufri Giriraj was grown as mono crop. Least number of cysts were recorded in potato + French bean intercropping in summer followed by cabbage crop in autumn season reducing PCN population by 20 percent from the initial level. In another field trial at Ooty, soybean and broad bean as intercrop with summer potato were evaluated. Potato + broad bean (*Vicia faba*) intercropping at 1:1 (50:50) proportions produced higher yield than all other combinations, whereas soybean was not found successful as intercrop with potato.

#### Technology for production of small sized seed tubers for newly released potato cultivars/hybrids

At Modipuram, potato variety Kufri Pukhraj produced significantly higher total and net tuber yield (44.3 and 40.6 t/ha, respectively) followed by Kufri Anand and Kufri Chipsona -3 in comparison to variety Kufri Surya. Row spacing of 60 cm gave higher total and net tuber yields as compared to 67.5 cm inter-row spacing. The potato yields were significantly higher at narrow plant spacing (15 cm) in comparison to 20 cm. The 15 cm intra-row spacing produced significantly higher total, net and seed sized tuber yields as compared to 20 cm intra-row spacing. The total and net tuber yield as well as seed sized tuber yields were significantly higher at 60 x 15 cm spacing with 1,11, 111 plants/ha followed by 67.5 x 15 cm spacing (98,765 plants/ha) in comparison to 60 x 20 and 67.5 x 20 cm spacings with 83,333 and 74,074 plant population/ha, respectively.

#### Development of Decision Support System (DSS)

##### Computer Aided Advisory System for Potato Crop Scheduling (CAASPS)

For providing information on the likely consequences of early or late planting of potato at about one thousand locations in India and in different varieties as well as the effect of harvest



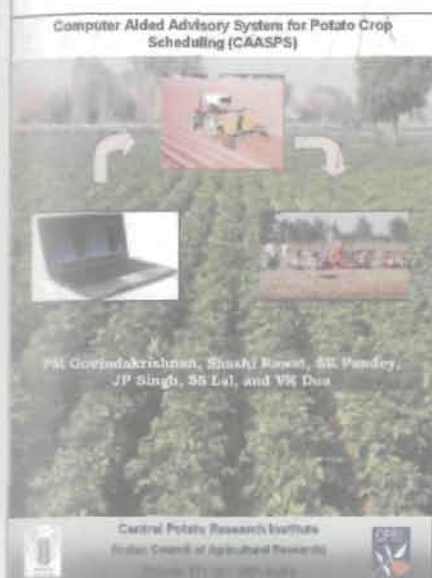


Fig. 8. Computer Aided Advisory System for Potato Crop Scheduling

at different durations, a simple decision support tool was developed (Fig. 8). The tool consists of a database of yield at 60, 70, 80 and 90 days after planting derived through INFOCROP-POTATO model. These data were generated by running the model under potential conditions for five dates of planting and for all the ten popular Indian potato varieties using the long term weather data for each location for the weather input. A user interface was developed in Visual Basic to access this database. A simple query system was designed for querying the database. The user first selects the State (Window 1), and then the Districts of the state and the locations within the district for which information is available, are displayed for selection of one of them (Window 2). Then the five dates of planting for which model has been run for the selected location is displayed and the user is required to select one of them (Window 3). When any of the dates is selected, the attainable yield data for all the ten varieties at five durations, corresponding to 60, 70, 80 and 90 days after start is displayed in tabular format (Window 4).

#### Thematic mapping for potato production

The total yield is an indicator of the bio-mass production potential of a location as affected by the availability of natural resources. An estimate

of the total dry weight (TDW) would indicate the suitability or otherwise of the site and also scope for yield improvement through breeding programmes and deploying appropriate agro-techniques. The TDW in this study was estimated using the Versteeg & van Keulen (1986) model for potential situation *i.e.* without any stresses. The results showed that wide spread areas in the states of the Indo-Gangetic plains and also the states of Rajasthan, Madhya Pradesh, Chattisgarh, Orissa and north eastern hill states have high to very high total yield potential, while reasonable total yields can be obtained in Karnataka, Maharashtra and some parts of Andhra Pradesh indicating possibilities of yield improvement in these states. The map also shows that potential to grow potato in some pockets in Kerala also exists.

In the northern Indo-Gangetic plains, the potato crop is mainly grown during the autumn season and the latter part of the growing season extends into the winter season. Therefore, many areas in the north experience ground frost wherever the minimum temperature falls very low. It is necessary to demarcate such areas so that appropriate agro-techniques could be developed for these locations and this study was taken up. The map shows that frost prone areas in the North West are contiguous and extensive (Fig. 9). Almost the entire state of Punjab and



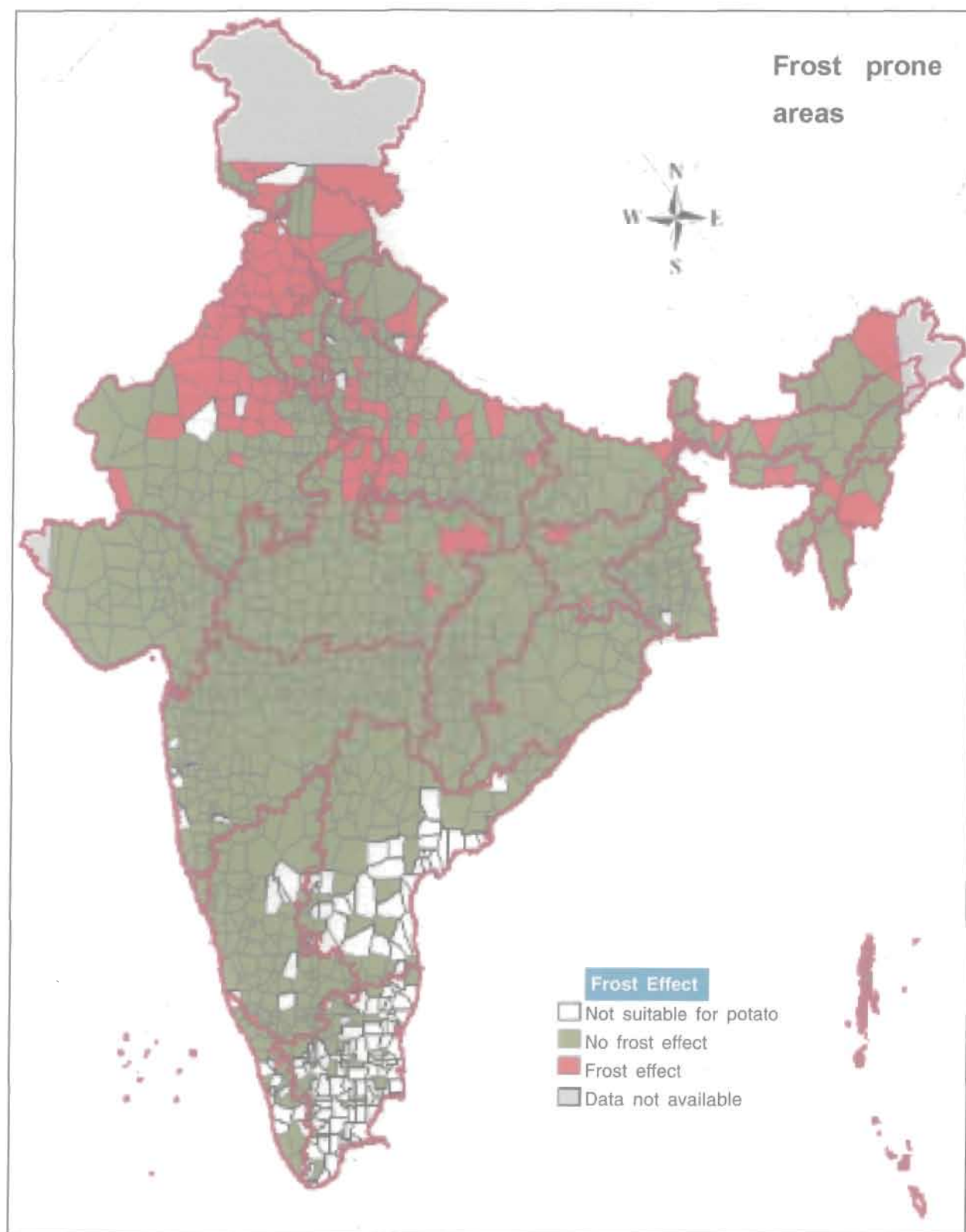


Fig. 9. Map showing frost prone areas for potato cultivation in India.

almost one third of Rajasthan are frost prone. These results are in confirmation with practical experience which indicates that winters are severe and frosts are almost regular and very severe in North West parts of the country and are less severe and not very regular towards the east. The map also shows that few pockets in Haryana, Uttar Pradesh, Madhya Pradesh and north eastern states are also likely to be affected by frost. In rest of India frost is not likely to occur during the potato crop season. Mapping of plateau areas and available growing period for potato in different regions of India were also taken up.

#### Acreage and production estimation of potato using remote sensing, GIS and crop modelling

The ground truth data were collected during peak crop season of potato in the states of Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal during the month of December to January for analysis of satellite data. The analysis for winter potato acreage estimation was done using IRS-P6 advanced wide field sensor (AWiFS) data. For remote sensing estimates, the IRS-P6 AWiFS data acquired on 18<sup>th</sup> October, 30<sup>th</sup> November and 5<sup>th</sup> December, 2008 were used for Punjab, of 18<sup>th</sup> October, 1<sup>st</sup> November, 21<sup>st</sup> November and 5<sup>th</sup> December, 2008 for UP, of 23<sup>rd</sup> November, 31<sup>st</sup> December, 2008 and 10<sup>th</sup> January, 2009 for Bihar and of 10<sup>th</sup> January, 2009 were used for West Bengal. This year, image analysis was done on TM tiles of 2 × 2° for Punjab, UP and Bihar and for West Bengal, complete enumeration approach was used. For potato crop acreage estimation, NDVI values and values of NIR and Red bands were used in algorithms. The remote sensing estimates for 2008-09 winter potato acreage for Punjab, Uttar Pradesh, Bihar and West Bengal states were 74.7, 447.4, 181.7 and 386.7 thousand hectares, respectively. An overall increase of 9.46% in potato acreage was observed in these states over the last year's estimate. The winter potato production in Punjab, Uttar Pradesh, Bihar and West Bengal estimated using INFOCROP-Potato simulation model with input of weather data upto January 31, 2009

was 1519, 9252, 2010 and 8055 thousand t, respectively. All India winter potato area and production extrapolated on the basis of these four states were 1329.3 thousand ha and 23717.5 thousand tones, respectively.

#### Impact assessment of climate change on potato

Climate change and global warming will have profound effect on potato production in India. A rise of 1.8 to 4°C in global temperature is projected along with doubling of CO<sub>2</sub> concentration from the current level of 360 ppm in the atmosphere by the year 2100. Other indirect effects of global warming include reduction in light intensity, shifting pattern of rainfall, less availability and deterioration in quality of irrigation water, increase in soil salinity and increasing incident of extreme weather events like floods, droughts and frosting.

Published scientific evidence through 1975 to 2007 suggests positive direct effect of elevated CO<sub>2</sub> while negative effect of rise in temperature on tuber yield of potato. An increase in tuber yield of 32-85% with reduced evapo-transpiration saving of 12-14 % water under elevated CO<sub>2</sub> is reported. Elevated CO<sub>2</sub> increases photosynthesis, biomass, mean tuber weight, dry matter and starch content. The rise in temperature over optimal, severely inhibits tuber initiation, with suppression of photosynthesis and translocation of photosynthates from leaves to tuber resulting in extremely low tuber yield regardless of CO<sub>2</sub> concentration. Rise in temperature and CO<sub>2</sub> are interlinked phenomenon under future scenarios of climate change and global warming. Therefore, due to their interaction effect, the elevated CO<sub>2</sub> does not appear to compensate for the detrimental effects of higher temperature on tuber yield in the tropics including India.

Future trends in global potato production under the impact of climate change in the subtropics including India indicate tuber yield losses (>20%) even after considering adaptations. The impact of climate change and global warming on potato production at regional and national level needs to be assessed urgently using approaches of modeling and GIS for advance planning and adaptations.

Photographs on cropping system experiments



Potato + garlic intercropping



Potato + wheat intercropping



Okra after potato



Okra after potato in potato + garlic intercropping



Potato + French bean intercropping in hills



# Integrated Nutrient and Water Management in Potato



**I**n the recent past the declining factor productivity of applied nutrients in our country has been attributed to multiple nutrient deficiencies and imbalance use of plant nutrients. The most widely recognized alternative is integrated nutrient management for sustaining potato productivity in the long run. The irrigation water also plays an important role in improving nutrient use efficiency. Thus the programme aims to develop integrated nutrient and water management techniques for sustained potato production.

## Nutrient efficiency of different potato cultivars

Potato varieties differ widely with regard to their nutrient use efficiency. Keeping this in view, hybrid JX576 was evaluated for nitrogen, phosphorus and potassium stress in three separate field experiments at Jalandhar using best control, Kufri Pukhraj which had been found most nitrogen, phosphorus and potassium efficient among the released varieties in various experiments conducted by different workers during last six years in India. The hybrid JX576 produced significantly higher tuber yield than other five cultivars tested particularly under nutrients stress *i.e.* at lower doses of nitrogen, phosphorus and potassium (Table 14). It gave 6.5 to 12.5 t/ha higher tuber yield under nitrogen stress (No nitrogen applied), 7.2 to 19.6 t/ha

higher yield under phosphorus stress and 4.5 to 22.6 t/ha higher tuber yield under potassium stress over other five cultivars tested. The hybrid JX576 required lower doses of nitrogen, phosphorus and potassium than other cultivars to produce particular fixed tuber yield in the same field (Table 15). Kufri Pukhraj and Kufri Pushkar required 24 and 53 kg  $P_2O_5$ /ha to produce tuber yield of 40 t/ha, respectively, whereas, hybrid JX576 achieved yield of 40 t/ha without any phosphorus application in the same field. Similarly hybrid JX576 produced tuber yield of 40 t/ha without any potassium application, whereas, cultivars Kufri Pukhraj and Kufri Pushkar needed 66 and 10 kg  $K_2O$ /ha to produce yield of 40 t/ha. The hybrid JX576 produced 46, 20 and 26% higher tuber yield than best control Kufri Pukhraj under nitrogen, phosphorus and potassium stress, respectively.

**Table 14. Total tuber yield (t/ha) of six potato cultivars/hybrid as affected by N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O application at Jalandhar during 2008-09**

| Cultivar         | Total tuber yield (t/ha)                      |      |      |      |      |
|------------------|-----------------------------------------------|------|------|------|------|
|                  | Rate of N (kg/ha)                             |      |      |      | Mean |
|                  | 0                                             | 80   | 160  | 240  |      |
| Kufri Badshah    | 15.2                                          | 28.7 | 35.7 | 36.8 | 29.1 |
| Kufri Jyoti      | 8.3                                           | 20.1 | 28.4 | 27.1 | 21.0 |
| Kufri Pukhraj    | 14.3                                          | 29.6 | 38.0 | 46.2 | 32.0 |
| Kufri Pushkar    | 13.6                                          | 31.8 | 42.3 | 44.1 | 32.9 |
| Hybrid JX576     | 20.8                                          | 39.9 | 45.9 | 48.9 | 38.9 |
| Kufri Chipsona-1 | 13.1                                          | 21.8 | 28.2 | 29.5 | 23.1 |
| Mean             | 14.2                                          | 28.7 | 36.4 | 38.8 |      |
|                  | Rate of P <sub>2</sub> O <sub>5</sub> (kg/ha) |      |      |      | Mean |
|                  | 0                                             | 25   | 50   | 100  |      |
|                  |                                               |      |      |      |      |
| Kufri Badshah    | 30.2                                          | 32.9 | 32.5 | 33.7 | 32.3 |
| Kufri Jyoti      | 24.2                                          | 27.1 | 25.6 | 26.7 | 25.9 |
| Kufri Pukhraj    | 36.6                                          | 40.1 | 42.2 | 41.7 | 40.1 |
| Kufri Pushkar    | 36.6                                          | 38.9 | 39.6 | 41.3 | 39.1 |
| Hybrid JX576     | 43.8                                          | 46.4 | 50.1 | 52.2 | 48.1 |
| Kufri Chipsona-1 | 28.4                                          | 31.1 | 30.8 | 31.9 | 30.5 |
| Mean             | 33.3                                          | 36.1 | 36.8 | 37.9 |      |
|                  | Rate of K <sub>2</sub> O (kg/ha)              |      |      |      | Mean |
|                  | 0                                             | 40   | 80   | 160  |      |
|                  |                                               |      |      |      |      |
| Kufri Badshah    | 25.5                                          | 28.4 | 29.3 | 29.5 | 28.2 |
| Kufri Jyoti      | 21.1                                          | 23.9 | 26.4 | 28.0 | 24.8 |
| Kufri Pukhraj    | 34.8                                          | 38.2 | 40.8 | 42.6 | 39.1 |
| Kufri Pushkar    | 39.2                                          | 42.1 | 41.9 | 42.3 | 41.4 |
| Hybrid JX576     | 43.7                                          | 47.9 | 49.8 | 51.1 | 48.1 |
| Kufri Chipsona-1 | 24.1                                          | 27.2 | 29.0 | 29.9 | 27.6 |
| Mean             | 31.4                                          | 34.6 | 36.2 | 37.2 |      |
| CD               |                                               |      |      |      |      |
| (0.05)           | N                                             |      | P    |      | K    |
| Cultivar         | 1.85                                          |      | 1.53 |      | 1.75 |
| Rate             | 1.50                                          |      | 1.22 |      | 1.44 |
| Cultivar x rate  | 3.71                                          |      | 2.73 |      | 3.50 |

## Screening of potato cultivars for P efficiency

To evaluate potato cultivars for their efficiency to utilize soil P and fertilizer P, nine potato cultivars

namely Kufri Bahar, Kufri Chandramukhi, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Ashoka, Kufri Badshah, Kufri Pukhraj, Kufri Jyoti and Kufri Sutlej were grown at Shimla during autumn season with and without recommended dose of phosphorus in field and in pots with slightly

Table 15. Rates of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O required by different genotypes to obtain fixed yields (2008-09)

| Cultivar         | N rates (kg/ha) for fixed yields of |         |         |         |         |
|------------------|-------------------------------------|---------|---------|---------|---------|
|                  | 20 t/ha                             | 28 t/ha | 35 t/ha | 40 t/ha | 45 t/ha |
| Kufri Badshah    | 25                                  | 75      | 146     | np      | np      |
| Kufri Jyoti      | 74                                  | 174     | np      | np      | np      |
| Kufri Pukhraj    | 29                                  | 76      | 126     | 170     | 227     |
| Kufri Pushkar    | 24                                  | 60      | 99      | 136     | np      |
| Hybrid JX576     | -ve                                 | 27      | 61      | 90      | 130     |
| Kufri Chipsona-1 | 58                                  | 165     | np      | np      | Np      |

|                  | P <sub>2</sub> O <sub>5</sub> rates (kg/ha) for fixed yields of |         |         |         |         |
|------------------|-----------------------------------------------------------------|---------|---------|---------|---------|
|                  | 26 t/ha                                                         | 30 t/ha | 33 t/ha | 40 t/ha | 45 t/ha |
| Kufri Badshah    | -ve                                                             | -ve     | 45      | np      | np      |
| Kufri Jyoti      | 30                                                              | np      | np      | np      | np      |
| Kufri Pukhraj    | -ve                                                             | -ve     | -ve     | 24      | np      |
| Kufri Pushkar    | -ve                                                             | -ve     | -ve     | 53      | np      |
| Hybrid JX576     | -ve                                                             | -ve     | -ve     | -ve     | 10      |
| Kufri Chipsona-1 | -ve                                                             | 19      | np      | np      | np      |

|                  | K <sub>2</sub> O rates (kg/ha) for fixed yields of |         |         |         |         |
|------------------|----------------------------------------------------|---------|---------|---------|---------|
|                  | 25 t/ha                                            | 27 t/ha | 29 t/ha | 40 t/ha | 45 t/ha |
| Kufri Badshah    | -ve                                                | 21      | 62      | np      | np      |
| Kufri Jyoti      | 55                                                 | 100     | np      | np      | np      |
| Kufri Pukhraj    | -ve                                                | -ve     | -ve     | 66      | np      |
| Kufri Pushkar    | -ve                                                | -ve     | -ve     | 10      | np      |
| Hybrid JX576     | -ve                                                | -ve     | -ve     | -ve     | 11      |
| Kufri Chipsona-1 | 10                                                 | 38      | 78      | np      | np      |

-ve = means higher than fixed yield was achieved in the absence of N, P or K

np = not possible because maximum achievable yield under the given conditions was less than fixed yield

acidic sandy loam soil. To explain the variability among cultivars, sand culture study was also undertaken to quantify the root parameters. All the cultivars were affected by late blight but the severity was very high in Kufri Bahar, Kufri Chandramukhi and Kufri Ashoka and yield level was also too low in these cultivars. In rest of the six cultivars there was clear indication of increased tolerance to late blight in P fertilized plots. The cultivars showed effect of P application differentially and Kufri Pukhraj showed almost no effect of applied P, showing its better efficiency in utilizing soil P. In sand culture also this variety showed maximum root/shoot weight ratio.

## Growth period specific potassium requirement of potato varieties

To work out the growth period specific potassium requirement of three potato varieties (Kufri Giriraj, Kufri Jyoti and Kufri Swarna) and one advance hybrid (OS/93-D-204), a trial was laid out at Ooty with varying potassium levels. However, no significant yield differences within a variety were observed due to application of potassium as the soils were rich in potassium content. The harvesting of the crop at early stage (100 days) resulted in significantly lower yields in all the varieties as compared to harvesting at 120 days.



## Response of potato cultivar Kufri Surya to N, P and K at Jalandhar

Potato cultivar Kufri Surya responded significantly to N, P and K at location-1 having low available N, P and K in soil but did not respond significantly at location-2 having high amounts of available N, P and K in soil. Quadratic equations were fitted to data of location-1 and optimum doses of N, P and K were calculated, which were 178 kg N, 104 kg  $P_2O_5$  and 139 kg  $K_2O$  /ha.

## Fertilizer requirement of Kufri Himsona in the hills

To standardize the fertilizer requirement of newly released potato processing variety Kufri Himsona for Nilgiri hills, a trial was initiated with nine different levels of fertilizers. Same treatments were also tested in potato variety Kufri Giriraj for comparison. Results showed that Kufri Himsona could not perform well under Nilgiri conditions because on an average its yield was only 68 per cent of that recorded from Kufri Giriraj. With recommended NPK it recorded only 50 per cent of the yield than that recorded with Kufri Giriraj. Even with higher levels of fertilization, the yield of Kufri Himsona could not improve significantly. The yield of processing grade tubers (>75g size) was also very poor (0.47 t/ha) when compared with Kufri Giriraj (5.8 t/ha).

## Nutritional management in seed potato crop at Ooty

In order to standardize the varietal specific fertilizer requirement for producing seed of two potato varieties (Kufri Giriraj and Kufri Swarna) in Nilgiris, a trial was conducted during summer season. The results indicated that Kufri Giriraj required 75, 135 and 75 kg of N,  $P_2O_5$  and  $K_2O$ /ha to produce higher number of seed sized tubers (25-75 g), whereas, Kufri Swarna required only 60, 112.5 and 75 kg of N,  $P_2O_5$  and  $K_2O$ /ha, respectively. This indicates that seed crop is to be fertilized at little lower rates than that of ware crop in the Nilgiris and between the varieties, Kufri Swarna requires still lesser quantities of fertilizers due to its higher fertilizer use efficiency.

## Integrated nutrients management in potato-radish crop sequence in the hills

Field experiments were conducted at Shimla to investigate the role of FYM on phosphorus and potassium economy in potato-radish crop sequence. The manurial treatments consisted of inorganic and organic source of nutrients. Based on, three years studies, the results revealed that the application of recommended dose of N along with 50% PK from inorganic fertilizers and rest from FYM (on K basis) enhanced yields of potato and radish as compared to other treatments. Application of FYM was beneficial in increasing the nutrients availability from the soil at the critical growth stages when plant needs were higher. For the higher productivity of potato-radish crop sequence, 25 to 50% dose of P and K can be met with FYM and if replacement of chemical fertilizer is beyond 50%, the economics may not be favorable as indicated by potato equivalent yield. These levels of P and K replacement in potato crop, met the full P and K requirement of succeeding radish crop due to higher residual effect of FYM than inorganic fertilizers.

## Effect of bio-fertilizers on nutrient economy in potato in the hills

A field experiment was conducted at Shimla to evaluate bio-fertilizers viz. *Azotobacter* + phosphorus solubilizing bacteria (PSB) for N and P economy in potato cultivar Kufri Jyoti. Results revealed that combined application of 50% of recommended dose of NPK along with tuber inoculation with biofertilizer+5 t/ha FYM and micronutrients was more effective in terms of growth attributes and total tuber yield and was at par with the treatment receiving 100% recommended dose of NPK, thus economizing on inorganic fertilizers by 50%.

In another field study at Shimla, results showed that growth attributes of potato plants like plant height, number of shoots and leaves/plant increased with increasing levels of nitrogen application alone or along with *Azotobacter*. However, combined application of 100% nitrogen along with tuber inoculation with *Azotobacter* gave the higher tuber yield.

At farmer's field in high hills of Shimla, application of 100% P along with PSB applied

through seed inoculation gave higher tuber yield, which was at par with 75% recommended dose of P+ PSB or 100% recommended dose of P application through fertilizer. Maximum tuber numbers were observed with 75% recommended P and PSB followed by 100% recommended dose of phosphorus.

#### Available P status of soils of different potato growing areas of Punjab

Recovery of applied phosphorus by potato crop is not more than 15-20%. Continuous application of phosphorus may lead to its build up in soil which may affect crop yields adversely due to antagonism of phosphorus with other nutrients like zinc, iron, etc as well as its indiscriminate application will add to the cost of cultivation. The surface (0-15 cm) soil samples were therefore, collected from different potato growing areas of Punjab (Jalandhar, Nakodar, Kartarpur, Kapurthala, Raiyya and Amritsar representing 80% of potato growing areas of Punjab) during 2007-08 potato crop season to find P status of these soils. These samples were analyzed for available P ( $\text{NaHCO}_3$  extractable P). None of the soil samples contained available P less than 10 ppm which is the critical limit established for potato in alluvial soils of Punjab (Table 16). As much as 47, 24, 29, 37, 23 and 40% soil samples from Jalandhar, Nakodar, Kartarpur, Kapurthala, Raiyya and Amritsar, respectively contained more than 40 ppm available P. The overall mean indicated that 20, 28, 17 and 35% of soil samples collected from different potato growing soils of Punjab were in the range of 10-

20, 20-30, 30-40 and >40 ppm available P, respectively. As much as 80% of total samples contained more than 20 ppm available P. Results suggested that high amount of phosphorus had accumulated in potato growing soils of Punjab and farmers should apply phosphorus to potato crop only after getting their soil tested for available P from soil testing laboratories.

#### Water management in potato

Productivity and quality of potato depend upon the proper balance between soil air and soil moisture in plant's root zone which can be achieved by the sound water management strategies. Keeping this in view, a field experiment was conducted at Modipuram to compute phasic water need of 4 potato cultivars (Kufri Bahar, Kufri Pukhraj, Kufri Sutlej and Kufri Anand) under drip, sprinkler and furrow methods of irrigation. Results revealed that irrigations applied at 150% cumulative pan evaporation (CPE) level gave significantly higher yield of potatoes under drip as well as sprinkler irrigated crop which was at par with that obtained when irrigations were applied at 125% CPE under drip irrigation (Fig. 10). In case of furrow irrigation, the yield of potato was significantly higher when irrigations applied at 20 mm CPE water level as compared to 25 and 30 mm CPE level. Potato cultivar Kufri Anand produced significantly higher total yields and tuber numbers followed by Kufri Pukhraj in comparison to other varieties under all irrigation methods.

**Table 16. Range and mean of available P in soil samples of different potato growing areas of Punjab and per cent of soil samples in different available P range**

| District   | Available P (ppm) |      | Percent of soil samples in different available P range |       |       |       |     |
|------------|-------------------|------|--------------------------------------------------------|-------|-------|-------|-----|
|            | Range             | Mean | Available P ( $\text{NaHCO}_3$ -P) range in soil (ppm) |       |       |       |     |
|            |                   |      | 0-10                                                   | 10-20 | 20-30 | 30-40 | >40 |
| Jalandhar  | 19-60             | 42   | 0                                                      | 5     | 16    | 32    | 47  |
| Nakodar    | 20-44             | 30   | 0                                                      | 13    | 63    | 0     | 24  |
| Kartarpur  | 20-58             | 34   | 0                                                      | 14    | 43    | 14    | 29  |
| Kapurthala | 14-64             | 34   | 0                                                      | 25    | 25    | 13    | 37  |
| Raiyya     | 10-55             | 27   | 0                                                      | 46    | 18    | 15    | 23  |
| Amritsar   | 16-42             | 30   | 0                                                      | 20    | 40    | 0     | 40  |
| Mean       |                   | 34   | 0                                                      | 20    | 28    | 17    | 35  |

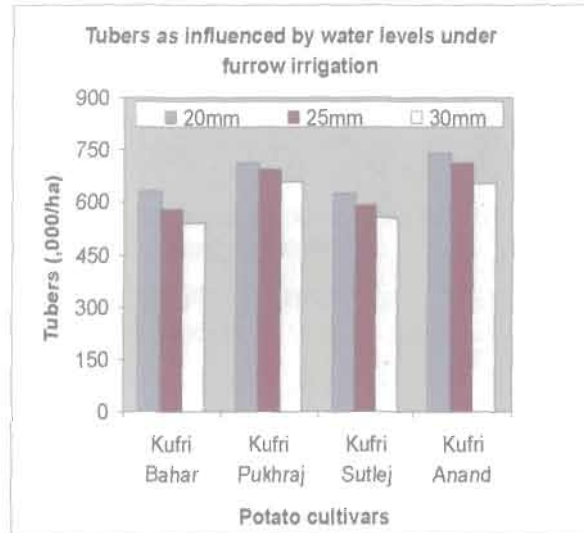
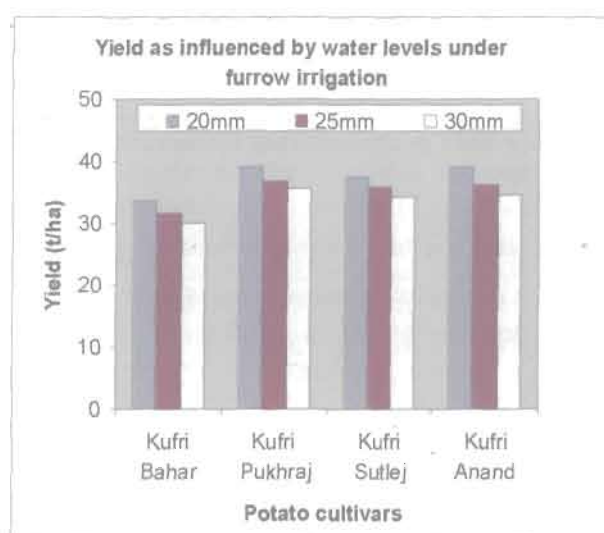
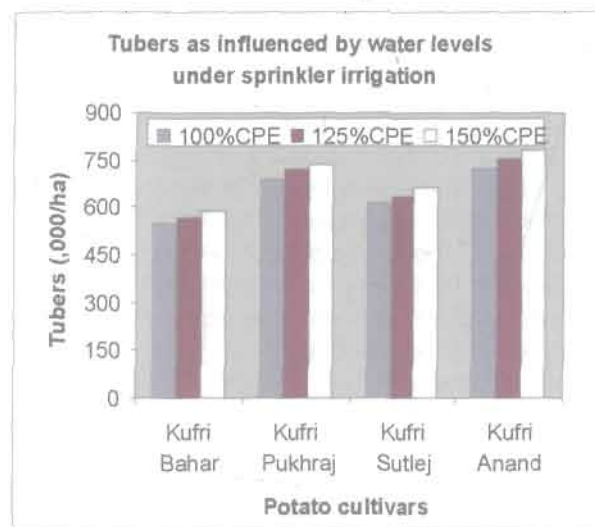
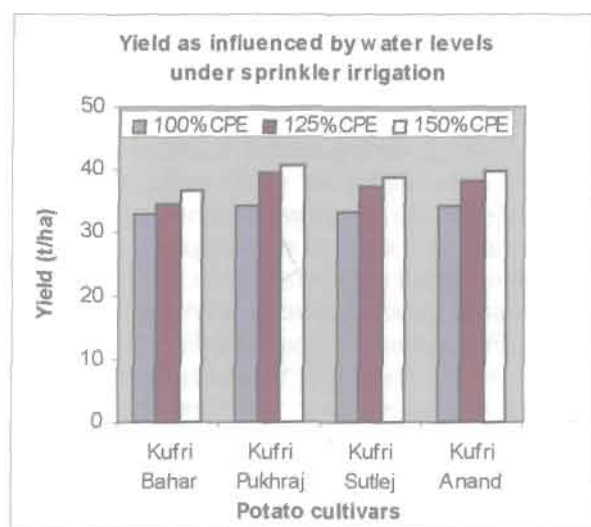
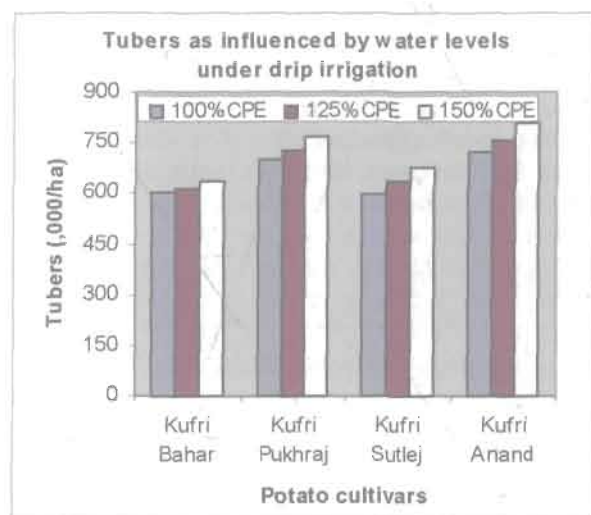
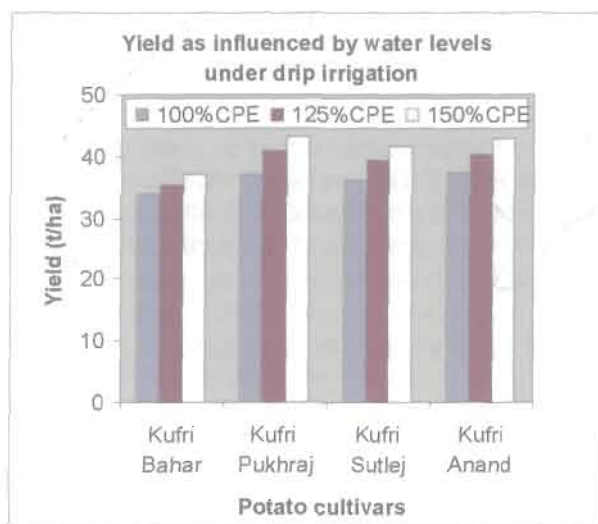


Fig. 10. Yield and tuber numbers as influenced by water levels under different irrigation methods



### Effect of raised bed planting method under drip fertigation

In raised bed planting patterns on potato under drip fertigation at Modipuram, single drip layout fertigation system for raised bed triple row potato planting with 1,25,000 plants/ha gave significantly higher yield of potatoes (39.8 t/ha) along with 50% water saving as compared to furrow irrigation method which produced 30.6 t/ha. This was followed by the treatment with 100% NPK fertigation for double row planting along with single drip lateral placed at 90 cm spacing with 1,11,111 plants/ha followed by double row planting with single drip lateral placed at 120 cm spacing with same plant population.

### Effect of bed planting patterns on potato production under sprinkler fertigation

At Modipuram, the raised bed/triple row potato planting at 120 cm spacing with 1,25,000 plants/ha under sprinkler fertigation produced significantly higher yield (40.0 t/ha) along with 40% water saving as compared to traditional furrow method of irrigation which gave 30.9 t/ha. Yield under this treatment was also superior over other treatments *i.e.* single row planting

(SRP) furrow irrigation, double row planting (DRP) furrow irrigation, SRP sprinkler irrigation and DRP sprinkler irrigation. This treatment also produced significantly higher yields of large (>75 g) as well as medium grade (25-75 g sized) tubers as compared to other treatments, which may be used as seed material for planting of additional area under potato without sacrifice in yield.

### Optimizing irrigation water and nitrogen needs of potato

An experiment was conducted at Modipuram with two potato cultivars Kufri Bahar and Kufri Anand, ten treatments of nitrogen doses and application schedules and two irrigation levels (under optimal and sub-optimal conditions). Irrigations applied at 20 mm CPE water level produced significantly higher yield of both potato varieties Kufri Bahar and Kufri Anand (Table 17) as compared to irrigations applied at critical stages of crop growth *i.e.* per-emergence stage, stolon formation stage, tuber initiation stage, early tuber enlargement stage and late tuber enlargement stage. The similar trend was also noticed in case of tuber numbers. Application of 180 kg N/ha produced higher yield of both the

**Table 17. Yield (t/ha) of potato cultivars as influenced by irrigation levels, nitrogen rates and application schedules**

| Treatment                                             | Kufri Bahar | Kufri Anand |
|-------------------------------------------------------|-------------|-------------|
| <b>Irrigation levels</b>                              |             |             |
| Optimum irrigation at 20 mm CPE                       | 35.3        | 40.5        |
| Sub-optimum irrigation at critical crop growth stages | 33.7        | 38.6        |
| CD (0.05)                                             | 1.6         | 1.8         |
| <b>N levels and application schedules</b>             |             |             |
| Control (0 kg N/ha)                                   | 21.9        | 21.5        |
| 120 kg N/ha in two splits                             | 31.9        | 39.4        |
| 120 kg N/ha in three splits                           | 36.3        | 41.7        |
| 120 kg N/ha in four splits                            | 33.9        | 38.6        |
| 150 kg N/ha in two splits                             | 36.4        | 41.5        |
| 150 kg N/ha in three splits                           | 37.8        | 43.3        |
| 150 kg N/ha in four splits                            | 35.0        | 40.4        |
| 180 kg N/ha in two splits                             | 36.5        | 42.6        |
| 180 kg N/ha in three splits                           | 39.0        | 44.4        |
| 180 kg N/ha in four splits                            | 37.2        | 42.1        |
| CD (0.05)                                             | 2.2         | 2.4         |

varieties in comparison to other nitrogen levels which was at par with that under 150 kg N/ha. The split application of nitrogen (1/3 basal at planting + 1/3 at earthing-up stage at 25 days after planting + 1/3 at 15 days after earthing-up stage) produced maximum yield of potatoes in comparison to two and four splits with all nitrogen levels. The yield of both the varieties at 180 kg N/ha with two splits was at par with the yield of 150 kg N/ha applied in three splits.

#### Maximization of seed size tuber yield under sprinkler irrigation system

Under sprinkler irrigation system at Modipuram, the seed size tuber yields of cultivar Kufri Arun improved by 28% in 3 row bed planting system followed by 2 row bed (17.3%) as compared to ridge furrow system. Total tuber yield was also 37% higher in 3 row bed (31.1 t/ha) over ridge furrow system (22.6 t/ha).

#### Influence of irrigation methods on potato productivity and quality

At Modipuram, significant improvement of 19.2% in processing grade and 9.6% in total tuber yield was recorded in controlled irrigation crop over conventional system (Table 18). Specific gravity and chip colour were not significantly affected by methods of irrigation. However, varieties had significant difference in both the parameters. In another field experiment at Modipuram, the cut seed pieces performance under controlled

irrigation and bed planting system were evaluated. Total tuber productivity was comparable only in cut tubers of 45-60 g to whole seed; whereas, with 15-30 g or 30-45 g it was significantly lower. Specific gravity and French fry colour remained unaffected due to cutting of seed pieces. Maximum process grade yield was observed with cultivar Kufri Chipsona-3 followed by Kufri Frysona. However, the maximum tuber yield was recorded in cultivar Kufri Chipsona-1.

#### Phasic water need of potato crop in hills

Field experiment was conducted at Shimla during summer season of 2008 to work out phasic water need of potato crop. Irrigations were applied at different soil moisture regimes during stolonization and tuberization phases of potato crop which coincides with drought period in Shimla hills. Optimum irrigation (4 in number, amounting 200 mm of irrigation water) during early crop development phases at 75% available soil moisture regimes (ASM) gave maximum potato yield (22.0 t/ha) followed by imposing mild water stress at tuberization stages (20.5 t/ha) and likewise, withholding one irrigation during stolonization stages (20.1 t/ha). However, these treatments behaved alike as the yield differences were non significant. The continuous water stress at stolonization and tuberization stages or withholding irrigation at stolonization or tuberization stages adversely affected crop yield (Table 19). The lowest crop yield (12.5 t/ha) was

Table 18. Grade wise tuber yield, specific gravity and chip colour at Modipuram

| Treatment                     | Mean tuber yield (t/ha) |       |       | Specific gravity | Chip colour (1-10 scale) |
|-------------------------------|-------------------------|-------|-------|------------------|--------------------------|
|                               | Processing              | Small | Total |                  |                          |
| Main plot (Irrigation method) |                         |       |       |                  |                          |
| Sprinkler                     | 15.82                   | 10.79 | 26.61 | 1.0824           | 2.28                     |
| Ridge furrow                  | 13.27                   | 11.00 | 24.27 | 1.0823           | 2.03                     |
| CD (0.05)                     | 2.19                    | NS    | 2.28  | NS               | NS                       |
| Sub plot (Cultivars)          |                         |       |       |                  |                          |
| KufriChipsona-1               | 12.95                   | 15.38 | 28.33 | 1.0835           | 1.37                     |
| Kufri Chipsona-2              | 15.45                   | 7.20  | 22.65 | 1.0905           | 2.16                     |
| Kufri Chipsona-3              | 14.85                   | 12.74 | 27.59 | 1.0840           | 1.38                     |
| Kufri Lauvkar                 | 14.98                   | 8.26  | 23.24 | 1.0715           | 3.72                     |
| CD (0.05)                     | NS                      | 1.97  | 3.59  | 0.0017           | 0.88                     |



under rainfed potato cultivation, which was 43% less than that with optimum water level,

indicating the need for applying supplemental irrigation water to potato crop.

**Table 19. Effect of phasic water application on yield of potato at Shimla**

| Treatments | Stage of growth and soil moisture level at which irrigation water is applied |               | Amount of irrigation water applied (mm) | Yield of potato (t/ha) | Production efficiency of irrigation water (kg/ha mm) |
|------------|------------------------------------------------------------------------------|---------------|-----------------------------------------|------------------------|------------------------------------------------------|
|            | Stolanization                                                                | Tuberization  |                                         |                        |                                                      |
| T1         | 75% ASM                                                                      | 75% ASM       | 200                                     | 22.0                   | 110                                                  |
| T2         | 75% ASM                                                                      | 50% ASM       | 150                                     | 20.5                   | 137                                                  |
| T3         | 50% ASM                                                                      | 75% ASM       | 150                                     | 20.1                   | 134                                                  |
| T4         | 50% ASM                                                                      | 50% ASM       | 100                                     | 17.0                   | 170                                                  |
| T5         | 75% ASM                                                                      | No irrigation | 50                                      | 16.5                   | 330                                                  |
| T6         | No irrigation                                                                | 75% ASM       | 50                                      | 15.0                   | 300                                                  |
| T7         | Rainfed                                                                      | Rainfed       | -                                       | 12.4                   | -                                                    |
| CD (0.05)  |                                                                              |               |                                         | 2.1                    |                                                      |





# Long term manurial/fertilizer experiments on potato based cropping systems



The long term manurial/fertilizer experiments initiated at Modipuram with the objectives to study the effect of application of organic manure, crop residue and inorganic fertilizers on sustainable crop production in promising potato based cropping systems were continued during the year.

Seven manurial/fertilizer treatments (Table 20) were imposed on three crop sequences viz. rice-potato-wheat, maize-potato-onion and sesamum-potato-green manure. Among the seven treatments tested, the yield of potato, wheat, onion and maize crops were higher in treatments receiving 100% recommended NPK through inorganic fertilizers than that of 100% organic treatments (Tables 20,21,22). Application of secondary nutrients along with 100% NPK did not increase the productivity of any system. The system productivity in inorganic treatments was 25-51% higher than organic treatments. The organic source of nutrients reduced the tuber number, indicating that nutrients supply from organic source was not sufficient to meet crop requirement. The system productivity was higher in maize-potato-onion (76.4 t/ha) followed by rice-potato-wheat (54.7 t/ha) crop sequence (Fig. 14). The lowest potato equivalent yield was recorded in sesamum-potato-green gram sequence (36.4 t/ha). In all the cropping systems under organic treatments, the tuber size remained smaller compared to treatments

receiving NPK through inorganic fertilizers. The incorporation of residues of preceding crop was not found effective in enhancing the crop yields. The weed population was more in organically raised crop, where no herbicide was used.

## Organic farming for potato production

With the aim to develop nutrient management techniques for organic potato production, field experiments were conducted at Modipuram and Shimla to study the impact of organic and inorganic source of nutrients on potato productivity and quality of produce and physical and chemical properties of soil.

### Effect of organic and inorganic sources of nutrients on tuber production

Integrated nutrients supply through NPK fertilizers in combination with farm yard manure

(FYM) or vermicompost at fixed site for seven years with five potato cultivars showed that vermicompost was superior to FYM (Fig. 11 and 12). Tuber yields improved over the years due to cumulative effect of organically manured plots and now after seven years appear to be stabilized. However, these could not match with that of inorganically fertilized plots. Kufri Anand, Kufri Sutlej, Kufri Pukhraj, Kufri Chipsona-1 and Kufri Chipsona-2 produced 32.0, 29.5, 31.2, 25.1 and 24.0 t/ha organic potato, when raised at fixed site for six consecutive years. Organic manuring increased the organic carbon, available NPK content and resulted in desirable reduction of soil bulk density (Table 23). The organic

treatments also enhanced the tuber quality parameters viz. dry matter content, specific gravity and chip colour in all potato cultivars compared to inorganic fertilizer treatments. In another experiment on application of variable ratios of fertilizers and vermicompost to supply nutrient equivalent of 180-80-100 kg/ha (approximately) as N,  $P_2O_5$  and  $K_2O$  on two potato cultivars, Kufri Anand and Kufri Chipsona-1, vermicompost (100%) gave 35.2% higher yield in Kufri Anand than Kufri Chipsona-1 (Fig. 13). Tuber yield was maximized in both the cultivars with the application of vermicompost (25%)+NPK fertilizer (75%). Kufri Anand performed better than Kufri Chipsona-1. The tuber yields from

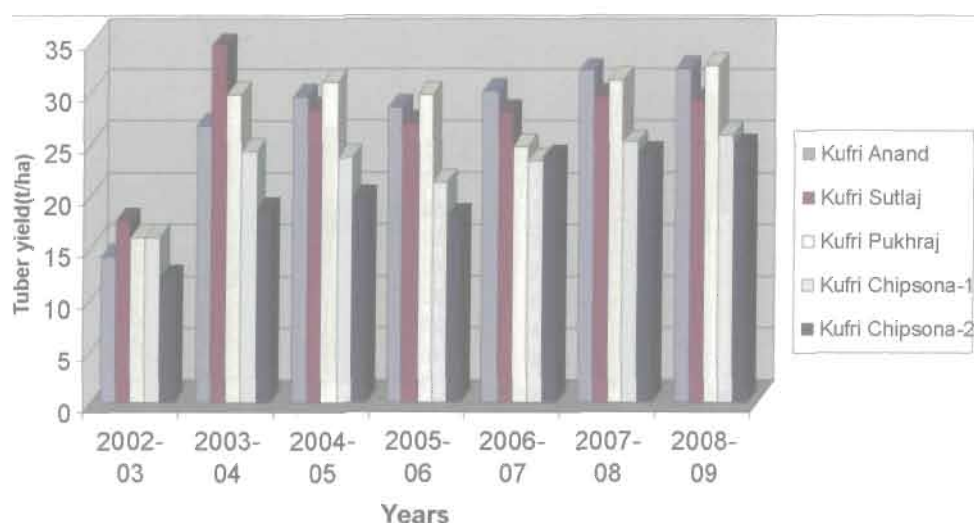


Fig. 11. Improvement in organic tuber yield in successive years from vermicompost

Table 20. Yield of rice-potato-wheat crop sequence and potato equivalent yield (PEY) as influenced by different management options

| Treatment                                   | Yield of crops (t/ha) |       |       |       |               |       |
|---------------------------------------------|-----------------------|-------|-------|-------|---------------|-------|
|                                             | Wheat                 |       | Rice  |       | Potato tubers | PEY   |
|                                             | Grain                 | Straw | Grain | Straw |               |       |
| Absolute control                            | 1.49                  | 2.70  | 4.74  | 3.30  | 8.28          | 33.67 |
| 100% NPK through inorganic                  | 3.89                  | 5.76  | 5.65  | 9.33  | 21.44         | 60.48 |
| 100% NPK through organic                    | 2.33                  | 3.50  | 5.35  | 6.80  | 18.30         | 49.78 |
| 50% inorganic + 50% organic                 | 3.28                  | 4.94  | 5.87  | 7.11  | 22.07         | 59.31 |
| 100% inorganic + secondary +micro nutrients | 4.15                  | 6.78  | 5.60  | 9.80  | 22.30         | 62.39 |
| 100% inorganic + crop residue               | 4.17                  | 5.80  | 5.91  | 10.39 | 25.32         | 66.51 |
| 100% organic + crop residue                 | 2.43                  | 2.93  | 5.87  | 8.06  | 17.02         | 50.90 |
| CD (0.05)                                   | 0.57                  | 1.23  | 0.55  | 1.86  | 3.63          | -     |



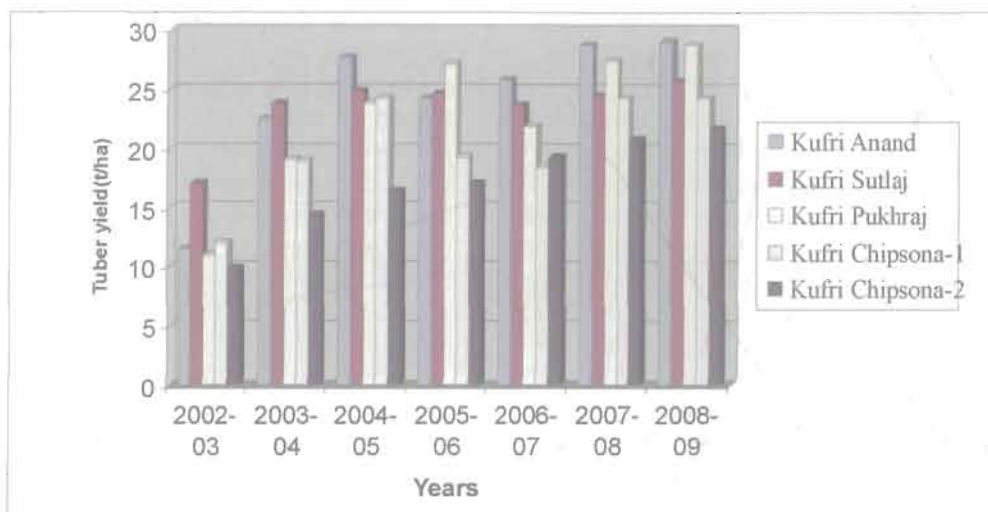
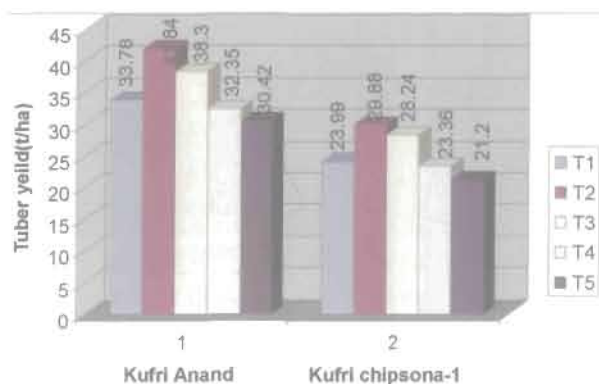
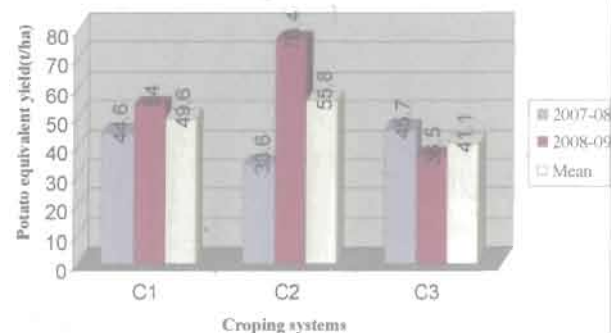


Fig. 12. Improvement in organic tuber yield in successive years from FYM



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

Fig. 13. Effect of fertilizer and vermicompost on tuber yield



C1: Rice- Potato-Wheat; C2: Maize- Potato-Onion; C3: Sesamum- Potato-green gram

Fig. 14. Potato equivalent yield in different cropping systems

100% vermicompost were less than 100% fertilizer, even when raised on same plots for seven consecutive years.

#### Effect of biofertilizers and conventional techniques on tuber production

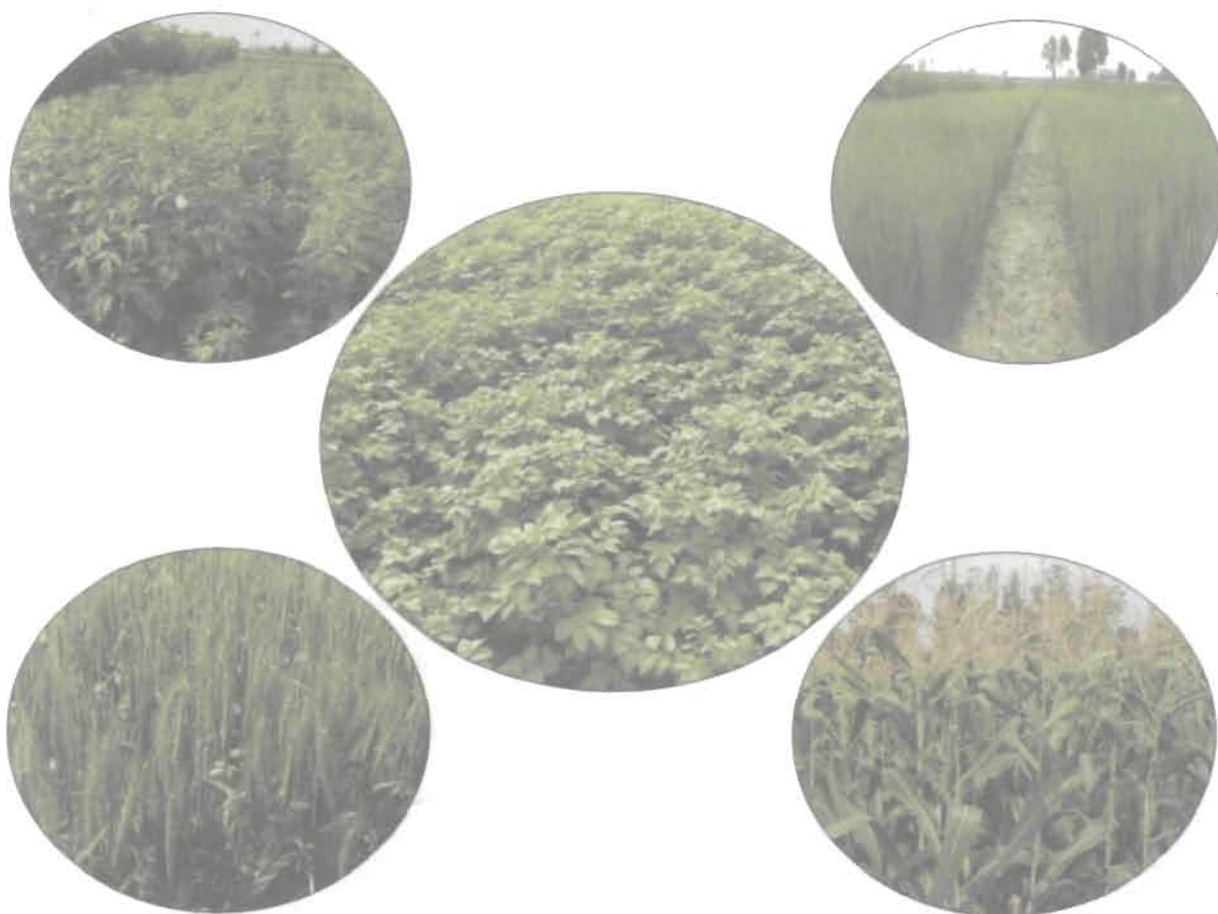
Application of bioagents ( $B_4$  and  $B_5$ ) increased the tuber yield when no nutrients were applied. However, with the application of nutrients through organic and inorganic sources, the effect was non-significant. Out of the two bioagents used,  $B_4$  was more effective. The use of

biofertilizers (*Azotobacter* and phosphobacteria) and bioagents ( $B_4$  and  $B_5$ ) in combination with organic and inorganic sources of nutrients, did not increase the tuber yield significantly. Quality parameters like dry matter content and specific gravity were better when raised organically. Chlorophyll meter reading recorded at 60 days after planting showed linear relationship with tuber yield. The total  $\text{NO}_3 - \text{N}$  content in soil profile under conventional treatment was higher than organic treatment. The organic carbon, microbial biomass carbon, dehydrogenase activity, water holding capacity and soil



**Table 21. Yield of maize-potato-onion crop sequence and potato equivalent yield (PEY) as influenced by different management options**

| Treatment                                    | Yields of Crops (t/ha) |       |       |               | PEY   |
|----------------------------------------------|------------------------|-------|-------|---------------|-------|
|                                              | Onion                  | Maize |       | Potato tubers |       |
|                                              |                        | Grain | Stalk |               |       |
| Absolute control                             | 17.00                  | 1.88  | 9.10  | 6.12          | 40.99 |
| 100% NPK through inorganic                   | 35.98                  | 4.19  | 19.63 | 20.83         | 95.26 |
| 100% NPK through organic                     | 23.57                  | 2.80  | 16.13 | 16.91         | 66.35 |
| 50% inorganic + 50% organic                  | 28.59                  | 3.67  | 19.67 | 21.28         | 82.01 |
| 100% inorganic + secondary + micro nutrients | 33.04                  | 4.38  | 20.47 | 25.09         | 95.25 |
| 100% inorganic + crop residue                | 33.50                  | 4.84  | 20.57 | 21.54         | 93.71 |
| 100% organic + crop residue                  | 20.61                  | 3.61  | 16.37 | 14.87         | 61.57 |
| CD (0.05)                                    | 3.09                   | 0.46  | 3.89  | 2.45          | -     |



**Photograph showing cropping systems in long term manurial/fertilizer experiments**

**Table 22. Yields of crops in green gram-sesamum-potato crop sequence and potato equivalent yield (PEY) as influenced by different management options**

| Treatment                                    | Yield of crops (t/ha) |         |               | PEY   |
|----------------------------------------------|-----------------------|---------|---------------|-------|
|                                              | Green gram            | Sesamum | Potato tubers |       |
| Absolute control                             | 0.44                  | 0.50    | 9.63          | 20.13 |
| 100% NPK through inorganic                   | 0.61                  | 0.60    | 29.52         | 43.58 |
| 100% NPK through organic                     | 0.56                  | 0.54    | 15.65         | 28.50 |
| 50% inorganic + 50% organic                  | 0.65                  | 0.61    | 28.48         | 43.08 |
| 100% inorganic + secondary + micro nutrients | 0.60                  | 0.61    | 30.50         | 44.71 |
| 100% inorganic + crop residue                | 0.60                  | 0.64    | 30.50         | 45.07 |
| 100% organic + crop residue                  | 0.65                  | 0.58    | 16.17         | 30.40 |
| CD (0.05)                                    | 0.11                  | 0.03    | 2.64          | —     |

**Table 23. Effect of organic manuring on soil properties at Modipuram**

| Soil property                     | Initial | 100% NPK inorganic | 100% Organic |
|-----------------------------------|---------|--------------------|--------------|
| pH                                | 7.02    | 7.06               | 6.80         |
| EC (ds/m)                         | 0.38    | 0.40               | 0.26         |
| Organic carbon (%)                | 4.0     | 0.41               | 0.62         |
| Available N (kg/ha)               | 170.4   | 176.4              | 203.4        |
| Available P (kg/ha)               | 22.2    | 35.8               | 48.5         |
| Available K (kg/ha)               | 190.5   | 240.2              | 270.7        |
| Bulk density (Mg/m <sup>3</sup> ) | 1.35    | 1.38               | 1.25         |

aggregation increased while bulk density decreased, where organic manures were applied. Thus soil tilth was improved and nitrate leaching was reduced when nutrients were applied through organic manures.

Effect of organic form of nutrients on potato crop in the hills

A field experiment was conducted at Shimla with five levels of vermicompost i.e. 0, 2.5, 5.0, 10.0, and 15.0 t/ha and compared with fertilizer application (120, 100 and 100 kg/ha N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O). The plant growth parameters viz. plant height, number of leaves, leaf area and tuber number per plant tended to increase in plots where 15 t/ha vermicompost and fertilizer application was done. The application of fertilizers and higher levels of vermicompost showed an increase in the tuber yield of large

and medium sized tubers but did not affected the small sized tubers. The application of 10-15 t/ha of vermicompost resulted in higher tuber yield over other vermicompost levels. The fertilizer application gave higher tuber yield (19.9 t/ha) which was 11.0, 20.1, 35.6, 48.2 and 56.7% higher over, 15, 10, 5, 2.5 and 0 t/ha vermicompost, respectively. Higher doses of vermicompost (10 and 15 t/ha) improved soil organic carbon and available soil moisture capacity and decreased soil bulk density besides improving soil fertility.

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

The objective of this project was to study the long term effect of application of organic



manure, crop residues and inorganic fertilizers on physical, chemical and biological properties of soil and pest complex and to study the pesticide residues in soil and crop produce.

The highest dry matter content in potato tubers was recorded in sesamum-potato-green gram crop sequence and was at par with other two cropping systems. Among the seven treatments tested at Modipuram, the dry matter content was higher in treatment receiving 100% organic fertilizer through vermicompost, which was at par with treatment receiving 50% organic + 50% inorganic and 100% NPK + secondary nutrients (Table 24). 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.

The tuber quality was at par in all the three cropping systems, but there was great difference in organic and inorganic treatments.

Incorporation of crop residues slightly decreased the reducing and non reducing sugar contents (Table 24). The grains/bulbs nitrogen content was higher in treatment receiving 100% NPK through inorganic sources. Rice cultivar *Sugandha-5* was infested by fungal disease. The disease severity was low under organic and control treatments as compared to inorganic treatment. Sesamum crop had an insect problem as there was severe attack by hairy caterpillar in all the treatments.

Mean nitrogen uptake by rice, wheat, maize, sesamum and green gram grain was 80.05, 48.45, 80.32, 20.87 and 20.93 kg/ha, respectively. The soil properties viz, organic carbon, available nitrogen, phosphorus and potassium improved, while bulk density decreased, by application of organic manure in

all the three cropping systems. In wheat grains, zinc and copper uptake varied from 99-271 and 2-9 g/ha, respectively. In rice the corresponding uptake was 137-190 and 10-13 g/ha, respectively. Depending on the treatment, zinc and copper uptake by potato tubers varied from 48-146 and 3-12 g/ha, respectively.

The soil analysis after potato harvest revealed that mineral N content was at par in all three cropping systems, but there was great difference in organic and inorganic treatments.

Incorporation of crop residues slightly increased the mineral nitrogen. The nitrogen uptake by rice, maize and sesamum grains was higher in treatment receiving 100% nutrients through inorganic fertilizers as compared to 100% organic treatment. In wheat, zinc uptake varied from 119 – 270 g/ha in different treatments. The higher zinc uptake (270 g/ha) was recorded in treatment receiving 100% NPK through fertilizer along with crop residue incorporation of preceding potato crop. In case of copper, its uptake varied from 5-11 g/ha, indicating its low removal by wheat grains from soil. In case of rice, zinc and copper uptake from soil varied from 274-450 g and 20-28 g per hectare, respectively. Similarly, the zinc and copper uptake in potato tubers varied from 51-58 g and 3-13 g/ha, and in maize, varied from 136-197 g/ha and 7-12 g/ha, respectively. The uptake of both the micronutrients was minimum in control, where no manures/fertilizers were applied. In sesamum (oil seed), highest zinc uptake (141 g/ha) was recorded in treatment receiving 100% NPK through fertilizers along with crop residue incorporation of preceding green gram crop. In case of copper minimum uptake of 1 g/ha was observed in treatment receiving 100% NPK through organic manure.





Table 24. Long-term effect of organic manures and inorganic fertilizers on quality of potato under different crop sequences

| Treatments                             | Rice –Potato –Wheat |                           |                               | Maize–Potato–Onion |                |                           | Sesamum–Potato–Green gram     |                    |                |                            |                               |                    |
|----------------------------------------|---------------------|---------------------------|-------------------------------|--------------------|----------------|---------------------------|-------------------------------|--------------------|----------------|----------------------------|-------------------------------|--------------------|
|                                        | Dry Matter (%)      | Reducing sugars (mg/100g) | Non-reducing sugars (mg/100g) | Starch content (%) | Dry matter (%) | Reducing sugars (mg/100g) | Non-reducing sugars (mg/100g) | Starch content (%) | Dry matter (%) | Reducing sugars (mg/100 g) | Non-reducing sugars (mg/100g) | Starch content (%) |
| Absolute control                       | 18.0                | 190.6                     | 260.2                         | 11.7               | 18.70          | 184.7                     | 248.0                         | 12.5               | 18.80          | 180.6                      | 238.0                         | 12.6               |
| 100% NPK through inorganic             | 16.8                | 200.3                     | 300.0                         | 10.5               | 17.06          | 194.7                     | 291.3                         | 10.8               | 17.60          | 190.3                      | 290.3                         | 10.8               |
| 100% NPK through organic               | 18.62               | 188.2                     | 260.0                         | 12.4               | 18.84          | 168.7                     | 246.3                         | 12.7               | 18.94          | 160.6                      | 240.3                         | 12.7               |
| 50% Inorganic + 50% organic            | 18.32               | 190.3                     | 270.0                         | 12.1               | 18.54          | 170.3                     | 257.3                         | 12.3               | 18.64          | 165.3                      | 247.3                         | 12.3               |
| 100% NPK + secondary + micro nutrients | 17.66               | 190.0                     | 280.0                         | 11.4               | 17.86          | 180.0                     | 274.0                         | 11.7               | 18.00          | 176.2                      | 270.0                         | 11.7               |
| 100% NPK + Crop residue                | 17.70               | 192.0                     | 290.2                         | 11.4               | 17.90          | 181.3                     | 276.7                         | 11.7               | 18.20          | 178.4                      | 272.2                         | 11.7               |
| 100% Organic + Crop residue            | 18.58               | 185.0                     | 262.3                         | 12.4               | 18.42          | 180.0                     | 263.3                         | 12.2               | 18.62          | 182.0                      | 258.5                         | 12.2               |
| Mean                                   | 17.9                | 190.9                     | 274.7                         | 11.7               | 18.19          | 179.9                     | 265.3                         | 12.0               | 18.40          | 176.2                      | 259.5                         | 12.0               |
| CD (0.05)                              | 1.40                | 7.48                      | 23.7                          | 0.9                | 1.42           | 7.6                       | 23.9                          | 1.0                | 1.38           | 7.4                        | 23.4                          | 1.0                |

# Mechanization of Potato Cultivation



**F**arm implements and equipment are needed for timely completion of various cultural operations and precise application of inputs for sustainable potato production. Keeping this in view this research programme aims to develop, fabricate and evaluate a rotary tiller with crumbler roller for seed bed preparation, design and development of planting, interculture and harvesting tools and aids for small and marginal farmers, development of a machine for making french fry cuts and design a low cost potato peeling machine. It also aims to develop potato implements and machines for stage I and II and also the aeroponic system for seed potato production.

## Development of a rotary tiller with crumbler roller for seed bed preparation

Fabrication work of rotary tiller with crumbler roller was carried out. It consists mainly of three systems namely main frame, cutting mechanism and power transmission systems. Shaft with L-shaped working tools (designated as the cutter drum) has been covered with an MS sheet guard (made out of 14 gauge MS sheet). This MS sheet guard has been provided with hinges and can be easily lifted up upon requirement. Two solid rubber lined wheels (of diameter 300 mm), have been provided on both sides of the cutter drum for getting the required depth of tillage. A hand actuated screw mechanism which alters the position of these wheels, controls the depth of tillage of this implement. These wheels can be very easily fitted or taken out from the

prototype unit upon requirement without the assistance of any hand tools. The working tools of the rotary tiller are mounted in relation to the cutter drum, in such a way that as the knife enters the soil, its stem provides the gradually increasing torque needed to overcome the resistance of the soil to cutting. In order to increase the working life of these knives, provision has been made during material selection, for self sharpening of the knives in the process of wear. In power transmission system, a chain drive (chain size 25 mm pitch) located at the side of the tiller, links the reduction gear-box to the cutter drum shaft. Provision has also been made for proper tensioning of the chain, upon requirement. Chain drive has been properly enclosed in an MS sheet casing. One portion of this chain remains constantly dipped in oil, so as to have proper lubrication of chain for smooth operation. An MS sheet cover has also been provided on the top of this casing, with the help

of nuts and bolts to open the system for any adjustments/repairs. A sliding type of inspection window on the side of this cover has also been provided so that any problem encountered in the field in the power transmission system, can be easily checked.

Crumbler roller attachment (size 1630 mm long and of 295 mm diameter) to the rotary tiller has also been fabricated. This cylindrical attachment consists mainly of six numbers of properly shaped MS flats (size 500×16 mm and 50×12 mm) welded on two numbers of MS sheet round plates (6 mm thick of diameter 285 mm). Average spacing between any two flats is 135 mm. Two MS flat rings have also been provided in the inner side of the attachment, at two intermittent locations for proper support and strength. Two bearings (size 6205) with brackets on 25 mm diameter MS shafts have also been provided on both sides so that the crumbler roller revolves freely. In order to fit this attachment to the prototype, the solid rubber lined wheels can be taken off and the attachment provided in stead. This attachment can also be fitted at the rear of a tractor drawn cultivator, if required. Upon performance evaluation, the rotary tiller was found to till an area of 0.26 hectares in an hour. The speed of operation was observed as 2.0-3.5 km/hr. The

salient features of rotary tiller with crumbler roller are given (Table 25).

Design and development of planting, interculture, harvesting and grading tools and aids for small and marginal farmers

Fabrication work of the manually/engine operated sieve type or endless screen type potato grader was completed. Main frame of the grader consists of a rectangular box made up mainly of angle iron. Improvements in the grading, collection and power transmission system of the grader was carried out. Grading unit consists mainly of two numbers of grading sieves/nets having 50 mm and 30 mm size square openings made out of 8 SWG MS wire. These grading sieves were properly aligned to keep a check on their sideways movement. Proper care has been taken to disallow any loosening of the wires of the grading nets during operation. Rod and hook type of bag holder for grade size 30 mm-50 mm has been made folding type to optimize the width of the grader. The height of the bag holders for 30-50 mm and more than 50 mm size grades has been so kept as to suit the average length of a gunny bag. Gunny bags are hung on the bag holding device provided at the outlet of each chute. Necessary modifications

**Table 25. Salient features of the rotary tiller with crumbler roller**

| Item                                             | Specifications                                              |
|--------------------------------------------------|-------------------------------------------------------------|
| Type                                             | Tractor mounted                                             |
| Overall dimensions(LXBXH)in mm                   | 1760X1720X940                                               |
| Cutting width                                    | 1420 mm                                                     |
| Diameter of the cutter drum                      | 530 mm                                                      |
| Type of the working tool                         | L-shaped                                                    |
| Size of the L-shaped cutting blade               | 82.5 mm wide and 355 mm long                                |
| Nos. of cutting blade assemblies                 | 6                                                           |
| Nos. of L-shaped cutting blades in each assembly | 6                                                           |
| Power transmission                               | From tractor's PTO through reduction gear box & chain drive |
| Speed ratio of the reduction gear box            | 1:6                                                         |
| Overall size of the crumbler roller attachment   | 1630 mm long and of 295 mm diameter                         |
| <b>Performance evaluation</b>                    |                                                             |
| Output in ha/hr                                  | 0.26                                                        |
| Depth of working (mm)                            | 100-150                                                     |
| Working speed (Km/hr)                            | 2.0-3.5                                                     |



were also made in the power transmission system of the grader, so that it can be easily operated with a diesel engine. Speed of the grading sieves can be easily varied as required by simply varying the speed of the engine. In power transmission system, idler sprockets wherever necessary have been provided to tighten the chains for their smooth movement. The salient features of manually/engine operated endless screen type potato grader are given (Table 26).

Performance and evaluation of the grader was carried out both manually and also by using a water cooled diesel engine (5 hp). Around 5-8 persons are required to work with this grader. They are used for operation, feeding, shifting of the filled up bags and for attaching empty bags with bag holders. This grader is suitable for grading even the freshly harvested tubers which

have been cured in the heaps for about 15-20 days after harvesting. This grader when operated manually with a person using a flywheel arrangement can handle on an average around 2.5 t of potatoes in an hour. However, on being operated with a 3-5 hp diesel engine, this prototype can grade 4.5 t of potatoes per hour, into three grades with almost negligible bruising. One has to replace the 750 mm diameter flywheel on the drive shaft with a 250 mm diameter flat belt pulley, in case the grader is required to be operated with an engine.

Fabrication work of a manually operated intercultural toolbar was also carried out. Main frame of the toolbar consists mainly of 12.7 mm diameter GI pipe. To push the implement an ergonomically designed handle (460 mm wide of 12.7 mm diameter GI pipe) resembling the shape of a bicycle handle, has also been

**Table 26. Salient features of manually/engine operated endless screen type Potato grader**

| Item                                                 | Specifications                                                                        |
|------------------------------------------------------|---------------------------------------------------------------------------------------|
| Type                                                 | Manually/Engine operated                                                              |
| Overall length (mm)                                  | 2600                                                                                  |
| Overall width (mm)                                   | 2350                                                                                  |
| Overall height (mm)                                  | 1630                                                                                  |
| Size of the grading sieves                           | 50 and 30 mm size square openings                                                     |
| Power requirement                                    | a) Manual operation                                                                   |
| Power transmission                                   | b) A 3 to 5 hp diesel engine                                                          |
| Method of feeding                                    | Through chain drive, belt and pulley arrangement                                      |
| Bagging system                                       | Generally manual feeding with baskets/gunny bags                                      |
| Transportability                                     | Bag holders provided                                                                  |
| <b>Performance evaluation</b>                        | Four nos. of solid rubber lined transport wheels provided                             |
| Output capacity                                      | a) 4.5 t/hr when operated with engine                                                 |
|                                                      | b) 2.5 t/hr when operated manually                                                    |
| Number of labourers needed to work with this machine | 5 to 8                                                                                |
| Suitability for freshly harvested tubers             | Can be used for freshly harvested tubers after curing them in heaps for 15 to 20 days |
| Numbers of grades obtained and range                 | Three grades                                                                          |
|                                                      | (i) First grade with tuber diameter exceeding 5 cm.                                   |
|                                                      | (ii) Second grade with tuber diameter between 3 and 5 cm.                             |
|                                                      | (iii) Third grade with tuber diameter below 3 cm.                                     |
| Tuber damage                                         | Almost negligible                                                                     |

provided. 17 mm long portion of the handle has also been bent at both the ends for easy holding of the handle with hands. A pneumatic wheel (size 87.5 mm × 200 mm) with iron rim has also been provided for proper movement of the implement in the field.

## Development of equipment and machines for small scale potato processing

### Development of a low cost potato peeling machine

Different disc plates, each of 320 mm diameter provided with various types of abrasive surfaces were designed, fabricated and evaluated to find out their suitability for peeling of potato tubers. Three types of abrasive surface discs developed included (a) cement made surface with stone chips embedded in it (b) GI sheet circular plate with punch holes all over its surface and (c) circular plate made of wire mesh surface.

An experimental set up was designed and fabricated to test and evaluate the different abrasive surface plates developed for peeling of potato tubers. It consisted of a main frame, feed trough or the potato hopper with provision for pouring of water. The transmission system consists of an electric motor, an adjustable sliding type frame and V-belt pulley system with fixed driven and an adjustable drive pulley. The main frame was made of 12 mm diameter GI pipe. The hopper trough was fabricated using 20 gauge GI sheet, having lid on the upper open end and without any base at the bottom. The trough was rigidly fitted to the main frame. Provision was made to pour water in the trough from one side through a pipe with funnel fitted over it. The power transmission system developed consisted of a 0.75 hp electric motor, that transmits power to the base plate developed for potato peeling through an adjustable variable V- pulley, especially developed for the purpose. The motor was placed in the vertical position and was fitted over a wooden base. This base with motor mounted over it, is supported by a moveable frame made of angle iron. A handle is provided on one end of the frame which when rotated, provides linear sliding motion to the

frame, with the help of a threaded shaft and bolt arrangement. This movement varies the size of the driving pulley, thus changing the speed ratio, hence the speed of rotation of the driven pulley and thereby that of the abrasive disc. The variable pulley is made of two separate parts that are fixed together with the help of a shaft having threads and a bolt. The diameter of pulley thus made can be changed with loosening or tightening of two parts of the pulley to find out the effect of speed of rotation on the peeling of potato tubers. The overall dimensions of the system developed were 1030x700x640 mm. The diameter of the rotating base plate with abrasive surface was kept as 320 mm. The variable pulley could be adjusted from 100 mm to 70 mm effective diameter. The pulley could provide speed ratio of 1.8 to 2.6 when used in combination to drive the fixed pulley of 180 mm diameter.

During actual operation, the electric motor rotates the variable or the drive pulley and transmits power to the 180 mm diameter fixed V-groove pulley with the help of A-42 V-belt, which rotates the abrasive disc mounted on the vertical shaft. This disc is so placed, that it acts as base to the trough hopper. During actual operation an abrasive plate is mounted in the base of the hopper. The hopper is charged with 3-4 kg of potato tubers. The motor is run and water is poured on the tubers in the hopper through funnel on pipe. The abrasive surface disc rotates and its rough surface coming in contact with the tuber skin peels it with its abrasive action. The peels along with the waste water pass below to the fixed plate which directs the same to an outlet. The machine is run till all the tubers get peeled. The machine is then stopped and the peeled tubers are taken out of the trough. A fresh feed is supplied and the process is repeated. The system developed thus is a batch type. The peelings along with the waste water are drained out from the gap on the side of rotating base plate. A collection chute for the waste is fitted below the base plate to receive the waste and is directed to the outlet, to avoid its spread and spoiling of the work place.

All the three abrasive surfaces were tried and evaluated for potato peeling using them with the set up prepared for potato peeling. The

cemented plate and metallic plate with perforations over its surface performed better than the wire mesh fitted plate surface. The machine was operated at various speeds. The perforated metal plate was also tried alone and with container of the perforated metal sheet around its periphery to achieve better peeling. It was found that perforated plate with out pointed surface was found better in term of performance and could be selected as abrasive surface to be employed as low cost technique for potato peeling. The base plate made of perforated sheet and with sides made of the same type further improved the peeling efficiency and proved better than the use of base plate alone.

#### Development of machine for making French fry cuts

The vibration of the French fry cutting machine was found to be excessive. Adjustments were made on the main frame and other systems. The components causing vibrations were identified and adjusted to reduce the vibrations and noise generated as a result of the same. The sheet cover provided as a safety guard was

found to be loose and causing the vibrations. The cover was tightened with the main frame and was modified in design to minimize the vibrations, hence the noise. The possibilities for automatic feeding of tubers were also explored. The system designed and used was found to decrease the reliability of the machine. It was also found to increase the complexity and thereby the cost of the machine. It was found that the existing system developed may not be much suitable for automatic feeding. If it is to be incorporated in the system, the machine may need to be re-designed.

A hand operated press lever type multipurpose device has been designed and fabricated to cut the tuber slices, making cubes and for cutting tubers in two or more pieces. The prototype consists of a wooden base, a frame to mount different attachments, a handle to press the plate vertically against the tuber and cutting attachment and a guide to align the pressure plate. Various cutting attachments are being developed to cut tubers for different purposes. The square shaped (120x80 mm) attachments with blades fitted as per need for preparation of tubers are being developed.

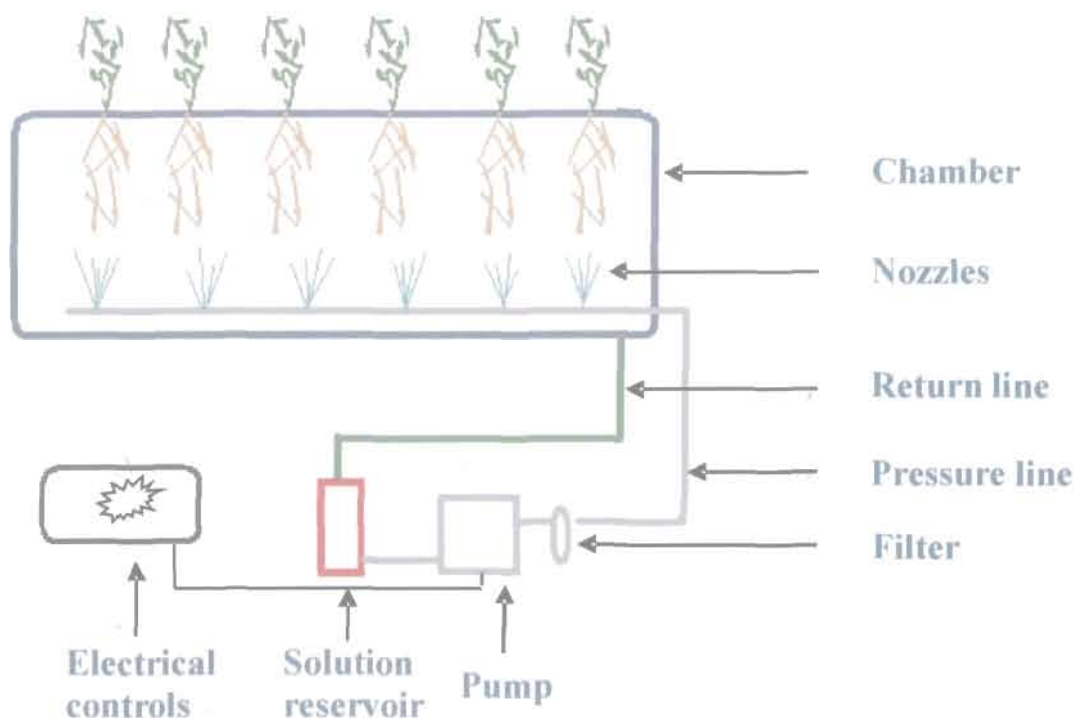


Fig 15. Schematics of aeroponics unit



## Development of implements for seed potato production

### Design and fabrication of mini aeroponics prototype for seed potato production

Aeroponics is misting of roots in the air. In this system roots grow in a dark enclosed chamber instead of soil or any other medium, while shoots grow in the natural sun light or artificial light. First mini prototype of aeroponics for

production of healthy mini tubers of potato was designed and fabricated at Modipuram (Fig. 15 and 16). In this aeroponics prototype, same nutrient solution was re-circulated in such a way that there was minimum loss of solution in the form of evaporation or leakage. Aeroponics prototype consists of a nutrient solution chamber, a pressure pump, a micro screen filter, two booms fitted with nozzles, two growth chambers provided with suitable top for supporting cuttings/micro tubers/rooted plants, control valves, pipes for delivery and return solution and polythene sheets for covering growth chambers.



Fig 16. Planting of plant cuttings and micro tuber in aeroponics unit



Fig 17. Digger shaker designed for stage II spreads tubers in narrow band as compared to traditional potato digger

Hollow cone nozzles, with 100 degree discharge angle and 40-60 psi were selected. These nozzles form a fine mist of nutrient solution. Based upon working pressure of nozzles, discharge per unit time and number of chambers and number of nozzles per boom, nutrient solution pipes, solution tank, pump, filter and return solution pipes were selected. An electric cyclic timer and conductor unit was used for operating pump in a predetermined time cycle. With this timer, pump can be operated or stopped from 1sec to any desired time as per the requirement. Unit was tested for 150 hours before transplanting of plant material. In this first ever trial, plant cuttings, micro tubers (produce of tissue culture) and tissue culture plants (after rooting and hardening) were transplanted in aeroponics unit.

## Long term testing of digger shaker for stage II

Potato digger shaker, designed for stage II of breeder seed production, after incorporating minor modifications and adjustments (Fig. 17) was field tested on long term basis. Performance of this machine was also compared with traditional two row digger shaker. This two row digger was being used prior to adopting new machine for stage II in breeder seed production programme. Both the machines were operated for 4-5 days for long term performance testing. For recording observations, machines were operated at same forward speed in the same field, with same hp tractors, side by side and observations were recorded for exposure, spreading pattern of tubers over the soils surface, exposure and cut percentage. The observations are given in Table 27.

**Table 27. Comparative performance of single row digger shaker for stage- II and two row traditional digger**

| Parameter                                 | Digger shaker for stage II (single row) | Two row digger |
|-------------------------------------------|-----------------------------------------|----------------|
| Number of rows of stage II ( 100 cm wide) | One                                     | One            |
| Exposure of percentage                    | 95-97%                                  | 85-88%         |
| Damage to tubers                          | <2%                                     | <2%            |
| Width of spread of tubers                 | 60 cm                                   | 95 cm          |











# *Division of Plant Protection*



# Diagnostics and detection of potato viruses and viroid



The programme deals with the development and application of sensitive and reliable diagnostics for the detection and identification of potato viruses and viroid. The programme has been running for the last more than four decades during which period steady improvement has been made in sensitivity and reliability of different diagnostic techniques. Chloroplast agglutination which was the only large-scale virus detection method with about 60% detection confidence up to 1980 was replaced with enzyme linked immunosorbent assay (ELISA) during 1984. ELISA has a better than 90% virus detection confidence level. Immuno electron microscopy was standardized for optimal detection of potato viruses with a better than 99% confidence level during late 1980s. Development and use of nucleic acid based virus detection techniques during late 1990s onward have tremendously enhanced the sensitivity of virus detection. The modern techniques of virus detection namely ELISA, IEM and RT-PCR/PCR/NASH were used to detect/diagnose viruses in different types of potato samples which included mericlones, leaf samples, microplants etc. during the year under review. A brief report of results achieved is given.

## Testing for PSTVd infection:

The following potato germplasm and mericlones were tested for PSTVd infection. The result is presented below.

- a) Ninety-six mericlones of 2 accessions CP-1391 and CP-2032 were tested for PSTVd infection after 6°C treatment for 5 to 10 months. All were still infected with PSTVd.
- b) One hundred and thirty nine germplasm accessions were tested and all except 5
- accessions i.e., CP-1225, 2333, 2940, 3673 and 3734 tested negative.
- c) Out of 40 DUS reference lines only two, i.e. 1875 and 2197 tested positive to PSTVd.
- d) Ninety-six mericlones of 5 accessions CP 1391, 1574, 3083, KDW-29 and KDW-34 were tested after 5 months treatment at 6°C and all the 20 mericlones of 1391, 12 of 1574, one of 3083 tested negative while the rest were positive to PSTVd.



- e) All the 38 accessions received from CIP tested negative to PSTVd in post-entry quarantine testing. Another lot of 19 accessions tested positive to PSTVd.

#### Testing of mericlones for viruses:

31 mericlones of three hybrids/cvs. namely K-22, J-93-86 and Gulmarg Special were screened for virus freedom. Out of 18 mericlones of K-22, 3 were free from viruses. All the 5 mericlones of Gulmarg Special had a high titre of PVX while all the eight of J-93-86 were free from viruses. In further screening of two more mericlones of Gulmarg Special, one was found to be virus free. Another batch of 33 mericlones of 23 germplasm accessions and 2 of Kufri Swarna were examined for virus freedom. While mericlones of all the germplasm accessions were free from viruses, those of Kufri Swarna still had a high titre of PVS.

#### Screening of germplasm accessions for virus resistance:

Seventy germplasm accessions were screened for resistance against PVX and PVY in the first season testing. Eight accessions (CP-1057, 1579, 1648, 2306, 3316, 3414, 3443 and 3759) were resistant to PVX, and 26 accessions (CP 1057, 1314, 1468, 1579, 1583, 1611, 1648, 1708, 1742, 1747, 1753, 1846, 1914, 1949, 2038, 2078, 2202, 2209, 2235, 2341, 3117, 3316, 3414, 3443, 3757 and 3759) were resistant to PVY. In the second season testing, 26 accessions found resistant to either or both the viruses in the previous season, were retested for virus resistance. Ten accessions viz., CP-1829, 2217, 2307, 3146, 3165, 3533, 3756, 3762, 3764 and 3765 showed resistance to both PVX and PVY; three namely CP 1218, 1933 and 3397 were resistant to only PVY and one viz. CP 1553 to only PVX.

#### Studies on endophytes in in vitro mother stocks and minitubers:

*In vitro* microplants (mother stocks) of 21 Indian potato varieties were tested for the presence of endophytic bacteria and fungi by plating their sap on three culture media namely crystal violet pectate medium (CVPM), nutrient agar medium (NAM) and potato dextrose agar medium (PDA). Stocks of 20 varieties had originated from

microplants, which were transplanted in the growth chambers in soil medium while that of one variety from its mericlone. Five microplants of each variety were checked. All stocks harboured Gram negative bacilli which produced smooth, irregular and large translucent colonies on CVPM and smooth, opaque, creamish white, butyrous colonies with musky odour on NAM. None of the samples, however, showed any fungal endophyte or pectolytic bacterium. Ten minitubers from tissue culture lab of Seed Technology Division and five tubers from the market were checked for the presence of pectolytic bacteria. Tubers from market showed the presence of pectolytic bacterium which was identified as *Pectobacterium carotovorum* subsp. *atroseptica*. No pectolytic bacterium was observed in minitubers obtained from the Seed Technology Division.

#### Validation of RT-PCR diagnostics of PVA and PVS:

Four lots each of 250 potato leaf samples received from field were tested with das-ELISA for aphid transmitted potato viruses including PVA. Nine samples tested positive for PVA and these were cross-checked with RT-PCR and immuno electron microscopy. Interestingly, only five tested positive to PVA both in RT-PCR (Fig. 18) and IEM. These studies highlighted the sensitivity of RT-PCR to be as high as IEM and up to 5% chances of false positives in ELISA.

The above samples were also tested for PVS with das-ELISA and seven samples tested positive to PVS. Positive samples were cross-



Fig. 18. Results of RT-PCR testing of PVA in nine samples found positive in ELISA; Lane 1: 1 Kb marker; lanes: 2: known positive sample; 3 to 11: test samples showing five to be positive and 3 to be negative; 12: healthy control. Arrow: amplified product in positive ones

checked with RT-PCR and IEM. Out of these 7 samples, five tested positive in both RT-PCR and IEM and the remaining two negative. These studies further confirmed that RT-PCR is as reliable as IEM and chances of false positives remain in ELISA.

Sequencing of the coat protein genes of PVS (Andean strain), PVX<sub>HB</sub> and PVX<sub>MS</sub>:

The CP genes of PVS and PVX cloned into pDrive vector were sequenced. The nucleotide sequence of coat protein genes are as follows:

CP gene of PVS (Andean strain):

ATGCCGCCGAAACCAGATCCGTCTAGTTCAGGGG  
AAGCACCACAAGCGATGCCACCTGCGCCACCACC  
GCGCTCACCAGGAAAGCGCATAAGCATGTGCAATCA  
GAAGGGCCAGGGCCAAATGAGGAAGCCATGCTG  
GAGCAAAGGCTCGTCAGATTGATTGAGCTCATGGCT  
GCGAAGAGGCACAACCTCTACATTGAGCAACATCTC  
TTTTGAAATAGGTAGGCCAGTCTAGAGCCGACCCCT  
GAGATGAGGAGGAATCCAGAGAATCCGTACTCCCG  
GTTCTCAATCGATGAGCTGTTCAAGATGGAATCCG  
ATCAGTGTCCAACAATATGGCAAATACTGAGCAGA  
TGGCACAACATCACCAGCAGATATAGCAGGGCTCGG  
TGTCCTACAGAGCACGTGGCTGGGGTCATACTGA  
AGGTGTAATCATGTGTGCAAGTGTGAGCAGTTCT  
GTCTACCTAGACCCTGCAGGAAGTGTGAGTTCCTA  
CTGGCGCAGTGCCCTTGGATTCCATAATTGCAATCA  
TGAAAATCGTGCCGGGTTGAGGAAGGTGTGTAGAT  
TGTATGCTCCGGTCTGTTTGAATTATATGCTTGTCCA  
GAATAGGCCACCTTCGGATTGGCAGGCCATGGGGT  
TTCAATGGAATGCGCGTTTCGCCGCTTTTGACACA  
TTTGATTATGTGACGAACGGCGCCGCGATCCAGCC  
TGTTGAGGGGCTCATCCGTAGGCCTACGCCTGAGG  
AAACAATAGCTCATAACGCTCACAAAAGCATGGCGA  
TCGACAAAGTCGAATGAAATGAAAGGCTGGCCAAAC  
CAACGTTGAGTATACTGGAGGCATGCTCGGTGCTGA  
GATTGTGCGTAAACATCGGAATGGAATAAACCAAG  
AACCGC

CP gene of PVX isolate RKB-30 (PVX<sub>HB</sub> strain) :

ATGTCAGCACCAGCTAGCACAACACAGGCCACAGG  
GTCAACTACCTCAACTACCACGAAAACTGCAGGC  
GCAACTCCTGCCACAGCTTCAGGACTGTTACCAT  
CCCGGATGGGGATTTCCTCAGTACAGCCCGTGCCA  
TAGTAGCCAGCAATGCAGTTGCAACAAATGAGGAC  
CTCAGCAAGATTGAGGCTATTTGGAAGGACATGAA  
GGTGCCACAGACACTATGGCACAGGCTGCTTGGG  
ACTTAGTCAGACACTGTGCTGATGTGGGCTCATCT  
GCTCAAACAGAAATGATAGATACAGGTCCCTATTCCA

ACGGCATCAGCAGAGCTAGATTGGCAGCGGCAAT  
TAAAGAGGTGTGCACACTTAGGCAATTTTGCATGA  
AGTATGCCCCAGTGGTATGGAAGTGGATGTTGACT  
AACAACAGTCCACCTGCTAACTGGCAAGCACAGG  
GTTTCAAGCCTGAGCACAAATTCGCTGCATTGAC  
TTCTTCAATGGAGTCACTAACCAGCTGCCATCATG  
CCCAAAGAGGGGCTCATCCGACCACCGTCTGAAG  
CTGAAATGAATGCTGCCCAAAGTGTGCTTTGTG  
AAGATTACAAAGGCCAGAGCACAATCCAACGACTT  
TGCCAGCCTAGATGCAGCTGTCACTCGAGGTCGT  
ATCACTGGGAACGACAACCGCTGAGGCTGTTGTCA  
CTCTCCCACCACCATAACTAGTC

CP gene of PVX isolate 1688 (PVX<sub>MS</sub> strain):

ATGTCAGCACCAGCTAGCACAACACAGACCACAG  
GGTCAACTACCTCAACTACCACGAAAACTGCAGG  
CGCGACTCCTGCCACAGCTTCAGGACTGTTCACTA  
TCCCGGATGGGGATTTCCTTAGCACAGCCCGTGCC  
ATAGTAGCCAGCAATGACGTTGCAACAAATGAGGA  
CCTCAGCAAGATTGAGGCTATTTGGAAGGACATGA  
AGGTGCCACAGACACTATGGCACAGGCTGCTTG  
GGACTTAGTCAGACACTGTGCTGATGTGGGCTCAT  
CTGCTCAAACAGAAATGATAGATACAGGTCCCTAT  
TCCAATGGCATCAGCAGAGCTAGACTGGCGGCGG  
CGATCAAAGAGGTGTGCACACTTAGGCAATTTTGC  
ATGAAGTATGCCCCAGTAGTGTGGAAGTGGATGTT  
GACTAACAACAGTCCACCTGCTAACTGGCAAGCA  
CAGGGTTTCAAGCCTGAGCACAAATTCGCTGCATT  
CGACTTCTTCAATGGAGTCACTAACCAGCCGCCA  
TCATGCCTAAAGAGGGGCTCATCCGGCCACCGTCT  
GAAGCTGAAATGAATGCTGCCCAAAGTGTGCTT  
TGTGAAGATTACAAAGGCCAGGGCACAATCCAAC  
GACTTTGCCAGCCTAGATGCGGCTGTCACTCGAG  
GTCGTATCACTGGAACAACAGCTGAGGCTGTTGTC  
ACTCTCCCACCATAACTAGTCAATCACGAATTCTGG  
ATCCG

Expression of coat protein of PVX and PVS:

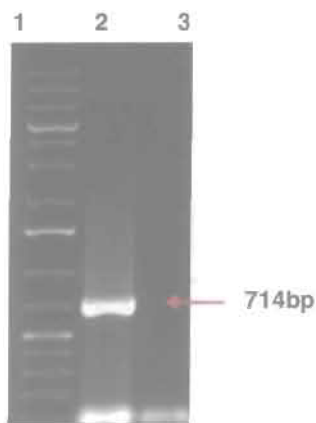
Primers were designed to directionally clone the CP gene into the p-MAL expression vector (New England Biolabs) so that the coding sequence of interest is fused in frame to the 3' end of the malE gene that encodes the maltose binding protein (MBP). The sequences of the designed primers were as follows:

PVX forward: ATGTCAGCACCAGCGAGCA;  
Reverse: CGCAAGCTTTTATGGTGGTGG.

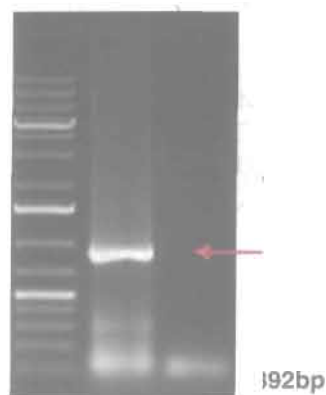
PVS forward: ATGCCGCCCAAACCGGATCC;  
Reverse: CGCAAGCTTTTATTGGGTGATT.

The CP genes of PVX and PVS were amplified from the pDrive vectors using the above primers. The fragments of expected size were obtained for both PVX (Fig. 19) and PVS (Fig. 20). The 3' overhangs of the amplified products were removed, restricted by HindIII and purified while vectors were restricted with XmnI and HindIII to create blunt and sticky ends. The restricted PCR

products of PVX, PVS and expression vector (p-MAL C2X, P2X, Fig. 21) were used for setting up ligation reaction. The ligated mix was used for transformation. Transformed (white) colonies appeared on LB plates (Luria- Bertani medium) containing 100ug/ml ampicillin. Molecular confirmation and protein expression is in progress.



**Fig. 19.** Lane1:1Kb Marker;  
Lane2: Amplified product of CP gene of PVX.  
Lane3: Healthy control.



**Fig. 20.** Lane1: 1 Kb Marker;  
Lane2: Amplified product of CP gene of PVS  
Lane 3: Healthy control



**Fig. 21.** Lane1:1kb marker, Lane2: uncut C2X (6.6 kb), Lane3: restricted C2X  
Lane 4: uncut P2X (6.7 kb), Lane 5: restricted P2X



# Management of late blight



Late blight disease of potato continued to play truant with the farmers across the country taking heavy toll on the potato crop. Traditionally, late blight was not a regular feature in the sub-tropical plains but, of late, it has started attacking the crop on regular basis. The disease first appears on early crop in places like *tarai* region where the ambient RH is high and subsequently, the inoculum spreads to the main season crop. Besides, there have been instances of adaptability of *P. infestans* to higher temperature as well, which facilitated early appearance of the disease. The pathogen population is continuously evolving leading to newer and newer forms, which have differential response to different fungicides and have the capacity to attack the hitherto known late blight resistant varieties. Build up of fungicide tolerance in the fungus across the country has further compounded the problem of late blight management. Most of the systemic fungicides, which are available in the market, are translaminar in nature, and therefore, a special package needs to be developed for effective management of this disease. Since the chemicals are quite costly and their excessive use adds to the increased cost of cultivation, it has become mandatory to develop models for application of need based fungicide on priority. The programme, therefore, aims to investigate the evolving population structure of *P. infestans* vis-à-vis changing climatic condition and cropping systems in the country with the objective of developing effective management schedules.

## Disease and pathogen profile

During the current year, late blight disease was recorded both in *Kharif* and *Rabi* season. It was more severe in the state of Karnataka where the average crop loss was recorded to the tune of 66.8 % in Hassan and Chikmagalore districts. During *Rabi* season, disease was first recorded during the first week of December in *Tarai* region of Uttar Pradesh, which subsequently spread to other parts in Western U.P. A sudden burst of late blight was

recorded in the last week of January leading to 15-40% crop loss. Similar situation was recorded in West Bengal and Bihar, where crop loss of 25-40% was recorded. Punjab state comparatively remained disease free. Severe late blight attack was also seen on tomato (Fig. 22) in the first week of January, which is not a usual feature in the region. Stem infection (Fig. 23) has become a regular feature in most of the potato growing regions of the country. At many places stem infection was higher than the foliage infection.



**Fig. 22. Tomato field with severe late blight disease; inset photo: fruit infection**



**Fig. 23. Potato field with severe late blight disease; inset photo: stem infection.**



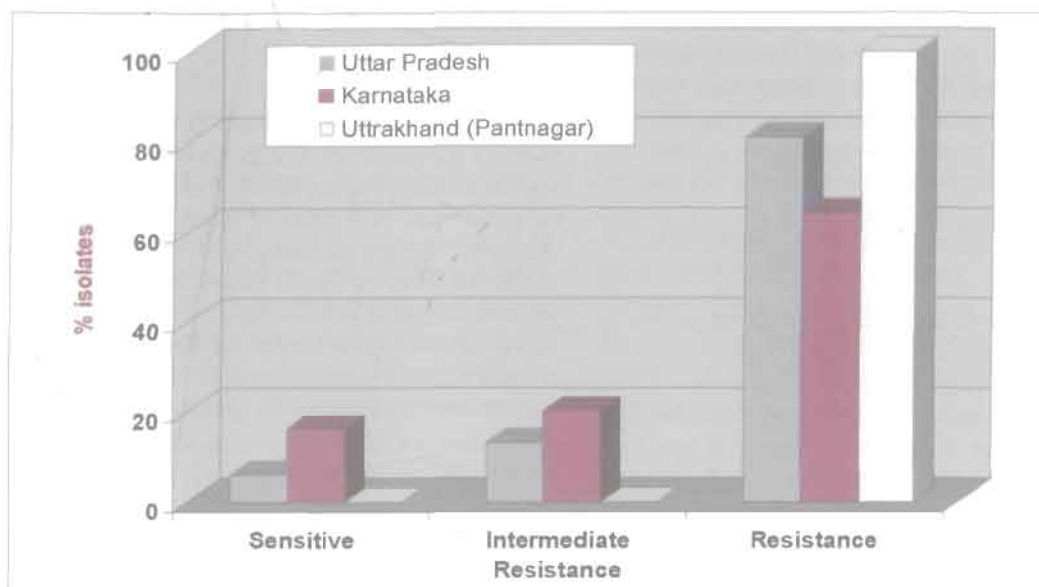


Fig. 24. Metalaxyl sensitivity of *P. infestans*

The profile of the causal organism (*P. infestans*) with regard to biological markers, like mating type, metalaxyl resistance and physiological races was almost similar to that of last year. Hill isolates (Himachal Pradesh hills) consisted of only  $A_2$  mating type whereas in the sub-tropical plains, the  $A_2$  mating type was either absent (Bihar, Punjab, Assam, West Bengal) or its frequency was low (up to 12%) in Uttar Pradesh and Karnataka. There has been a decline in the effectiveness of metalaxyl-based compounds over the years (Fig. 24). In the current crop season, the same trend was maintained. In the state of U.P., 54% of the *P. infestans* population showed tolerance to metalaxyl up to 200 ppm whereas at 400 ppm, 22 % of the isolates were tolerant. Similar situation was noticed with regard to isolates collected from Karnataka. In H.P. hills, almost 87% of the isolates showed tolerance up to 200 ppm, whereas at 300 ppm, 39% of the isolates were observed to be tolerant. Isolates collected from Punjab and Assam showed tolerance up to 41% and 33% respectively at 200 ppm. Tolerance level was comparatively low in West Bengal (10% at 150 ppm) and Bihar (23.5% at 150 ppm). Since the tolerance limit has almost crossed the recommended level of metalaxyl, it is amply clear that metalaxyl-based compounds need to be put on hold till the tolerance in the pathogen population recedes to the base level. Monitoring of physiological races across the country revealed that the *P. infestans* population

consisted of only complex races ranging from 8 to 11 genes. It was true for both hills and the plains. The pathogen population was also analyzed for mitochondrial haplotype present in the country and their dynamics. Till 2002, only Ib haplotype was known to occur in the country. Mt DNA Ia was first reported in 2002 and since then it is being recorded on continuous basis. During the current year, analysis of the pathogen population collected from Karnataka, Himachal Pradesh and Punjab revealed that 65% of the isolates belonged to the Ia haplotype whereas the remaining 35% consisted of Ib type. It tends to suggest that the new population, which was introduced during 2002 is on the rise and it is in the process of displacing the old population consisting of Ib type.

#### Disease epidemiology

Like previous year, the models for applying need-based application of fungicides were developed this year as well. The accuracy of the models under different situations (spraying with mancozeb, combination of mancozeb and metalaxyl and unsprayed control) ranged from 97- 99%. The pooled analysis of data over five years also yielded moderate level of success. The accuracy of the models ranged from 77- 81% indicating that these models are quite robust and can be integrated in developing DSS for managing late blight. Yield loss assessment models developed for the current year were also



found to be accurate in predicting crop loss due to late blight. The efficacy of the models, by and large, remained the same suggesting that yield loss models were robust and can be integrated with DSS for late blight management.

#### Late blight management using botanicals and fungicides

One of the effective botanicals identified in the preceding year was further tested for its effectiveness against late blight. The ethyl acetate fraction, crude and gradient extracts were compared for their efficacy against late blight using detached leaf method, whole plant and field applications. Besides, the extracts/fractions were also compared for their efficacy on zoospore germination. Results revealed that at 10,000 ppm concentrations, all extracts were highly effective in controlling the disease. On whole plant, the ethyl acetate fraction was highly effective as compared to crude and gradient extracts. Under field conditions, both ethyl acetate fractions and crude extracts were equally effective (13.3% as against 100% in unsprayed control).

The newly released fungicides, namely Amistar (azoxystrobin 23 SC), Section (fenamidone 10% + mancozeb 50%) and Curzate (cymoxanil 8 % + mancozeb 64%) were compared with metalaxyl-based fungicides against late blight. Results revealed that application of above fungicides at an interval of 9 days were almost at par with each other with disease severity of 23.3%, 26.7% and 28.3% in Curzate, Amistar and Section treated plots respectively as against 35.0% in metalaxyl + mancozeb and 100% in control. However, when these fungicides were alternated with mancozeb, their efficacy was reduced considerably.

#### Breeding for high yielding, late, blight resistant cultivars for Indian hills

Breeding late blight resistant cultivars is a primary objective of this programme. Despite the fact that host resistance is short lived, there is no option but to exploit it, as it is the only cost effective method of late blight management, especially in third world countries. During 2008-09, over 12,000 seedlings from 12 cross combinations were screened and over 600 resistant ones were selected for further evaluation. Similarly, 448 genotypes were evaluated under initial evaluation trials out of which 128 genotypes were selected from  $F_1C_1$ - $F_1C_4$  population. As a breeding strategy, hill hybrids were evaluated under subtropical plains for their suitability. Out of five hybrids tested, hybrid SM/00-42 was found to be the best. Efforts are also being made to broaden the genetic base of the potato varieties using wild/semi cultivated *Solanum* species having resistance to late blight viz., *Solanum chacoense*, *S. microdontum* and *S. verrucosum*. Eight meiotic tetraploids based on the agronomic performance and resistance to late blight were evaluated, out of which 5 MT's were found to yield higher than cv. Kufri Jyoti and Kufri Bahar. These hybrids have been selected for further evaluation. Mapping population derived from the cross *S. spegazzinii* and *S. chacoense* developed earlier was conserved *in vitro*. The extent of polymorphism of the two parents of the mapping population was studied using 64 AFLP primer combinations. A total of 4002 loci were amplified out of which 2698 (67%) were polymorphic. Besides, mapping population has been genotyped using 12 AFLP selective primer pairs and a total of 699 loci were amplified out of which 539 were polymorphic.

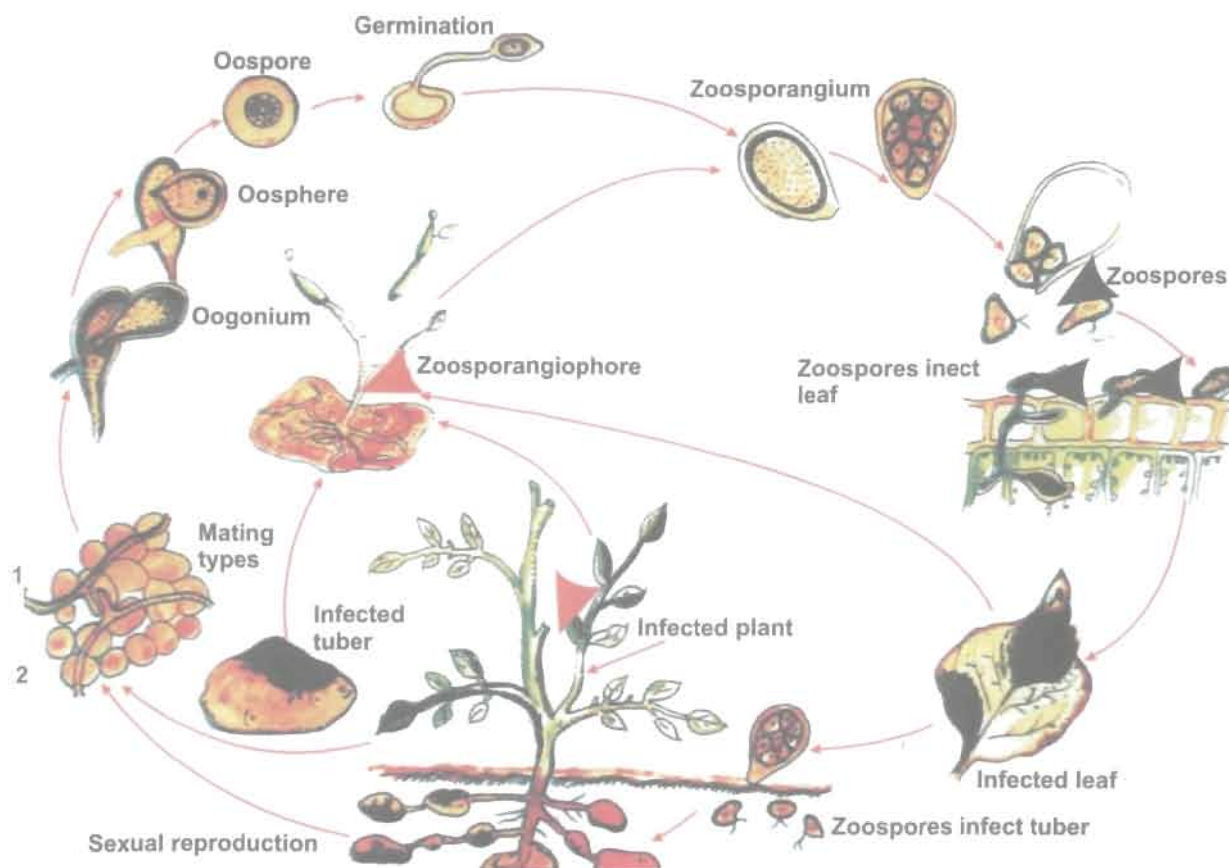
**Table 28. Segregation ratios obtained in test crosses based on SCAR marker analysis**

| Sr. No. | Cross combination          | Seedlings evaluated | Band    |        | Segregation ratio |
|---------|----------------------------|---------------------|---------|--------|-------------------|
|         |                            |                     | Present | Absent |                   |
| 1       | K Chipsona-3 X YY-6/3 C10  | 23                  | 17      | 6      | 2.83 : 1          |
| 2       | K Chipsona-3 X YY-13/3 C76 | 11                  | 9       | 2      | 4.50 : 1          |
| 3       | K Girdhari X YY-6/13 C30   | 13                  | 8       | 5      | 1.60 : 1          |
| 4       | QB/A 9-120 X YY-6/3 C11    | 31                  | 30      | 1      | 30.00 : 1         |
| 5       | K Girdhari X YY-13/3 C96   | 41                  | 32      | 9      | 3.56 : 1          |

## Combined resistance to late blight and PVY

In an effort to develop parental lines having PVY extreme resistance in triplex/quadruplex conditions, five test crosses were attempted between multiplex clones and PVY susceptible commercial cultivars / hybrid (nulliplex). DNA extracted from the seedling was analyzed for presence of SCAR marker tightly linked to the *Ryadg* gene imparting extreme resistance to PVY. Out of these clones, one clone YY-6/3-C11 appeared to be a putative triplex clone

(Table 28). This clone would be exploited for developing varieties having extreme resistance to PVY. Based on our earlier studies, 13 hybrids were selected for their combined resistance to late blight and PVY for further evaluation under field conditions. Majority of these hybrids had good agronomic traits besides having combined resistance to late blight and PVY, and of them, ten hybrids were retained for further evaluation. The presence of *Ryadg* gene imparting extreme resistance in these hybrids was also confirmed by SCAR analysis.



Life cycle of *Phytophthora Infestans* in Shimla hills



# Integrated Disease Management



Soil and tuber diseases of potato assume special significance in a vegetatively produced crops like potato. They not only cause economic losses but also spread far and wide through the infected seed tubers which form the bulk of planting material. Russet scab of potato has recently emerged as a major problem in seed production especially in north-western plains. Major commercial potato varieties are susceptible. Russet scab is not controlled by seed treatment with boric acid or organomercurials hence the problem assumes special significance. So far soil solarization is the only method found effective to manage the disease. Commercial varieties and potato germplasm is being screened to locate the sources of disease resistance for use in breeding resistant varieties. Experiments are also being carried out to manage the disease through different soil and seed treatments. Black scurf, charcoal rot, common scab and dry rots are some of other major tuber diseases which affect potato tubers. Work carried out at the institute showed boric acid as an alternative to the organomercurials. The technology for its large scale use has been standardized and is being followed by the potato growers. Biocontrol agents such as *Trichoderma viride*, *Bacillus subtilis* and certain plant extracts have been found effective for control of black scurf disease. These were evaluated in combination with safe chemicals for further effective control of the diseases. *B. subtilis* (B5) besides potato also brings about a significant increase in yield of paddy crop. The findings were again confirmed this year. Measures such as use of plant extracts, biocontrol agents and safe chemicals can help us in management of tuber diseases in an environmentally friendly way.

## *Russet scab of potato and its management*

Russet scab of potato has emerged as a serious problem in seed production especially in north-western plains. The Institute is carrying out intensive research for ecofriendly management of this disease of complex etiology. Eighteen potato varieties were screened for their susceptibility to russet scab under field

conditions at Jalandhar. Based on disease severity, they could be categorized into different resistance groups: highly resistant, resistant, moderately resistant, susceptible and highly susceptible (Table 29). Out of 195 accessions of germplasm evaluated against russet scab, six CP numbers viz. 1187, 1243, 1349, 1388, 1418 and 1476 were found promising with no russet scab incidence. Among five different soil treatments tried during the year, soil solarization



from mid-May to mid-June was the only method found effective for control of russet scab. It reduced russet scab severity from 42.8% in the untreated to 26.7% in the solarized soil. Out of 8 new chemicals evaluated for control of russet scab, seed treatment with streptocycline (0.05%), aureofungin (0.02%) and soil application of bleaching powder (50 kg/ha) reduced russet scab by 9.4, 16.7 and 24.1% respectively, over the untreated control.

## Management of other tuber diseases of potato

*Trichoderma viride* prepared in two different formulations were evaluated alone and in combination for control of *Rhizoctonia solani* causing black scurf of potato. The combination of two formulations further improved control of the disease by 6 to 10% at Gwalior. *T. viride* worked very well in combination with boric acid for control of black scurf disease of potato. Results of a field trial indicated that *T. viride* and in

combination with 2% boric acid reduced severity of black scurf from 64.6% in untreated control to 33.8% in the treated. Extracts of *Vinca rosea* (Sada Bahar), *Ocimum canum* (Tulsi), *Withania somnifera* (Ashwagandha), *Azadirachta indica* (Neem) and *Eucalyptus globulus* (Eucalyptus) applied to seed tubers (1:3 W/V) before planting reduced black scurf incidence from 90.8% in untreated control to between 50.5 to 63.3% in the treated disease tubers. The disease severity was also reduced from 33.2% to 11.8 to 18.0% in the treated (Table 30) at Gwalior. Commercially available plant products such as powder of *Withania somnifera* (Ashwagandha) and *Ocimum sanctum* (Tulsi) alone or in combination with half of the recommended dose of boric acid (1.5%) however, did not control the disease effectively. Boric acid did not control dry rot infections that have already established during storage of potato tubers in heaps for one month after the harvest. Thirty isolates of *R. solani* were collected during the current year for further studies. Potato collar rot caused

Table 29. Resistance against russet scab in potato varieties planted on different dates

| Variety            | Disease severity (%) |         |         |        |      | Resistance group |
|--------------------|----------------------|---------|---------|--------|------|------------------|
|                    | Sept. 25             | Oct. 10 | Oct. 25 | Nov.10 | Mean |                  |
| Kufri Pushkar      | 3.5                  | 5.9     | 1.5     | 4.8    | 3.9  | HR               |
| Kufri Anand        | 3.9                  | 3.8     | 4.1     | 2.6    | 3.6  | HR               |
| Kufri Pukhraj      | 8.5                  | 5.9     | 6.2     | 1.9    | 5.6  | R                |
| Kufri Giriraj      | 9.2                  | 6.8     | 6.2     | 6.6    | 7.2  | R                |
| Kufri Dewa         | 5.2                  | 13.9    | 7.0     | 6.3    | 8.1  | R                |
| Kufri Ashoka       | 11.5                 | 10.0    | 4.4     | 7.1    | 8.2  | R                |
| Kufri Chipsona 1   | 13.9                 | 3.2     | 8.9     | 11.5   | 9.4  | R                |
| Phulwa             | 17.5                 | 13.5    | 18.9    | 19.3   | 17.3 | MR               |
| Kufri Jawahar      | 26.3                 | 15.4    | 18.0    | 27.9   | 21.9 | MR               |
| Kufri Jyoti        | 28.3                 | 27.1    | 17.9    | 32.6   | 26.5 | MR               |
| Kufri Lauvkar      | 24.4                 | 33.9    | 24.9    | 26.4   | 27.4 | MR               |
| Kufri Bahar        | 23.4                 | 28.7    | 28.1    | 29.5   | 27.4 | MR               |
| Kufri Satlej       | 41.8                 | 42.3    | 4.1     | 41.1   | 37.2 | S                |
| Kufri Badshah      | 38.6                 | 44.5    | 1.5     | 43.1   | 42.2 | S                |
| Kufri Lalima       | 39.4                 | 40.8    | 50.7    | 51.4   | 45.6 | S                |
| Kufri Chandramukhi | 40.0                 | 55.2    | 51.6    | 52.9   | 49.9 | S                |
| Kufri Sherpa       | 60.0                 | 56.0    | 7.0     | 51.7   | 53.6 | HS               |
| Kufri Sindhuri     | 67.0                 | 65.2    | 6.2     | 63.3   | 65.8 | HS               |

Table 30. Management of black scurf of potato through plant extracts

| Treatments                 | Emergence (%) | Dis. incidence (%) | Dis. severity (%) | Yield (q/ha) |
|----------------------------|---------------|--------------------|-------------------|--------------|
| <i>Vinca rosea</i>         | 94.0          | 50.5               | 14.2              | 316          |
| <i>Ocimum canum</i>        | 93.8          | 54.3               | 13.8              | 306          |
| <i>Withania Somnifera</i>  | 95.3          | 50.8               | 11.8              | 300          |
| <i>Azadirachta indica</i>  | 93.3          | 58.3               | 15.4              | 308          |
| <i>Eucalyptus globulus</i> | 92.8          | 63.3               | 18.0              | 275          |
| Untreated (Control)        | 92.5          | 90.8               | 33.2              | 309          |
| C.D. (0.01)                | NS            | 8.8                | 3.2               | NS           |

by *R. solani* was encountered sporadically in Merrut and Ghaziabad districts and incidence up to 35% was observed in some of the fields of Fatehpur region of eastern UP. An experiment has been initiated to work out an efficient and cost effective integrated disease management schedule for cultivation of suitable potato varieties in early, main and late crop season.

### Integrated management of bacterial wilt and other tuber borne diseases of potato by bacterial antagonists

The antagonist B5 has been identified as a promising biocontrol agent for bacterial wilt pathogen. The same isolate also acts as growth promoting rhizobacterium in several crops. The efficacy of the isolate was evaluated for management of other tuber-borne diseases like black scurf.

Seed treatment with 3% boric acid + *Bacillus subtilis* (B5) @ 0.25% was the best for control of black scurf disease of potato. It reduced disease incidence from 92.8% in control to 8.0% in the treated and the

disease index from 2.95 to 0.25 units. *B. subtilis* B5 applied to potato seed tubers @ 0.25% by dip treatment increased tuber yield by 12.9% over control in a field trial carried out at Modipuram. *B. subtilis* B5 applied to paddy crop as seedling dip increased yield from 36 q/ha in untreated control plots to 46.0 q/ha in variety Pusa Sugandha and 42.8 q/ha in variety Pusa Basmati -1 (Fig. 25). One hundred fifty three kg of *B. subtilis* (B5) formulations were supplied to 10 AICRP centres and other agencies on demand.

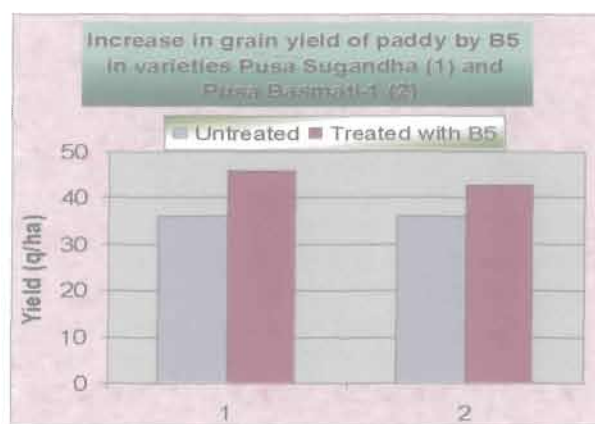


Fig. 25. Increase in grain yield of paddy by B5 in varieties Pusa Sugandha (1) and Pusa Basmati-1 (2)

# Integrated Pest Management



**A**mong the potato pests, potato tuber moth, white grub, cut worm, white fly and aphids remained important. Achievements made during the year are given here.

## Vector monitoring and management

The first appearance of peach aphid (*Myzus persicae* Sulz.) was recorded in the 3<sup>rd</sup> week of November at Modipuram which crossed the critical level (20 aphid/100 leaves) by 4<sup>th</sup> week of December, 2008. The cotton aphid (*Aphis gossypii* Glov) started building up in third week of October, attained peak level in the first week of November and declined to minimum in December 2008. At Patna, four aphid species i.e. *M. persicae*, *A. gossypii*, *A. fabae* and *Rhopalsiphum rufiabdominalis* were recorded in potato crop. *M. persicae* first appeared during 3<sup>rd</sup> week of December and reached the critical level by 1<sup>st</sup> week of January. Thereafter, it rapidly multiplied during January and February due to favorable temperature. Maximum population of 9,556 aphids/100 compound leaves was recorded on unsprayed crop. On the contrary, a maximum population of 48 /100 compound leaves was recorded for the cotton aphid (*A. gossypii*) on unsprayed crop. At Gwalior, *M. persicae* population remained

low upto third week of December and crossed the critical level in the 2<sup>nd</sup> week of January 2009. At Shillong aphid population was monitored in Kufri Giriraj, Kufri Jyoti, Kufri Girdhari and Kufri Megha and the mean number of aphids was maximum in Kufri Giriraj (26.83) followed by Kufri Jyoti (22.40), Kufri Girdhari (7.25) and Kufri Megha (5.13).

## Population dynamics and management of sucking pests at Modipuram

Populations of sucking pests were recorded under different combinations of pesticide treatments. Though initial population of whitefly was low in all the treatments, its population increased during the later stages of the crop. Soil treatment with Cartap hydrochloride at planting followed by foliar sprays of acetamiprid or thiamethoxam resulted in good control of whitefly, leaf hopper and both the aphid species but failed to give satisfactory control of broad mite (Fig. 26).





Cartap+thiamethoxam treated



Control plot

**Fig. 26. Management of sucking pests of potato.**

## Monitoring of white grub population

Light trap installed at Shimla and Fagu for white grub beetles and 157 beetles were collected from CPRI, Lower Lab, Shimla during 5<sup>th</sup> June to 22<sup>nd</sup> July. Peak population was observed on 18<sup>th</sup> June (30 beetles) and 20<sup>th</sup> June (39 beetles). Beetle population declined after 15<sup>th</sup> July and on 21<sup>st</sup> July onwards no beetle was trapped. Similarly, 1,680 beetles were collected from two traps and alternate hosts from Fagu. Beetles started appearing on 25<sup>th</sup> May and the peak population was observed on 25<sup>th</sup> June (500 beetles) and 11<sup>th</sup> July (450 beetles). After 25<sup>th</sup> July, decline in beetle population was observed and no beetle was observed after 31<sup>st</sup> July. *Brahmina coriacea* was the predominating species followed by *Holotricha* spp. at both the places while *Anomala dimidiata* was found only at Fagu and its number was less than 1% as compared to *B. coriacea*.

## Virus vectors relationship

At Gwalior tubers of susceptible potato variety Kufri Chandramukhi were grown on five different dates during September (10<sup>th</sup>, 17<sup>th</sup>, 24<sup>th</sup>, 30<sup>th</sup> day) and first week of October (6<sup>th</sup> day), and adult thrips from diseased plants were released on 13-19 days after planting.

Out of three plants planted in September, only one plant developed disease symptoms, while the other two plants and control plants did not show any symptoms. Presence of tospovirus in thrips was confirmed by PCR technique. The results showed that *Thrips palmi* is main vector of tospovirus and responsible for stem necrosis disease in early planted crop in central India.

## Management of potato tuber moth in country stores at Kangra valley

The potato tuber moth (PTM) *Phthorimaea operculella* (Zeller) is economically most significant potato pest in the mid-hills. Cooler climatic condition in this region allows on-farm storage of potatoes from May-August which expose them to PTM attack. The efficacy of the sprout inhibitor CIPC (chlorpropham) was evaluated for PTM management at ambient temperature (25±2°C) at Kangra valley of Himachal Pradesh. Twenty farmers' stores were selected. CIPC (Grow stop basis 30EC) was sprayed on stored potatoes @ 6 ml in 14 ml water/quintls of potato using (ULV sprayer). After 2 weeks of storage, 1.0-24.5 % tubers were infested with PTM in control while the treated tubers were free from PTM attack in 18 stores. After 7 weeks of storage, PTM infestation was 0-8% in CIPC treated tubers

vis-à-vis 5.0-25.0 % in control. The CIPC residues ranged from 0.34 to 0.8 mg/ kg fresh weight of tubers in unpeeled tubers up to 7 weeks of storage (permissible 30 mg/kg). This study suggested that the sprout suppressant CIPC can be used for PTM control. Trials conducted in the stores of CPRS, Shillong during 2008-09 also revealed that CIPC treatment in Kufri Giriraj and Kufri Jyoti kept PTM infestation under check recording only 2-4% tuber infestation and less than 0.06 holes/tuber while in control 8-10% infestation and 0.8 holes/tuber (Fig. 27).

In trial at Shillong with cv. Kufri Megha revealed that CIPC, Cypermethrin and Lantana leaves treatment were best as they recorded no infestation at the end of 3 months of storage.

## Toxicity analysis of CIPC to different stages of PTM

The effect of CIPC against different stages of *P. operculella* (PTM) was evaluated through bioassays. The relative susceptibility of various stages of PTM was studied by topical application in the laboratory at 26°C incubation temperature. LC<sub>50</sub> of CIPC to eggs was 0.0359%. The susceptibility of CIPC decreased with increased age of larvae. The LC<sub>50</sub> increased from 0.0398% for neonate larvae to

0.0487%, 0.0512% and 0.0795 for second, third and fourth instar larvae, respectively. Pupa was found highly susceptible as compared to fourth instar larvae with LC<sub>50</sub> of 0.0500%. CIPC was found highly effective against adults. The results indicated good prospects of CIPC application for management of potato tuber moth in Country stores.

## Management of white grubs

Seven locally available plants and their extracts in cattle urine were tested against white grubs at Shimla. The extract of Neem seed kernel @ 5ml/ l proved very effective with no damage of tubers. This was followed by the extract of Jatropha kernel with 1.0% tuber damage on number basis and 1.7% on weight basis (grub population 0 and 0.33%, respectively). All other extracts were also superior to untreated control with tuber damage of 13.2 and 17.8% on number and weight basis respectively, with maximum grub population of 3.67 %.(Table 31). In Shillong, soil treatment of Carbofuran at the time of planting, drenching with Chlorpyrifos and Imidacloprid and a combination of the two as well as soil treatment with EPN, *S. carpocapse* and *H. indica* at the time of appearance of the pest was attempted for the management of white grubs. Results revealed that *H. indica* recorded the least infestation at

**Table 31. Effectiveness of botanical extracts in cattle urine in the management of white grub under field conditions**

| Treatment@<br>5ml/ litre              | Plant part<br>used | % Tuber damage  |                  |                 |                 | Mean grub<br>population/ plot |                  |
|---------------------------------------|--------------------|-----------------|------------------|-----------------|-----------------|-------------------------------|------------------|
|                                       |                    | 2007            |                  | 2008            |                 | 2007                          | 2008             |
|                                       |                    | Number<br>basis | Weight<br>basis  | Number<br>basis | Weight<br>basis |                               |                  |
| <i>Jatropha curcas</i>                | Kernel             | 0.00<br>(0.55)* | 0.00<br>(0.55)*  | 0.99<br>(3.68)* | 1.68<br>(4.69)* | 0.67<br>(1.05)**              | 0.33<br>(0.88)** |
| <i>Azadirachta indica</i>             | Kernel             | 0.00<br>(0.55)  | 0.00<br>(0.55)   | 0.00<br>(0.55)  | 0.00<br>(0.55)  | 0.33<br>(0.88)                | 0.00<br>(0.71)   |
| <i>Sapindus mukorossi</i>             | Kernel             | 7.32<br>(15.65) | 14.34<br>(22.22) | 3.06<br>(10.05) | 5.44<br>(13.44) | 1.67<br>(1.17)                | 1.00<br>(1.22)   |
| <i>Chrysanthemum cinerariaefolium</i> | Flowers            | 5.17<br>(12.88) | 11.01<br>(19.16) | 3.18<br>(10.26) | 5.73<br>(13.85) | 1.00<br>(1.15)                | 0.67<br>(1.05)   |
| <i>Nerium oleander</i>                | Flowers            | 8.03<br>(16.44) | 14.44<br>(22.31) | 4.31<br>(11.95) | 7.46<br>(15.83) | 1.33<br>(1.34)                | 0.67<br>(1.05)   |





Application of CIPC



CIPC Treatment



No treatment

Fig. 27. Application of CIPC on potato tubers, treated tubers and untreated control after 4 months storage

harvest of 0.05 grubs per 5 plants and per cent tuber damage of 0.4 followed by Imidacloprid (0.15 grubs/5 plants and 0.3% tubers damage) drenching at the time of appearance of the pest. The same treatments also recorded a yield of 200 and 193 q/ha as compared to 16.4 q/ha in untreated control. There was >80% reduction in grub population due to *S. carpocapsae* and *H. indica* treatment at Shimla. Percent plant damage/plot was 0-11.1 in *S. carpocapsae* treatment, 2.8-13.9 in *H. indica* treatment and 30.6 in control. Mean number of grubs/plot was 0-1.3, 0.33-1.7 and 3.3 respectively in *S. carpocapsae*, *H. indica* and control at three dosages ( $1 \times 10^5$ ,  $3 \times 10^5$ ,  $6 \times 10^5$ /m<sup>2</sup>). Percent reduction in tuber damage was >55 %.

#### Bio-intensive management of cutworm and red ants at Patna

Four different microbial agents i.e. *Metarrhizium anisopliae*, *Bacillus thuringiensis*, *Beauveria bassiana* and *Heterohabditis indica* were tried against cutworm and red ant in field twice first just after emergence of the crop and second after 30 days of first spray in comparison to chlorpyrifos -20 EC on plant foliage. Result revealed that among microbial agents, *B. bassiana* and *H. indica* were found most effective against red ant and cutworm, respectively.

#### Evaluation of different chemical and bio-pesticides / plant extracts against leaf-eating caterpillars

Four different neem formulations i.e. Azadirachtin (Vangaurd- 0.15% EC, Neem (Ranker 0.2% EC), Neemgold (0.03% EC) and Nimbicidine were tried against different defoliators and leaf eating caterpillars in comparison to 5 chemical insecticides i.e. Cypmerthrin – (Stop-20EC) Thiodan (Endosulfan-35EC), Spinosid (tracer), Alphamethrin (Stop-10EC) and Chlorpyrifos-20EC @ 0.5Kg a.i./ha on plant foliage first on emergence of the crop and second after 30 days of first spray. Results revealed that all formulations of neem extract were found equally effective to protect defoliators and checked damage up to 70%. It was less effective to chemical pesticides as they checked more than 90% foliage damage.

#### Pesticide residue analysis

Results from toxicology Lab. of UHF, Solan indicated that the residue of Imidacloprid (Confidor 200 SL) in unprocessed potato was between 0.109-0.287mg/kg, with an average value of 0.182 mg/kg. However, in processed (cooked) potato and in soils of treated plots residues was non-detectable and was below the LOQ of 0.10 mg/kg. No residue of EBDC, Phorate and Chlorpyrifos were detected in any of the potato sample.



# Management of Potato Nematodes



Potato cyst nematode (*Globodera pallida* and *G. rostochiensis*) also known as Golden Nematode or potato eelworms, is considered as one of the major pests throughout the world (Fig. 28). Quarantine restrictions have been imposed in most countries including India to arrest its spread. In India, this nematode pest of potato is restricted to the Nilgiri hills of South India and a domestic quarantine has been imposed to restrict movement of potato from the region to prevent its further spread. The programme aims at developing resistant cultivars for the area and also to develop an integrated nematode management package for potato cyst nematodes (PCN) in the Nilgiris.

## Breeding for resistance to late blight and potato cyst nematodes

Twenty three bi-parental crosses involving selected late blight and potato cyst nematode resistant parents were made during the year 2008-09 and 67,400 seeds were obtained. Fifteen thousand  $F_1$  seedlings belonging to 9 cross combinations were sown in boxes. Ten thousand three hundred seedlings were transplanted in the field/polyhouse and screened under natural conditions for late blight resistance. On maturity, the tubers were harvested and 981 selections were made based on tuber characters and late blight resistance. In the autumn season, 130 single hills obtained from the crosses OS/2000  $\times$  E/79-42, OS/94-I-112  $\times$  K.Pukhraj, OS/93-D-204  $\times$  E/79-42, OS/



Fig. 28. PCN infected crop

94-L-956  $\times$  E/79-42 were evaluated for tuber character and field resistance to late blight and 63 were selected. Under initial evaluation of hybrids, 1,155 clones were evaluated in single hill/observational rows along with Kufri Giriraj and Kufri Swarna as check varieties and 520

**Table 32. Effect of nematicides on the multiplication of PCN and tuber yield of potato**

| Treatment                | Yield (kg/plot)* |               |              | PCN multiplication(Rf)** |               |              |
|--------------------------|------------------|---------------|--------------|--------------------------|---------------|--------------|
|                          | Kufri Jyoti      | Kufri Giriraj | Kufri Swarna | Kufri Jyoti              | Kufri Giriraj | Kufri Swarna |
| Carbofuran @ 2 kg a.i/ha | 27.70            | 28.11         | 38.24        | 0.90                     | 1.06          | 0.69         |
| Carbofuran @ 4 kg a.i/ha | 29.54            | 28.15         | 40.48        | 0.80                     | 0.88          | 0.67         |
| Phorate @ 2 kg a.i/ha    | 27.35            | 26.00         | 37.35        | 1.28                     | 1.28          | 0.77         |
| Phorate @ 4 kg a.i/ha    | 27.45            | 27.69         | 38.95        | 1.25                     | 1.19          | 0.73         |
| Untreated control        | 25.31            | 22.13         | 36.83        | 1.57                     | 1.38          | 0.94         |

\* Plot size = 9 m<sup>2</sup>; \*\* Rf = nematode reproduction factor

clones were selected. Five tubers from each of the selections in F<sub>1</sub>C<sub>2</sub> to F<sub>1</sub>C<sub>4</sub> would be evaluated for nematode resistance. Fifty five advance generation hybrids were evaluated along with Kufri Giriraj and Kufri Swarna as checks. Of these, thirty two hybrids were selected. Five tubers of the selections were collected for screening against PCN under glass house conditions. The details of evaluation and selection of advance hybrids are given below:

#### Confirmatory yield trial-1

Out of the 11 advance generation hybrids evaluated, 7 yielded significantly higher. Based on agronomic traits, field resistance to late blight and cyst nematodes, seven hybrids viz., OS/94-I-126, OS/01-118, OS/01-161, OS/01-392, OS/01-497, OS/01-516 and OS/02-80 were selected. The dry matter content of the selections ranged from 16 - 18.6% (K.Giriraj 14.1%; K.Swarna 14.9%).

#### Confirmatory yield trial-2

All the 16 hybrids assessed were found to be better than the controls. Based on yield, tuber characters and field resistance to late blight and cyst nematodes, ten hybrids viz., OS/03-17, OS/03-26, OS/03-30, OS/03-55, OS/03-87, OS/03-94, OS/03-99, OS/03-108, OS/03-132 and OS/03-175 were selected for further test. Dry matter content ranged from 13.2-19.3 % (K.Giriraj 12.71%; K.Swarna 15%).

#### Preliminary yield trial-1

Out of the 12 hybrids evaluated, 9 yielded significantly higher. On the basis of yield, tuber

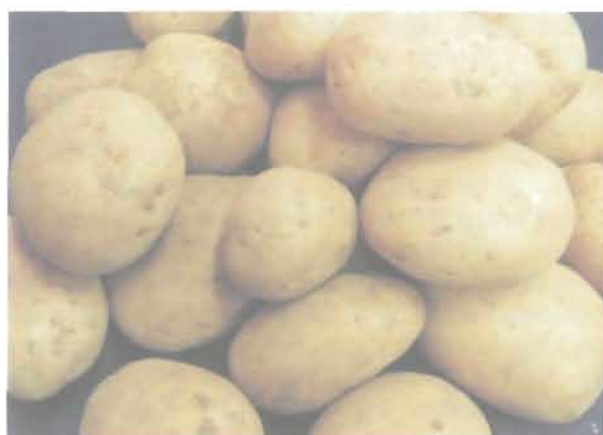
character and field resistance to late blight and potato cyst nematodes, eight hybrids viz, OS/03-2, OS/03-25, OS/03-32, OS/03-304, OS/04-79, OS/04-251, OS/04-471 and OS/04-492 were retained for further evaluation. The dry matter content of the selections ranged from 16.7 - 20.74% (K.Giriraj 15.4%; K.Swarna 14.0%).

#### Preliminary yield trial-2

Out of 16 hybrids evaluated, 8 yielded significantly higher. Based on yield, tuber characters and field resistance to late blight and PCN, seven hybrids viz, OS/03-88, OS/04-544, OS/05-23, OS/05-55, OS/05-78, OS/05-155 and OS/05-229 were selected for further test.

#### Multilocation trial

The promising hybrid OS/93-D-204 possessing combined resistance to both species of PCN (Fig. 29 and 30) and late blight which performed well in adaptability trials during previous years



**Fig. 29. OS/93-D-204 Tubers**



was introduced in All India Coordinated Research Project (Potato) trials to conduct multilocation tests in Nilgiris.

### Integrated management of potato cyst nematodes

Carbofuran performed better than @ 2kg and Phorate in suppressing PCN and improving potato yield of all the cultivars (Kufri Jyoti, Kufri Giriraj and Kufri Swarna) tested (Table 32). Organic soil amendment with neem cake in combination with *T. viride* recorded maximum increase in yield and reduction in PCN multiplication followed by spent mushroom compost and eucalyptus cake in combination with *T. viride* (Table 33). *P. fluorescens* gave maximum reduction in PCN multiplication and improvement in potato yield followed by



Fig. 30. OS/93-D-204 Crop

*Paecilomyces lilacinus* (Table 34). Performance of potato varieties/lines individually and in combination with the nematicide revealed that

Table 33. Effect of organic amendments on the multiplication of PCN and tuber yield of potato

| Treatment                             | Yield (kg/plot)* | PCN multiplication (Rf)** |
|---------------------------------------|------------------|---------------------------|
| T1 - Eucalyptus cake @ 10 t/ha        | 23.37            | 1.44                      |
| T2 - Spent mushroom compost @ 10 t/ha | 25.43            | 1.36                      |
| T3 - Neem cake @ 5 t/ha               | 26.28            | 1.27                      |
| T4 - T1 + <i>Trichoderma viride</i>   | 23.50            | 1.44                      |
| T5 - T2 + <i>T. Viride</i>            | 26.83            | 1.26                      |
| T6 - T3 + <i>T. Viride</i>            | 31.47            | 1.03                      |
| T7 - Carbofuran @ 2 kg a.i/ha         | 29.25            | 0.78                      |
| T8 - Untreated control                | 20.90            | 1.89                      |

\* Plot size = 9 m<sup>2</sup>; \*\* Rf = nematode reproduction factor

Table 34. Effect of biological control agents on the multiplication of PCN and tuber yield of potato

| Treatment                                  | Yield (kg/plot)* | PCN multiplication (Rf)** |
|--------------------------------------------|------------------|---------------------------|
| <i>Paecilomyces lilacinus</i> @ 20 kg /ha  | 24.48            | 1.47                      |
| <i>Pochonia chlamydospora</i> @ 20 kg /ha  | 23.00            | 1.05                      |
| <i>Trichoderma viride</i> @ 20 kg /ha      | 23.97            | 1.50                      |
| <i>Pseudomonas fluorescens</i> @ 10 kg /ha | 25.03            | 1.42                      |
| <i>Pseudomonas</i> sp. @ 10 kg /ha         | 23.57            | 1.65                      |
| Carbofuran @ 2 kg a.i/ha                   | 27.18            | 0.92                      |
| Untreated control                          | 22.78            | 1.90                      |

\* Plot size = 9 m<sup>2</sup>; \*\* Rf = nematode reproduction factor



varieties/ lines with Carbofuran application performed better than those without Carbofuran. The hybrid OS/93-D-204 recorded relatively higher tuber yield and lower PCN multiplication than other varieties/ lines tested. Maximum reduction in PCN population was recorded in the

fields where the recommended practice of potato + French beans intercropping in summer and cabbage crop in autumn season was followed (Table 35). Crop rotation with radish was another effective system to contain PCN population.

**Table 35. Yield and PCN populations of two year long rotations**

| 2007    |                  |                        |          |                  |                        | 2008     |                  |                        |          |                  |                        |
|---------|------------------|------------------------|----------|------------------|------------------------|----------|------------------|------------------------|----------|------------------|------------------------|
| Summer  | Yield<br>kg/plot | PCN<br>after<br>summer | Autumn   | Yield<br>kg/plot | PCN<br>after<br>autumn | Summer   | Yield<br>kg/plot | PCN<br>after<br>summer | Autumn   | Yield<br>kg/plot | PCN<br>after<br>autumn |
| K.Jyoti | 62.6             | 248                    | K.Jyoti  | 40.0             | 500                    | K.Jyoti  | 54               | 645                    | K.Jyoti  | 42.4             | 702                    |
| K.Jyoti | 62.0             | 240                    | K.Swarna | 73.0             | 395                    | K.Jyoti  | 72               | 466                    | K.Swarna | 65.6             | 396                    |
| K.Jyoti | 60.0             | 243                    | Cabbage  | 150.0            | 278                    | K.Swarna | 117              | 110                    | K.Jyoti  | 57.3             | 162                    |
| K.Jyoti | 60.0             | 242                    | Carrot   | 29.3             | 464                    | K.Swarna | 98               | 327                    | K.Jyoti  | 47.5             | 372                    |
| K.Jyoti | 62.4             | 245                    | Cabbage  | 173.3            | 253                    | Carrot   | 89.3             | 265                    | K.Jyoti  | 50.0             | 300                    |
| K.Jyoti | 63.2             | 240                    | Carrot   | 71.7             | 482                    | Cabbage  | 183              | 355                    | K.Jyoti  | 54.2             | 406                    |
| K.Jyoti | 61.0             | 243                    | Radish   | 70.0             | 309                    | K.Jyoti  | 82               | 388                    | Radish   | 66.8             | 315                    |
| CV%     |                  | 6.72                   |          |                  | 11.66                  |          |                  | 7.76                   |          |                  | 10.79                  |





# *Division of Crop Physiology and Post Harvest Technology*





# Diversified Utilization of Potatoes



This programme explores the possibilities of utilizing potatoes in various ways to increase processing of potatoes in the country, and aims to determine quality changes associated with processing.

## Decreasing oil content in fresh fried chips

Potato chips contain 28-40% oil depending upon the dry matter content and other parameters affecting oil absorption during frying. Because of increasing health concerns, it is desirable to decrease the oil content, without affecting other quality parameters. An experiment was conducted to evaluate the effect of blanching time and temperature, use of some hydrocolloids and potato starch treatments on oil content of the chips. The potatoes of variety Kufri Chipsona-1 stored at 12°C with CIPC were used and lowest oil content was obtained with 70°C treatment for 2 minutes. Therefore, this blanching temperature and time were used in the other experiments. The treatment with 0.5% magnesium chloride with blanching and 0.5% calcium chloride with blanching led to decrease in oil content of chips (Table 36). Similarly treatment of potato chips with starch (0.25%) and blanching also led to decrease in oil content of potato chips (Table 36).

## Use of Benedict's reagent for quick estimation of glucose in chipping potatoes

Benedict's qualitative and quantitative reagents were used for estimation of glucose. Potato juice was extracted from tubers of Kufri Chipsona-1. Potato juice heated with Benedict's qualitative reagent gave an average reading of 0.5%, while the reading for same sample using YSI Biochemistry Analyser was 0.34%. The reaction of potato juice with Benedict's quantitative reagent was found to be negative, possibly because of interfering compounds in the potato juice. The strips impregnated with Benedict's qualitative reagent were also prepared by dipping 2.5 inches long and 0.5 cm broad Whatman No. 1 filter papers in Benedict's reagent and drying them in hot air oven at 60°C for one hour. The strips were then kept between two halves of the cut tubers (samples from the same lot) so that the strips get wet with the potato juice. On drying in air no colour developed in the strips, but when strips were kept in microwave oven for 15 seconds, an intense yellow colour developed,

**Table 36. Effect of treatment with magnesium chloride, calcium chloride and potato starch along with blanching on chip quality**

| Treatment              | Blanching* | Chip colour<br>(subjective) | Hunter colour |      |      | Chip yield (%) | Moisture (%) | Oil (%) |
|------------------------|------------|-----------------------------|---------------|------|------|----------------|--------------|---------|
|                        |            |                             | dl            | da   | db   |                |              |         |
| MgCl <sub>2</sub> 0.5% | Blanched   | 3.8                         | 56.7          | 5.33 | 24.2 | 30.7           | 1.0          | 34.1    |
| Control                | Blanched   | 1.5                         | 53.7          | 5.8  | 23.2 | 32.4           | 1.5          | 37.3    |
| MgCl <sub>2</sub> 0.5% | Unblanched | 1.3                         | 52.9          | 7.33 | 23.5 | 30.7           | 1.3          | 34.7    |
| Control                | Unblanched | 1.7                         | 57.2          | 5.52 | 23.9 | 30.7           | 1.7          | 32.6    |
| CaCl <sub>2</sub> 0.5% | Blanched   | 2.1                         | 60.3          | 4.34 | 24.9 | 29.1           | 2.3          | 26.9    |
| Control                | Blanched   | 1.9                         | 60.7          | 3.71 | 25.0 | 30.6           | 2.3          | 29.5    |
| CaCl <sub>2</sub> 0.5% | Unblanched | 2.1                         | 57.9          | 4.57 | 24.6 | 29.2           | 1.6          | 33.5    |
| Control                | Unblanched | 1.5                         | 60.8          | 3.55 | 24.4 | 28.1           | 2.1          | 30.2    |
| Starch 0.25%           | Blanched   | 4.4                         | 55.3          | 3.72 | 22.3 | 30.0           | 4.0          | 26.8    |
| Control                | Blanched   | 4.7                         | 50.0          | 6.57 | 22.1 | 30.8           | 3.9          | 35.5    |
| Starch 0.25%           | Unblanched | 4.0                         | 55.0          | 3.70 | 23.4 | 33.2           | 3.0          | 34.8    |
| Control                | Unblanched | 3.6                         | 53.6          | 4.37 | 23.1 | 33.7           | 3.5          | 34.9    |

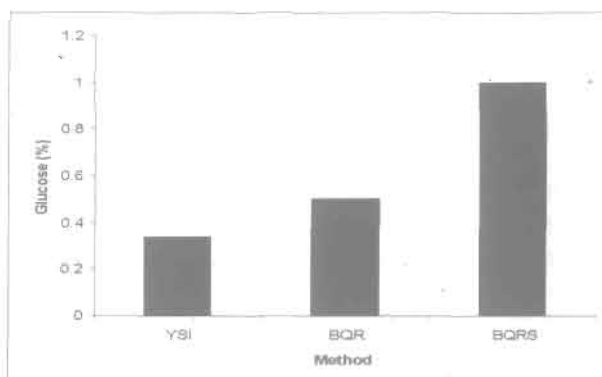
\*70°C for 2 minutes

corresponding to 1% glucose. The values of glucose corresponded well with chip colour values of 7.0 of the same lot. The comparative values by three methods have been depicted in Fig. 31.

Properties of starch in local potato cultivars grown at Shillong

Five local cultivars viz., Lah Sorkari, Lah Sintiu, Lah Arpor, Lah Sow Khasi and Lah Sow Simit and two improved cultivars viz., Kufri Megha and

Kufri Giriraj grown at Central Potato Research Station, Shillong, were estimated for dry matter and starch content in tuber samples. Starch was separated from the tubers and amylose content, viscosity, swelling volume and optical density of starch were determined. Compared to Kufri Megha, the tuber dry matter and starch content were significantly higher in the local cultivar Lah Sow Simit. The viscosity of starch was significantly higher in Lah Sow Khasi and significantly lower in the other four local cultivars, as compared to Kufri Megha. The starch viscosity was least in Lah Arpor. Among the five local cultivars of Meghalaya, Lah Sow Khasi had low amylose content but the starch viscosity and swelling volume were higher. Lah Sow Simit showed higher tuber dry matter content and its starch had higher amylose content and better clarity.



**Fig. 31. Glucose concentration as determined by different methods (YSI = Biochemistry analyzer; BQR = Benedict's qualitative reagent; BQRS= Benedict's qualitative reagent strips)**

Effect of growing season on properties of potato starch

Effect of growing season on the properties of starch was studied in three potato cultivars grown as early and main crops at CPRIC, Modipuram. Seed tubers of three cultivars viz., Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Bahar were planted on 1-10-2006 to raise the early crop. In case of the main crop, planting

**Table 37. Effect of growing season on physicochemical properties of starch separated from three potato cultivars**

| Season/cultivar   | Dry matter (%) | Starch content (%) | Amylose content (%) | Viscosity (cP) | Swelling volume (ml/g) | Optical density |
|-------------------|----------------|--------------------|---------------------|----------------|------------------------|-----------------|
| <b>Early crop</b> |                |                    |                     |                |                        |                 |
| Kufri Chipsona-1  | 23.5           | 17.7               | 18.2                | 2252           | 31                     | 1.491           |
| Kufri Chipsona-2  | 25.0           | 19.3               | 17.1                | 2090           | 29                     | 1.474           |
| Kufri Bahar       | 21.7           | 15.7               | 17.8                | 2410           | 27                     | 1.527           |
| Mean              | 23.4           | 17.5               | 17.7                | 2251           | 29.0                   | 1.497           |
| <b>Main crop</b>  |                |                    |                     |                |                        |                 |
| Kufri Chipsona-1  | 22.5           | 16.6               | 17.6                | 2281           | 40                     | 1.559           |
| Kufri Chipsona-2  | 24.4           | 18.7               | 16.5                | 2325           | 31                     | 1.534           |
| Kufri Bahar       | 21.1           | 15.1               | 17.7                | 2565           | 36                     | 1.608           |
| Mean              | 22.7           | 16.8               | 17.3                | 2390           | 35.7                   | 1.567           |
| LSD (5%)          |                |                    |                     |                |                        |                 |
| Season (S)        | NS             | NS                 | NS                  | 43             | 2.6                    | 0.027           |
| Cultivar (C)      | 1.5            | 0.9                | 0.9                 | 53             | 3.2                    | 0.034           |
| S × C             | 2.1            | 1.5                | 1.3                 | 75             | 4.6                    | 0.048           |

was done on 27-10-2006. Starch was separated from harvested tubers and amylose content, viscosity, swelling volume and optical density of starch were determined. The effects of growing season on the physicochemical properties of starch are shown in Table 37. The dry matter and starch contents were higher in the tubers harvested from the early crop but the differences were statistically non-significant. The difference in the amylose content of starch was also statistically non-significant. Significant differences were observed in viscosity and swelling volume, with starch separated from tubers harvested from the main crop showing higher viscosity and swelling volume. However, the clarity of starch was better in the early crop.

#### Extraction of starch from freshly harvested potatoes and after heap storage

Starch was extracted from 13 varieties/hybrid immediately after harvest. Both, Kufri Chipsona-3 and an advanced hybrid, MP/98-71 produced maximum starch yield (12.16% on fresh tuber wt), while Kufri Pukhraj gave lowest starch recovery (6.94%) (Table 38). The starch extraction efficiency of the varieties varied between 43.2-56.8% of the total solids present with an average recovery of 49%.

Extraction of starch from 4 varieties after 100 days of storage in the heap, revealed that the starch recovery was related to dry matter or solid content of the tubers. Kufri Chipsona-3 produced maximum starch yield (12.47% on fresh tuber wt) followed by MP/98-71(12.22%), while Kufri Pukhraj gave lowest starch recovery (4.83%) (Table 38). Phosphorus content of the starches from different varieties/hybrids after 180 days of storage at 10-12°C ranged between 477 (MP/98-172) to 1114 ppm (Atlantic). Among Indian varieties, Kufri Himsona showed maximum phosphorus content (1023 ppm).

#### Preparation of flakes

Potato flakes were prepared from 6 varieties/hybrid immediately after harvest. Atlantic produced maximum flake yield (16.9%) followed by Kufri Chipsona-3 (15.3%). Flakes prepared from all the cultivars were acceptable in colour.

#### Determination of textural properties of French fries

Analysis of texture of frozen French fries made from potatoes after 100 days of storage in the



**Table 38. Starch recovery from potato varieties/hybrid after 100 days of storage in the heap**

| Variety/hybrid | Tuber dry matter (%) | Recovery of starch on fresh tuber wt (%) | Per cent starch recovery of the tuber solids present | Dry residue obtained on fresh tuber wt (%) |
|----------------|----------------------|------------------------------------------|------------------------------------------------------|--------------------------------------------|
| K. Chipsona-1  | 21.2                 | 8.59                                     | 40.5                                                 | 3.33                                       |
| K. Chipsona-3  | 23.0                 | 12.47                                    | 54.2                                                 | 4.46                                       |
| K. Pukhraj     | 14.5                 | 4.83                                     | 33.3                                                 | 3.71                                       |
| K. Sutej       | 19.2                 | 8.42                                     | 43.9                                                 | 4.62                                       |
| MP/98-71       | 24.4                 | 12.22                                    | 50.1                                                 | 3.78                                       |

heap revealed that fries made from K. Surya and an advanced hybrid MP/98-71 were firmer in texture (1076 and 1066 g force, respectively) in comparison to K. Chipsona-1 (811 g force) and K. Chipsona-3 (907 g force). Fries made from all the varieties/hybrid were acceptable in colour.

#### Influence of industrial processing on nutritional composition of products

Three products viz., French fries, flakes and chips were prepared from six varieties/hybrid and total solid content and nutritional composition of these products were determined and compared with fresh potato on per serving basis. For French fries, 100g was taken as one serving; for flakes 25 g dissolved in water to make 100 g constituted one serving; while for chips, 35 g was considered as one serving as this is the quantity normally people consume at a time. French fries had maximum content of total solids, free amino acids, and soluble protein, while flakes had lowest amounts of reducing

sugars, total phenols and ascorbic acid (Table 39). Chips provided minimum amounts of sucrose, free amino acids and soluble protein on per serving basis, although it contained maximum oil. The results indicated that steps involved in the processing of flakes and chips caused considerable loss in reducing sugars, sucrose, free amino acids, total phenols and soluble protein when compared to fresh potatoes (Table 39). There were large differences in the contents of different nutrients present within the product prepared from different varieties.

#### Effect of home processing on nutritional and anti-oxidant constituents in potatoes

Influence of pressure cooking and microwave cooking on the total solids, nutritional constituents and three anti-oxidants compounds viz., total phenols, L-ascorbic acid and total carotenes was studied in three varieties. Microwave cooking increased the total solid content, while both the processes reduced the

**Table 39. Changes in total solids and nutritional constituents during industrial processing of potatoes into different products (average of six varieties)**

| Potato product | Constituents <sup>1</sup> |                     |              |                      |                   |                    |                      |
|----------------|---------------------------|---------------------|--------------|----------------------|-------------------|--------------------|----------------------|
|                | Total solids (g)          | Reducing sugar (mg) | Sucrose (mg) | Free amino acid (mg) | Total phenol (mg) | Ascorbic acid (mg) | Soluble protein (mg) |
| Raw            | 21.7                      | 83.5                | 170.2        | 657                  | 45.9              | 12.1               | 1.93                 |
| French fries   | 39.1                      | 55.9                | 132.5        | 937                  | 56.7              | 15.3               | 2.72                 |
| Flakes         | 25.0                      | 20.8                | 62.0         | 465                  | 27.7              | 12.1               | 1.31                 |
| Chips          | 23.3                      | 27.2                | 52.9         | 382                  | 38.3              | 17.3               | 1.12                 |

<sup>1</sup> All nutritional constituents are presented on an as-served basis for a 100 g serving of each product except for chips, where 35 g serving was used for comparison

**Table 40. Effect of home processing on the total solids and nutritional constituents of potatoes (average of three varieties)**

| Treatment         | Constituents <sup>1</sup>        |                                     |                              |                                      |                                   |                                    |                                      |                                                         |
|-------------------|----------------------------------|-------------------------------------|------------------------------|--------------------------------------|-----------------------------------|------------------------------------|--------------------------------------|---------------------------------------------------------|
|                   | Total solids <sup>1</sup><br>(g) | Reducing sugar <sup>1</sup><br>(mg) | Sucrose <sup>1</sup><br>(mg) | Free amino acid <sup>1</sup><br>(mg) | Total phenol <sup>1</sup><br>(mg) | Ascorbic acid <sup>1</sup><br>(mg) | Soluble protein <sup>1</sup><br>(mg) | Total caroten <sup>1</sup><br>enes <sup>1</sup><br>(ug) |
| Raw potato        | 18.3                             | 187.0                               | 154.1                        | 597.6                                | 49.9                              | 17.12                              | 1578                                 | 70.0                                                    |
| Pressure cooking  | 18.8                             | 177.0                               | 103.0                        | 452.5                                | 47.7                              | 13.87                              | 1736                                 | 99.9                                                    |
| Microwave cooking | 22.6                             | 124.6                               | 142.2                        | 586.8                                | 60.3                              | 15.81                              | 1588                                 | 106.6                                                   |

<sup>1</sup>per 100 g wt

contents of sucrose, free amino acids, total phenols and ascorbic acid when compared to fresh potatoes (Table 40). Both the cooking methods increased the contents of soluble protein and total caroten<sup>1</sup>es significantly. Pressure cooking increased the reducing sugar content, while a reduction was observed in microwave cooking.

Determination of acrylamide content in chips prepared from freshly harvested potatoes.

The report that potato chips contain acrylamide, which is toxic to humans has caused safety concerns. The acrylamide

content in potato chips prepared from Indian potato varieties is not known. Therefore, acrylamide content was determined in chips prepared from 26 Indian potato varieties grown at CPRS, Kufri. Table 41 shows the acrylamide content in ten popular potato varieties. Minimum acrylamide was observed in the two processing varieties Kufri Chipsona-1 (65 mg/kg) and Kufri Chipsona-2 (82 mg/kg). Maximum acrylamide was observed in Kufri Kanchan (1177 mg/kg) and Kufri Anand (1096 mg/kg). There was a significant positive correlation between acrylamide content and chip colour score ( $r=0.52^{**}$ ,  $n=26$ ). The correlation between acrylamide and reducing sugars content was also positive but non-significant.

**Table 41. Acrylamide content in potato chips and its relation with chip colour score (1-10 scale) and reducing sugars content in tubers**

| S. No. | Variety               | Acrylamide content<br>in potato chips<br>(mg/kg wt) | Chip colour<br>score * | Reducing sugars<br>content<br>(mg/100 g f. wt) |
|--------|-----------------------|-----------------------------------------------------|------------------------|------------------------------------------------|
| 1.     | Kufri Kanchan         | 1177                                                | 6.3                    | 330                                            |
| 2.     | Kufri Chipsona-1      | 65                                                  | 2.3                    | 131                                            |
| 3.     | Kufri Suttlej         | 421                                                 | 6                      | 384                                            |
| 4.     | Kufri Jyoti           | 241                                                 | 4.6                    | 387                                            |
| 5.     | Kufri Giriraj         | 968                                                 | 7.3                    | 302                                            |
| 6.     | Kufri Anand           | 1096                                                | 9                      | 503                                            |
| 7.     | Kufri Ashoka          | 505                                                 | 8                      | 397                                            |
| 8.     | Kufri Chipsona-2      | 82                                                  | 4.6                    | 194                                            |
| 9.     | Kufri Chandramukhi    | 115                                                 | 5                      | 180                                            |
| 10.    | Kufri Pukhraj         | 375                                                 | 7                      | 628                                            |
|        | <b>CD (P&lt;0.05)</b> | <b>133</b>                                          | <b>0.8</b>             | <b>34</b>                                      |

\*Scored on a scale of 1-10 of increasing dark colour.



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



*P*otato, a semi perishable commodity can not be stored without refrigeration for more than 4-6 weeks after harvest because of enormous losses. Storage of potatoes is intended to conserve them with minimum loss in quantity and quality according to mode of their utilization. This programme aims at developing efficient refrigerated and non-refrigerated methods for storage of table and processing potatoes, evaluation of potato genotypes for storability and processing quality and identification of naturally occurring compounds as potential replacements for chemical sprout inhibitors.

## Improved technology for storage of potatoes by traditional methods

An improved storage technology involving essential pre and postharvest measures viz., tuber maturity and haulm cutting prior to harvest, curing and selection of potatoes prior to storage, providing ventilation during storage and by 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 heaps and pits. A film on 'Improved practices for storage of potatoes' of 12 minutes duration depicting details of the improved technology has been released in Hindi and

*English for the benefit of farmers and the processing industry.*

## Demonstration and validation of improved heap storage technology at farmers' fields

Improved technology with the use of CIPC (Oorja) @ 40 ml tonne<sup>-1</sup> of potatoes in methanol was successfully demonstrated in four villages of Punjab. Sprout growth remained significantly suppressed and total losses in tubers were reduced (by 58.7%) up to 90 days of storage (DOS) (Table 42). In cv. Kufri Pukhraj stored for table purpose, the farmer could market 6.5% more weight



of potatoes and fetch 35% higher price than the control tubers, besides saving on desprouting labour cost (approx. Rs. 30/q). In cv. Kufri Chipsona-1 stored in collaboration with the processing industry (Satnam Agri Products Ltd, Jalandhar), reducing sugar concentrations decreased from 155 to 34 mg/100 g fr. wt. during storage up to 110 days and chip colour improved significantly. Stored potatoes were successfully used in the industry in making good quality flakes and French fries up to the end of June. Improved heap storage technology can thus be used to increase remunerations from potato cultivation and to preserve the quality of table and processing potatoes at lower storage cost. Heap stored potatoes can feed the processing industry from April to June and potatoes stored at 10-12°C can be used from July to October.

## Mode of CIPC application

Sprout inhibition treatment with CIPC (Oorja) spray in methanol remained effective even at lower rates (10-40 ml/t). The treatments significantly reduced sprouting, sprouting index, sprout weight and total losses in potatoes up to 120 days of storage (DOS) in heaps in cv. Kufri Chipsona-1, whereas, spray application in water (50 ml/tonne) remained less effective up to 90 DOS (Fig. 32). The sprout inhibition effect was not uniform and recorded sprouting at places where CIPC concentration presumably remained low. The treatment increased rottage in cvs. Kufri Chandramukhi and Kufri Pushkar and internal sprouting in 25% of sprouted tubers of cv. Kufri Pushkar

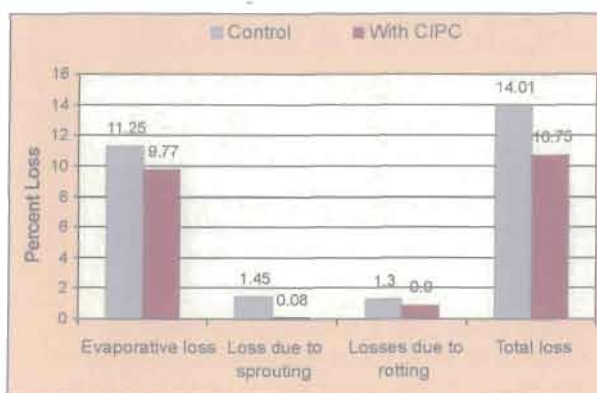


Fig. 32. Quantitative losses in potatoes up to 90 days of storage in heaps using CIPC spray in water

under heap and pit storage. The chip colour of treated and untreated potatoes was at par (Table 43), however dry matter content was higher in control tubers due to increased water loss from sprouts.

## Evaluation of potato varieties stored in the heap for French fries

Evaluation of CIPC treated tubers of three potato varieties/hybrid after 100 days of storage in the heap for French fries revealed that acceptable fries can be prepared from large size tubers (7-9 cm long) of all the varieties/hybrid stored in the heap and the fries made from K. Surya and an advanced hybrid MP/98-71 were superior in texture (1076 and 1066 g force respectively).

Table 42. Losses in potatoes after 90 days of storage in heaps at farmer's fields in Punjab

| Location<br>Village (distt.)    | Variety          | Storage<br>condition | Treatment | Sprout wt.<br>(g/kg<br>tuber wt.) | Rottage<br>(%) | Total<br>weight<br>loss (%) |
|---------------------------------|------------------|----------------------|-----------|-----------------------------------|----------------|-----------------------------|
| Badshahpur(Jalandhar)           | Kufri Chipsona-1 | Under shed           | CIPC      | 1.13                              | 0.26           | 5.17                        |
|                                 |                  |                      | Control   | 26.13                             | 0.47           | 12.15                       |
| Sham Chaurassi<br>(Hoshiarpur)  | Kufri Chipsona-1 | Under shed           | CIPC      | 0.57                              | 0.51           | 4.05                        |
|                                 |                  |                      | Control   | 18.27                             | 0.73           | 11.11                       |
| Khatkar Kalan,<br>(Nawanshahar) | Kufri Chipsona-1 | Under trees          | CIPC      | 0.93                              | 0.11           | 4.97                        |
|                                 |                  |                      | Control   | 30.0                              | 0.15           | 11.40                       |
| Sultanpur (Jalandhar)           | Kufri Pukhraj    | Under trees          | CIPC      | 2.90                              | 0.15           | 4.79                        |

## CIPC residue analysis in potatoes stored in heap and pit

The potatoes treated with CIPC and stored in heaps and pits at CPRS, Jalandhar were analysed for CIPC residue and for this purpose, the tubers were taken out of the storage twice (April and July), brought to Shimla and were fixed for residue analysis in their peels. In the samples collected in April, the maximum residues were observed in Kufri Chipsona-1 tubers sprayed with Oorja chemical (@50 ml/tonne) dissolved in methanol and stored in heap followed by Oorja treatment and stored in pit (Table 44). This was followed by Kufri Chipsona-1 tubers sprayed with Oorja chemical (@40 ml/tonne) dissolved in methanol and stored in heaps. The minimum residues were observed in peels of Kufri Chipsona-1 treated with the minimum dose of Oorja (10 ml/tonne) dissolved in methanol and stored in heap. In samples collected in July, the maximum peel residues were observed in Kufri Chipsona-1 tubers sprayed with Oorja in methanol and stored in heap. This was followed by GS basis sprayed tubers which were stored at 10-12°C. The minimum residues were observed in Kufri Chandramukhi which was sprayed with Oorja dissolved in water (@50 ml/tonne) and stored in heaps. The control tubers showed only negligible concentrations of CIPC, which may be due to contamination of the tubers. The residues tended to decrease with the storage duration and were generally less in July samples compared to samples collected in April. However, all the residue levels were much below the permissible limit of 30 mg/kg tubers hence, the tubers were safe for consumption.

## Storability of processing hybrids

Evaluation of 12 advanced hybrids for storability at room temperature revealed minimum total weight loss in MP/03-796 (12.9%) followed by MP/2K-516 (13.1%) and MP/01-916 (15.4%) up to 90 days of storage. The losses were at par with the control cvs. Kufri Surya (12.1%) and Kufri Chipsona-1 (15.6%).

## Processing and nutritional qualities of potato varieties/hybrids as influenced by skin curing in the soil and by pre-storage curing in the heap

Five varieties/hybrid were evaluated for chipping and nutritional qualities in freshly harvested potatoes at 100 days; in potatoes harvested after 20 days of skin curing in the soil and then after 10 days of pre-storage curing in the heap. Skin curing in the soil slightly deteriorated the chip colour and texture, decreased chip yield, sucrose, total phenols, free amino acids and total carotene with an increase in peeling loss and reducing sugars, while pre-storage curing in the heap deteriorated the chip colour and texture significantly with an increase in peeling loss, reducing sugars, free amino acids, total phenols and ascorbic acid and decrease in chip yield, sucrose, total carotene as compared to freshly harvested potatoes (Table 45). Evaluation of four varieties/hybrid for French fries in freshly harvested potatoes at 100 days; potatoes harvested after 20 days of skin curing in the soil and then after 10 days of pre-storage curing in the heap revealed that fry colour deteriorated and total processing losses increased both during skin curing and pre-storage in the heap.

**Table 43. Processing quality of potatoes stored in heap with and without CIPC spray treatment (cv. K.Chipsona-1)**

| Treatment | Dry matter (%) | Reducing sugar | Sucrose | Phenol | Free amino acids | Chip Colour score |
|-----------|----------------|----------------|---------|--------|------------------|-------------------|
| CIPC      | 22.3           | 40.2           | 258.4   | 63.9   | 950.1            | 2.4               |
| Control   | 23.2           | 30.6           | 257.4   | 51.9   | 942.9            | 2.3               |

\*mg/100 g fresh weight



## Processing quality changes during storage at intermediate temperatures (12°C)

Storage life of potatoes with respect to processing quality was studied in eight Indian and two exotic cultivars at 12°C for 7 months with two CIPC fog treatments by monitoring the colour of potato chips using Hunter colour meter. Cultivar Kufri Chipsona-2 maintained the highest dL values denoting more acceptable colour till the end followed by Kufri Himsona and Kufri Surya (Fig. 33). Highly acceptable chip colour in Kufri Chipsona-2 well corroborated with lower reducing sugar concentration. Sucrose concentration at the start of storage was low (46-70 mg/100g fr. wt) in Kufri Jyoti, Lady Rosetta and Atlantic, however, the values could not be related to reducing sugar accumulations during storage.

## Effect of storage temperature on processing quality

In evaluation studies at different temperatures with four cultivars viz. Kufri Jyoti, Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Pukhraj, the mean increase in dry matter content after 150 days of storage was 1.2, 1.8, 2.1 and 2.3%, while reducing sugar content increased by 437, 202, 156 and 148 mg/100g f. wt at 4, 8, 10 and 12°C, respectively. Consequently the chip colour deteriorated and none of the four cultivars

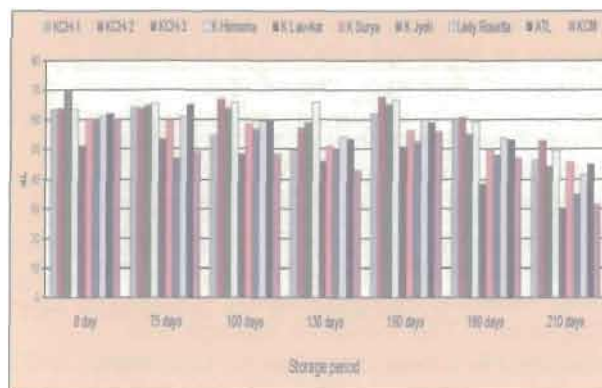


Fig. 33. Hunter colour values (dL) of chips of 10 varieties after storage at 12°C with CIPC (KCH-1=Kufri Chipsona-1, KCH-2=Kufri Chipsona-2, KCH-3=Kufri Chipsona-3, K Himsona=Kufri Himsona, K Lauvkar= Kufri Lauvkar, K Jyoti= Kufri Jyoti, ATL=Atlantic, KCM=Kufri Chandramukhi)

produced chips of acceptable quality after storage at all the four temperatures. The sucrose content increased at 4°C and 8°C and remained constant at 10 and 12°C. Phenols and free amino acids content also recorded an increasing trend during storage.

Potatoes of three varieties viz., Kufri Jyoti, Kufri Chipsona-1 and Kufri Chipsona-2 stored at 4, 8 and 12°C were reconditioned by raising the temperature by 0.5°C degree per day until it reached 20°C and the potatoes were kept for 15 and 21 days at 20°C. Reconditioning for 15 days was not very effective. But reconditioning for 21

Table 44. CIPC residues (mg/kg fresh weight) in potatoes (cv. Kufri Chipsona-1) stored under traditional storage systems at Jalandhar in comparison with those stored at 10-12°C

| Treatment                   | Dose        | Storage method | CIPC residue in Peels (April) | CIPC residue in Peels (July) |
|-----------------------------|-------------|----------------|-------------------------------|------------------------------|
| Oorja spray methanol        | 50 ml/tonne | Heap           | 9.34                          | 4.79                         |
| Oorja spray methanol        | 50 ml/tonne | Pit            | 7.42                          | 0.83                         |
| Oorja spray methanol        | 40 ml/tonne | Heap           | 6.76                          | 1.27                         |
| Oorja spray methanol        | 30 ml/tonne | Heap           | 4.25                          | 0.66                         |
| Oorja spray methanol        | 20 ml/tonne | Heap           | 2.70                          | 0.79                         |
| Oorja spray methanol        | 10 ml/tonne | Heap           | 2.38                          | 1.20                         |
| Oorja spray water           | 50 ml/tonne | Heap           | 6.63                          | 0.27                         |
| GS Basis spray water        | 80 ml/tonne | Heap           | 3.03                          | 1.74                         |
| GS Basis sprayed directly   | 80 ml/tonne | 10-12°C        | —                             | 3.34                         |
| GS Basis sprayed and stored | 80 ml/tonne | 10-12°C        | —                             | 3.72                         |



days resulted in reduction of reducing sugars leading to improved chip colour in Kufri Chipsona-1 and Kufri Chipsona-2.

**Percent ion leakage:** Percent ion leakage from tuber tissue has been found to be negatively correlated with the keeping quality of potatoes. After 180 DOS, maximum leakage was observed in tubers stored at 4°C in all the three varieties, maximum being in Kufri Chipsona-1. The minimum leakage was observed in tubers stored at 12°C in Kufri Jyoti.

**Rate of tuber respiration:** Rate of tuber respiration is known to be affected by the storage temperature and may be related with the respiratory losses in the tubers. The respiration rate generally increased with the storage duration and was the maximum after 180 DOS, irrespective of the variety or temperature. On average, the higher rate of tuber respiration was observed in Kufri Chipsona-2 compared to Kufri Chipsona-1 and Kufri Jyoti.

**CIPC residues:** The CIPC residues were analysed in peels of the tubers of four varieties stored at four temperatures. The residues increased after 2<sup>nd</sup> fogging in tubers stored at 4C, whereas, they were lower at temperatures of 8, 10 and 12C in comparison to after 1<sup>st</sup>

fogging (Table 46). All the residues, however, were well below the acceptable levels

Changes in anti-oxidant enzymes and antioxidant compounds in potatoes during storage at different temperatures

With a view to correlate activities of anti-oxidant enzymes and antioxidant compounds with keeping quality of potato varieties especially during high temperature storage, changes in the activities of enzymes such as catalase, peroxidase, ascorbate peroxidase and Glutathione reductase and levels of total phenols, L-ascorbic acid and total carotenes were studied in 5 cultivars stored at 4°C, 10-12°C and at high temperature in a heap store (15-31°C, RH 60-93%) up to 150 days. Catalase activity decreased up to 100 days and increased on 150 days (Table 47). Potatoes stored in the heap had lower catalase activity with K. Chipsona-1 showing maximum activity while it was lowest in K. Suttlej. Peroxidase activity increased up to the end of storage period and was maximum in K. Surya and minimum in K. Pukhraj. Ascorbate peroxidase activity increased during storage and was generally lower at higher temperature (Table 47). Glutathione reductase activity showed no specific pattern during storage and was

**Table 45. Processing quality of potatoes as influenced by skin curing in the soil and during pre-storage curing in a heap**

| Variety/hybrid | Freshly harvested potatoes at 100 days |                                              |                             | Harvested after 20 days of skin curing in the soil |                                 |                | After 10 days of pre-storage curing in the heap |                                 |                |
|----------------|----------------------------------------|----------------------------------------------|-----------------------------|----------------------------------------------------|---------------------------------|----------------|-------------------------------------------------|---------------------------------|----------------|
|                | Chip colour <sup>1</sup>               | Texture of chips <sup>2</sup> (No. of peaks) | Reducing sugar <sup>3</sup> | Chip colour                                        | Texture of chips (No. of peaks) | Reducing sugar | Chip colour                                     | Texture of chips (No. of peaks) | Reducing sugar |
| K. Chipsona-1  | 2.5                                    | 67                                           | 26.5                        | 3.5                                                | 29                              | 72.0           | 3.0                                             | 25                              | 107.0          |
| K. Chipsona-3  | 3.5                                    | 29                                           | 43.0                        | 3.5                                                | 35                              | 58.5           | 3.5                                             | 25                              | 73.0           |
| K. Surya       | 2.25                                   | 70                                           | 35.5                        | 3.5                                                | 41                              | 67.0           | 4.0                                             | 25                              | 46.5           |
| MP/98-71       | 5.25                                   | 45                                           | 182.0                       | 4.5                                                | 42                              | 102.5          | 4.0                                             | 22                              | 43.0           |
| Atlantic       | 1.25                                   | 57                                           | 20.0                        | 2.0                                                | 47                              | 29.5           | 2.5                                             | 39                              | 48.0           |
| Mean           | 2.95                                   | 53.6                                         | 61.4                        | 3.4                                                | 38.8                            | 65.9           | 3.4                                             | 27.2                            | 63.5           |

<sup>1</sup>On a 1-10 scale of increasing dark colour, chip colour score up to 3 was acceptable

<sup>2</sup>Higher number of peaks indicate more crispness of chips

<sup>3</sup>mg/100 g fresh tuber wt

normal. Sprouting index, sprout weight, number of sprouts/tuber and maximum sprout length in potatoes after 105 days of storage were at par with the control.

Naturally occurring volatile compounds for sprout inhibition

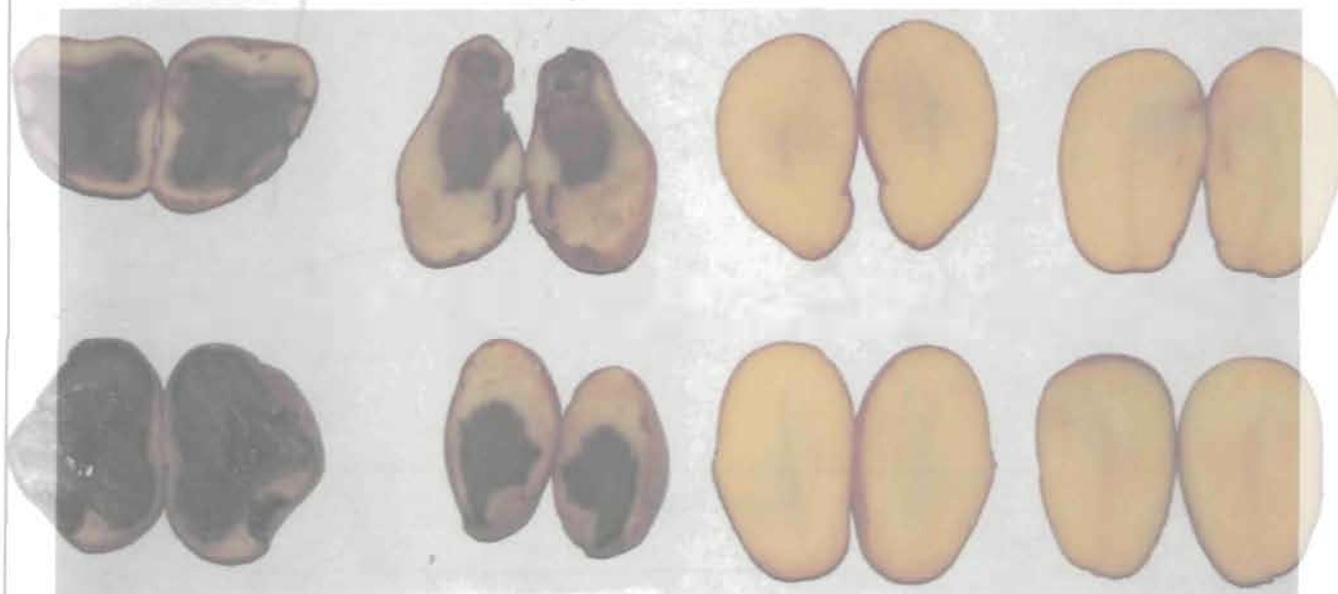
**Clove oil in combination with CIPC:** Filter papers soaked in clove oil placed among CIPC treated potatoes in gunny bags @ 1ml clove oil/kg of tubers resulted in minimum sprouting

(3%) up to 90 days of storage in heaps as compared to 20% sprouting observed in tubers treated with CIPC alone.

**Diphenylamine:** Atomize application of diphenylamine in concentrations ranging between 100-750 mg/kg tuber weight recorded significant sprout suppression at  $24\pm 2^{\circ}\text{C}$  up to 90 DOS without any increase in rottage of tubers. Sprout suppression effect increased linearly with the increase in concentration of diphenylamine up to 750 ppm.



# Physiological Response of Potato Plants to Heat and Water Stress



## Hybridization and Evaluation of clones for heat tolerance

Seedlings raised from 4 crosses made during 2007 were screened in the glasshouse. Seedlings were checked for tubers after 4 weeks (1<sup>st</sup> screening) and 8 weeks (2<sup>nd</sup> screening). 90 seedlings were selected during 1<sup>st</sup> screening and 187 during 2<sup>nd</sup> screening. After maturity the seedlings were harvested (total 277) and the tubers were sent to CPRIC Modipuram for multiplication and further screening

In the field selection at Modipuram 735 clones were evaluated at  $F_1C_1$  stage and 567 clones from 9 families were selected at  $F_1C_1$ ; 100 clones were evaluated at  $F_1C_2$  and 30 were selected; 101 clones were evaluated at  $F_1C_3$  and 45 promising clones were selected; 65 clones were evaluated at  $F_1C_4$  stage and 21 promising clones were selected. Nine clones at  $F_1C_5$  stage were evaluated in replicated field trial with Kufri Surya as control. At 75 DAP harvest none of the clones was better than the control Kufri Surya and none of them was selected for further evaluation.

## Studies on water stress

Nine selected varieties were exposed to water stress. Out of these Kufri Arun and Kufri

Jawahar were found to be most drought tolerant based on total tuber yield as well as reduction in tuber yield under water stress. Studies on antioxidants under stress revealed that Kufri Kuber had 4-6 times high ascorbic acid content compared to other varieties (Fig. 34). Forty two clones selected for water stress were exposed to mild water stress (75% irrigation). 10 clones did not show any reduction in yield upon exposure to water stress (Table 48). However, based on the yield performance 34 were selected for further evaluation.

## Optimization of fertilizer requirement for Kufri Surya

Fertilizer requirement for optimum tuber yield in



Table 48. Yield performance (kg/1.8m<sup>2</sup>) of selected potato hybrids (WS/2005) under well watered control and water stress condition at Modipuram during 2008-09

| S. No. | Hybrid No. | Control | Stress |
|--------|------------|---------|--------|
| 1      | 171        | 3.58    | 4.86   |
| 2      | 151        | 4.01    | 5.00   |
| 3      | 145        | 3.57    | 4.26   |
| 4      | 190        | 3.55    | 4.08   |
| 5      | 164        | 4.33    | 4.72   |
| 6      | 152        | 4.90    | 5.32   |
| 7      | 141        | 4.71    | 5.08   |
| 8      | 121        | 5.59    | 5.63   |
| 9      | 128        | 4.22    | 4.25   |
| 10     | 139        | 5.28    | 5.23   |
| 11     | 158        | 3.66    | 3.48   |

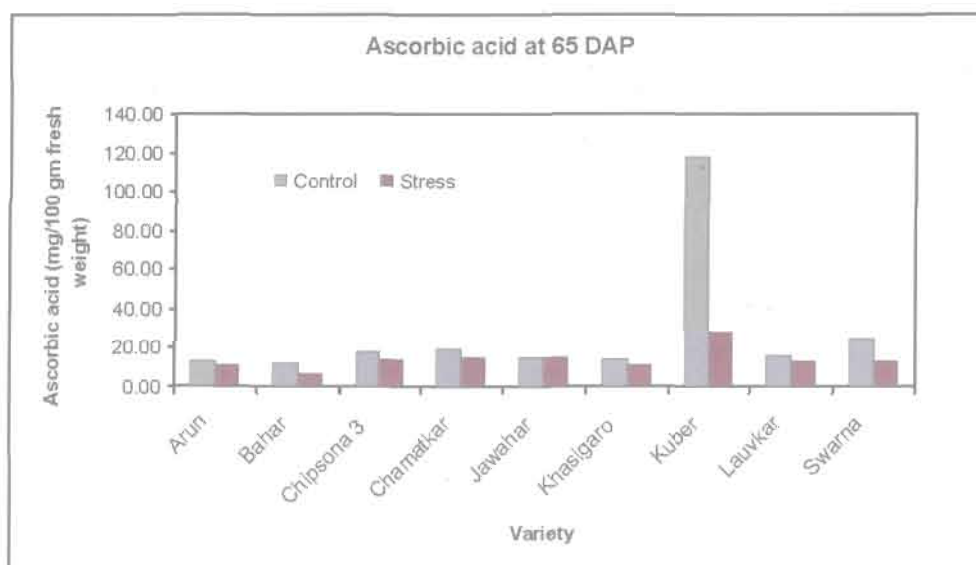


Fig. 34. Ascorbic acid content in leaves of well-watered (control) and water stressed plants on peak stress at 65 days after planting in selected potato cultivars

Kufri Surya during early crop at one location in Jalandhar was 178 kg N, 104 kg P<sub>2</sub>O<sub>5</sub> and 139 kg K<sub>2</sub>O. However at second location with high native fertility, the response of the variety was non significant for N, P and K. At Modipuram the fertilizer requirement for optimum yield was 300 kg N, 80 kg P and 100 kg K per ha.

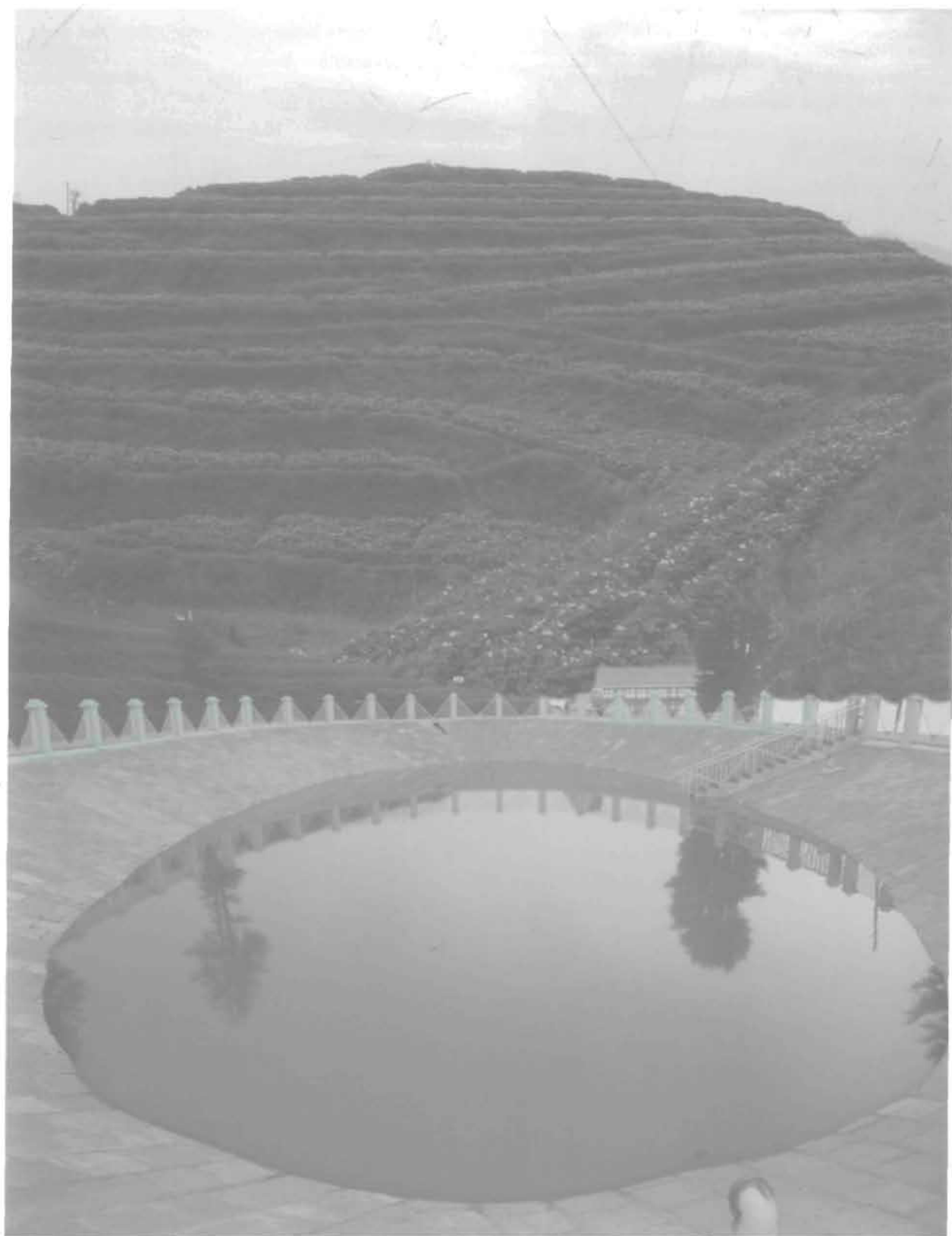
Optimization of crop geometry for early potato planting

Significant improvement in marketable and total tuber number was recorded with 45 × 20 cm geometry in comparison to 60 × 20 cm spacing (Table 49).

Table 49. Mean tuber no. (000 ha<sup>-1</sup>) and yield (q/ha<sup>-1</sup>) under different crop geometry

| Treatment                 | Mean tuber no. (000 ha <sup>-1</sup> ) |       |       | Mean tuber yield (qha <sup>-1</sup> ) |       |       | Net yield |
|---------------------------|----------------------------------------|-------|-------|---------------------------------------|-------|-------|-----------|
|                           | Marketable                             | Small | Total | Marketable                            | Small | Total |           |
| Main plot (Crop Geometry) |                                        |       |       |                                       |       |       |           |
| 45x20 cm                  | 417.7                                  | 102.8 | 520.6 | 217.7                                 | 10.9  | 228.6 | 173.3     |
| 60x20 cm                  | 343.4                                  | 69.4  | 412.8 | 169.1                                 | 7.7   | 176.8 | 135.2     |
| 75x20 cm (paired row)     | 436.2                                  | 117.0 | 553.2 | 204.5                                 | 12.3  | 216.8 | 150.3     |
| S Em ±                    | 23.17                                  | 5.98  | 24.99 | 8.06                                  | 0.79  | 8.18  | 8.18      |
| LSD (0.05%)               | 71.4                                   | 18.4  | 77.0  | 24.8                                  | 2.4   | 25.2  | 25.2      |
| Sub plot (Cultivar)       |                                        |       |       |                                       |       |       |           |
| K. Surya                  | 361.9                                  | 60.9  | 422.9 | 200.6                                 | 6.2   | 206.8 | 152.7     |
| K. Ashoka                 | 450.3                                  | 120.3 | 570.7 | 209.0                                 | 13.3  | 222.3 | 167.8     |
| K. Bahar                  | 384.9                                  | 108.1 | 493.0 | 181.7                                 | 11.4  | 193.1 | 138.6     |
| S Em ±                    | 23.17                                  | 5.98  | 24.99 | 8.06                                  | 0.79  | 8.18  | 8.18      |
| LSD (0.05%)               | 71.4                                   | 18.4  | 77.0  | NS                                    | 2.4   | 25.2  | 25.2      |









## *Division of Seed Technology*



# Seed Science and Production Technology



The conventional seed potato production programme involving tuber indexing and multiplication of breeder seed through different stages was continued. However, to improve the virus freedom in the stocks augmentation of micropropagation was strengthened by producing large number of *in vitro* plants, microtubers and minitubers at Shimla and CPRIC, Modipuram. Since, the mini tubers < 3 g have high mortality rate in field, a recycling technique of their multiplication was introduced under protected conditions at CPRIC, Modipuram, CPRS, Jalandhar, Gwalior and Patna to make judicious use of precious seed material. Further virus free buffer stocks of new varieties were developed for *in vitro* mass multiplication for a complete switch over of breeder seed production through *in vitro* micro propagation. The progress report on these activities is as under. In this report two seasons' (2007-08 and 2008-09) reports are being given to make the information up-to-date.

## 1. Conventional Seed Production Technology (2007-08)

### i) Tuber indexing, testing and inspection

Indexing of 32216 tubers of 25 varieties was done at Modipuram (10836), Jalandhar (3700), Gwalior (8992), Patna (1816), Kufri (4352) and Shimla (2520) through ELISA in glass/net houses and also through sprout ELISA at Gwalior. The field inspection of crop was undertaken at all the stations. The percentage of healthy tubers in tuber indexing of clones at Modipuram, Jalandhar, Gwalior, Patna, Kufri and

Shimla (buffer stocks) was 97, 98, 96, 97, 97 and 100% respectively.

### iii) Breeder seed production

**Stage-I (clonal multiplication):** The clonal multiplication was under taken in 3.486 ha in plains and 0.50 ha in hills and a production of 376.30 and 68.79 q respectively was obtained. Health standard in field at Modipuram, Jalandhar, Gwalior, Patna and Kufri was 84, 99, 96, 87 and 79% respectively. The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 154.23, 133.07, 52.31, 88.94 and 137.58q/ha respectively.



**b) Stage-II (clonal increase):** The production programme was taken in 8.978 ha and a total production of 1310.66 q was achieved at all stations in the plains. In hills only 1.02 ha area was planted and a production of 151.65q was obtained. The average production at Modipuram, Jalandhar, Gwalior, Patna and Kufri was 174.08, 173.77, 78.72, 221.66 and 148.68 q/ha respectively.

**c) Stage-III (bulk increase):** In this stage 21.85 ha was planted at all the four stations in the plains and a total production of 4644.77q was achieved, whereas, in the hills the production obtained was 329q in 1.95 ha. The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 245.95, 228.55, 140.29, 206.02, and 168.72q/ha respectively.

**d) Stage-IV (breeder seed):** At all stations in the plains 98.41 ha was planted and 19412.30q (2415.38q in 12.25ha) production was achieved whereas, in the hills the production was 642.50q in 4.45 ha. (including 50q in 0.70ha under MM-I at Kufri) The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 232.24, 243.82, 112.32, 184.16 and 144.38q/ha respectively.

### iii) Production and supply of breeders seed

A total production of 26930.37q of 25 varieties was achieved in 140.564ha in hills (1186.94q in 7.84ha) and in plains (25743.43q in 132.724ha) Table 50. Out of which a total of 21480.92q of 17 varieties was supplied from plains and 886.62q of 4 varieties from hills (Table 51). About 4562.83q was kept for own planting in the plains and hills.

iv) Quality seed production- 570.21q quality seed was produced at Ooty out of which 345.40q was supplied and remaining quantity was used for sowing in autumn and spring crops.

## 2. Conventional Seed Production Technology (2008-09)

### i) Tuber indexing before planting

Indexing of tubers was done at different stations and 32788 healthy indexed tubers of 22 varieties and two hybrids were planted in stage-I at Modipuram (12916), Jalandhar (3000), Gwalior

(12236), Patna (1001), Kufri (3635). In addition to it 1440 tubers were also indexed at Shimla for Manipur Govt. out of which 1260 samples were found healthy. Healthy tuber percentage in tuber indexing at Jalandhar, Gwalior, Patna and Kufri was 95, 98, 97 and 88 respectively.

### ii) Breeder seed production

**a) Stage-I (clonal multiplication):** The clonal multiplication was under taken in 3.431 ha in plains and 0.37 ha in hills and a production of 313.74 and 44.17q respectively was obtained. The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 132.84, 79.47, 57.45, 116 and 119.38/ha and health percentage 91, 90, 98, 97 and 98, respectively.

**b) Stage-II (Clonal increase):** The production programme was taken in 10.004 ha and a total production of 1605.49 q was achieved at all stations in the plains. In hills only 1.10 ha area was planted and a production of 155.50q was obtained. The average production at Modipuram, Jalandhar, Gwalior, Patna and Kufri was 196.25, 167.63, 71.43, 256.14 and 141.36q/ha respectively.

**c) Stage-III (bulk increase):** In this stage 19.85 ha was planted at all the four stations in the plains and a total production of 3949.01q was achieved, whereas, in the hills the production obtained was 269.39q in 1.95 ha. The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 230.04, 246.76, 108.25, 184.95 and 138.15q/ha respectively.

**d) Stage-IV (breeder seed):** At all stations in the plains 92.08 ha was planted and 20173.27q production was achieved whereas, in the hills the production was 377.10q in 4.70 ha. The average production at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 257.69, 272.15, 127.23, 174.49 and 80.23q/ha respectively.

### iii) Production of breeder seed:

A total production of 26502.67q of 24 varieties and two hybrids was achieved in 133.585 ha in plains and hills. In plains 25656.51q (including NSP) in 125.465ha and in hills 846.16q in 8.12ha (Table 52).

### iv) Production of quality seed:

At CPRS Shillong a total of 386.72q quality seed was produced in 3.99 ha under conventional system.

## II. Hi-Tech Seed production Technology (2008-09)

### i) Production and supply of microtubers, microplants and buffer stocks:

A total of 12930 *in vitro* test tube plantlets of 17 varieties and 33425 micro/ mini/ buffer stock tubers of 18 varieties produced at CPRI, Shimla were supplied to different stations of CPRI on the basis of their need and 3034 test tube plantlets of 15 varieties were used for planting at CPRI, Shimla. In addition to this 31002 test tube plantlets and 8732 microtubers of 6 varieties were also produced at tissue culture laboratory CPRI, Modipuram.

### ii) Maintenance and multiplication of virus free buffer stocks

Disease free buffer stock tubers of twenty three varieties viz. Kufri Anand, Kufri Arun, Kufri Ashoka, Kufri Badshah, Kufri Bahar, Kufri Chandramukhi, Kufri Chipsona 1, Kufri Chipsona 2, Kufri Chipsona 3, Kufri Giriraj, Kufri Girdhari, Kufri Himalini, Kufri Himsona, Kufri Jyoti, Kufri Jawahar, Kufri Kanchan, Kufri Lalima, Kufri Lauvkar, Kufri Pukhraj, Kufri Shailja, Kufri Sindhuri, Kufri Surya and Kufri Sutlej were planted under controlled conditions in the poly house in pots as well as in beds. During its growth period samples were collected on single plant basis and tested for viruses PVX, PVS, PVY, PVM, PVA, PLRV and PALCV by ELISA. The diseased plants were removed and the healthy ones were retained for basic seed multiplication. Total of 1078 samples were tested in twenty three varieties all the samples except six samples of Kufri Surya were found free from all the viruses tested and a total of 3044 tubers were produced.

### iii) Supply of microplants to private seed producing organizations

A total of 319 disease free microplants of different varieties multiplied were supplied to 15 different private seed producing organizations and a revenue of Rs 477500/- was generated.

### iv) Breeder Seed production through tissue culturally developed material

**a) Generation-0:** A total of 858173 tubers were produced from microplants (2,85,557 from 48,277), microtubers (30,355 from 10,162) recycled <3g (4,91,755 from 80,821) and minitubers (50506 from 9221) after planting in the net house at Modipuram, Jalandhar, Patna Kufri and Shimla.

In addition to it a production of 249.11 and 571.09 kgs. was achieved from 3356 minitubers and 9007 <3gm tubers respectively at Gwalior.

**b) Generation.1:** A total production of 1127.93q was achieved in generation-1 in an area of 5.371ha from the produce of net house generation-0 in the field at Modipuram, Jalandhar, Gwalior and Kufri.

**c) Generation 2:** A total production of 3586.06q was achieved in generation-2 in an area of 15.24ha from the produce of generation-1 in the field at Modipuram, Jalandhar, Gwalior and Kufri.

### v) Quality Seed production through tissue culturally developed material

178.47q quality seed was produced at Shillong from 2.16ha. In addition to it, 10412 tubers were produced from 2765 minitubers in Generation-0 at Ooty.

### iii) Supply of breeder & quality seed

A total of 22848.91q of 20 varieties was supplied from plains before cold store and 564.49q of 5 varieties from hills.

A total of 1198.47q quality seed (1003.3 from NSP and 195.17q) was supplied from Ooty and Shillong, respectively.

## IV. Seed Research (2008-09)

### 1. Studies on improvement of *in vitro* performance of Kufri Jyoti

In India the major variety under cultivation is Kufri Jyoti but it is not performing well under *in vitro* as well as *in vivo* conditions as compared to other varieties. So the efforts have been made to improve the *in vitro* performance of the



cultivar Kufri Jyoti. Among the explants sprouts performed better than nodal cutting without any bacterial contamination, but the nodal cuttings taken from poly house was having more bacterial contamination and the growth was slower than sprouts. For eliminating bacteria from the *in vitro* cultures antibiotics Carbenicillin disodium salt was effective in controlling the bacteria and enhancing the *in vitro* growth of microplants. For eliminating the fungal contamination from *in vitro* cultures, two different fungicides viz. Bavistin and Amphotericin-B were incorporated into the culture media after filter sterilization. Bavistin at 0.1% concentration suspended the fungal infection/ contamination in *in vitro* cultures upto 21 days whereas; higher concentration i.e. 0.2% retards the *in vitro* growth of microplants. Washing of fungal contaminated microplants' nodal cutting with Bavistin solution under sterile conditions eliminated the fungus in subsequent cultures. Among the two different carbon sources and two different gelling agents Kufri Jyoti is performing better in sucrose with phytigel.

## 2. Effect of CCC on potato seed production and prolonging the shelf life of potato seed under normal storage

In the varieties Kufri Giriraj, Kufri Swarna and Kufri Jyoti soaking of tubers in 100 ppm CCC reduces the weight loss during storage to the tune of 4 - 4.5 % than control. In addition to this, CCC treatment increases the number of

seed size tubers (25-75 gm). But soaking before storage and spraying with CCC in the field affected the plant growth more severely and resulted in reduction of tuber number and yield.

## 3. Studies on organic and inorganic seed potato production

The organic farming reduced the yield of Kufri Swarna and Kufri Jyoti by about 40%, whereas in case of Kufri Giriraj it was 46%. The percentage reduction of no. of seed sized tubers under organic farming was 22, 55 and 2% in Kufri Swarna, Kufri Jyoti and Kufri Giriraj respectively as compared to inorganic approach.

## 4. Effect of degeneration of potato varieties in the Nilgiri hills

The trial was conducted with three varieties viz. Kufri Giriraj, Kufri Jyoti and Kufri Swarna and two advance hybrids OS/93-D-204 and OS/94-L-956 with two types of seed material i.e. four year old and fresh breeder seed with two different types of nematicide i.e. phorate and furadan applied separately and in combinations. The plots planted with breeder seed produced higher yield as well as total number of tubers in all the grades when compared to four year old seed material. In case of hybrids OS/93-D-204 and OS/94-L-956 application of furadan increased the yield and the number of different grades of tubers.





Table 50. Station, variety and stagewise area (ha) planted and production (q) obtained during 2007-08

| Station/variety  | Stage-I |        | Stage-II |        | Stage-III |         | Stage-IV |         | Total |          |
|------------------|---------|--------|----------|--------|-----------|---------|----------|---------|-------|----------|
|                  | Area    | Prod.  | Area     | Prod.  | Area      | Prod.   | Area     | Prod.   | Area  | Prod.    |
| <b>A.Plains</b>  |         |        |          |        |           |         |          |         |       |          |
| <b>Modipuram</b> |         |        |          |        |           |         |          |         |       |          |
| Kufri Anand      | 0.10    | 16.15  | 0.44     | 82.40  | 0.50      | 111.75  | 2.77     | 893.90  | 3.81  | 1104.20  |
| Kufri Arun       | -       | -      | -        | -      | -         | -       | 0.70     | 35.14   | 0.70  | 35.14    |
| Kufri Badshah    | 0.10    | 17.05  | 0.37     | 67.90  | 0.50      | 83.55   | 0.65     | 174.04  | 1.62  | 342.54   |
| Kufri Bahar      | 0.60    | 98.20  | 1.63     | 285.50 | 5.00      | 1246.50 | 21.50    | 5159.94 | 28.73 | 6790.14  |
| Kufri Chip.-1    | 0.15    | 19.40  | 0.67     | 111.85 | 1.50      | 324.75  | 6.00     | 1446.20 | 8.32  | 1902.20  |
| Kufri Chip.-2    | 0.01    | 0.85   | 0.11     | 6.40   | 0.20      | 56.25   | 0.38     | 77.00   | 0.70  | 140.50   |
| Kufri Chip.-3    | 0.10    | 13.85  | 0.13     | 23.70  | 0.24      | 68.25   | -        | -       | 0.47  | 105.80   |
| Kufri Giriraj    | -       | -      | -        | -      | -         | -       | 0.35     | 69.00   | 0.35  | 69.00    |
| Kufri Himsona    | 0.02    | 1.90   | 0.05     | 4.00   | -         | -       | -        | -       | 0.07  | 5.90     |
| Kufri Pukhraj    | 0.06    | 11.50  | 0.21     | 44.70  | 0.40      | 164.50  | 2.35     | 358.40  | 3.02  | 579.10   |
| Kufri Sadabahar  | 0.02    | 2.45   | -        | -      | -         | -       | -        | -       | 0.02  | 2.45     |
| Kufri Surya      | 0.10    | 11.95  | 0.21     | 35.60  | 0.50      | 108.75  | 1.85     | 394.15  | 2.66  | 550.45   |
| Kufri Sutlej     | 0.10    | 17.00  | 0.38     | 69.10  | 0.60      | 157.50  | 3.20     | 623.64  | 4.28  | 867.24   |
| MP/98-71         | 0.01    | 1.00   | -        | -      | -         | -       | -        | -       | 0.01  | 1.00     |
| Total            | 1.37    | 211.30 | 4.20     | 731.15 | 9.44      | 2321.80 | 39.75    | 9231.41 | 54.76 | 12495.66 |
| <b>Jalandhar</b> |         |        |          |        |           |         |          |         |       |          |
| KCM              | 0.02    | 1.39   | 0.16     | 13.32  | 0.30      | 86.16   | 3.00     | 672.17  | 3.48  | 773.04   |
| Kufri Jyoti      | 0.40    | 52.62  | 0.56     | 103.97 | 3.00      | 608.50  | 11.50    | 2432.96 | 15.46 | 3198.05  |
| Kufri Badshah    | 0.07    | 8.76   | 0.18     | 31.10  | 0.70      | 175.36  | 3.00     | 854.82  | 3.95  | 1070.04  |
| Kufri Sutlej     | 0.02    | 2.03   | 0.03     | 5.28   | 0.10      | 24.00   | 0.40     | 97.90   | 0.55  | 129.21   |
| Kufri Pukhraj    | 0.06    | 11.05  | 0.13     | 30.53  | 0.70      | 203.00  | 2.50     | 755.27  | 3.39  | 999.85   |
| Kufri Pushkar    | -       | -      | -        | -      | -         | -       | 2.00     | 648.50  | 2.00  | 648.50   |
| Total            | 0.57    | 75.85  | 1.06     | 184.20 | 4.80      | 1097.02 | 22.40    | 5461.62 | 28.83 | 6818.69  |
| <b>Gwalior</b>   |         |        |          |        |           |         |          |         |       |          |
| KCM              | 0.18    | 9.46   | 0.50     | 40.40  | 0.73      | 81.50   | 5.46     | 494.91  | 6.87  | 626.27   |
| Kufri Jyoti      | 0.34    | 13.84  | 0.59     | 40.75  | 1.23      | 159.00  | 3.43     | 352.35  | 5.59  | 565.94   |
| Kufri Sindhuri   | 0.12    | 5.35   | 0.35     | 42.00  | 0.86      | 146.30  | 6.41     | 946.91  | 7.74  | 1140.56  |
| Kufri Lauvkar    | 0.29    | 14.79  | 0.57     | 31.40  | 1.27      | 193.00  | 5.45     | 566.68  | 7.58  | 805.87   |
| Kufri Chip.-1    | 0.17    | 10.54  | 0.30     | 18.41  | 0.14      | 18.50   | 4.46     | 486.56  | 5.07  | 534.01   |
| Kufri Chip.-2    | 0.13    | 7.61   | 0.59     | 53.10  | 0.76      | 97.50   | 1.71     | 171.31  | 3.19  | 329.52   |
| Kufri Arun       | 0.09    | 7.46   | 0.10     | 10.10  | 0.22      | 35.10   | -        | -       | 0.41  | 52.66    |
| Kufri Kanchan    | -       | -      | -        | -      | -         | -       | 0.12     | 12.20   | 0.12  | 12.20    |
| Kufri Pukhraj    | -       | -      | -        | -      | -         | -       | 0.22     | 30.90   | 0.22  | 30.90    |
| Total            | 1.32    | 69.05  | 3.00     | 236.16 | 5.21      | 730.90  | 27.26    | 3061.82 | 36.79 | 4097.93  |

**Patna**

|               |       |        |       |         |       |         |       |          |         |          |
|---------------|-------|--------|-------|---------|-------|---------|-------|----------|---------|----------|
| Kufri Arun    | 0.057 | 4.20   | 0.050 | 12.70   | 0.30  | 50.80   | -     | -        | 0.407   | 67.70    |
| Kufri Ashoka  | 0.024 | 3.40   | 0.075 | 21.60   | 0.40  | 91.95   | 1.07  | 187.00   | 1.569   | 303.95   |
| Kufri Pukhraj | 0.048 | 5.45   | 0.311 | 68.55   | 0.50  | 155.90  | 3.08  | 640.90   | 3.939   | 870.80   |
| Kufri Jyoti   | 0.048 | 3.45   | 0.153 | 30.20   | 0.60  | 109.15  | 2.25  | 287.15   | 3.051   | 429.95   |
| Kufri Kanchan | 0.049 | 3.60   | 0.120 | 23.80   | 0.60  | 86.65   | 2.60  | 542.40   | 3.369   | 656.45   |
| Kufri Lalima  | -     | -      | 0.009 | 2.30    | -     | -       | -     | -        | 0.009   | 2.30     |
| Total         | 0.226 | 20.10  | 0.718 | 159.15  | 2.40  | 494.45  | 9.00  | 1657.45  | 12.344  | 2331.15  |
| Total A:      | 3.486 | 376.30 | 8.978 | 1310.66 | 21.85 | 4644.17 | 98.41 | 19412.30 | 132.724 | 25743.43 |

**B. Hills****Kufri/Fagu**

|                |       |        |      |         |       |         |        |          |        |          |
|----------------|-------|--------|------|---------|-------|---------|--------|----------|--------|----------|
| Kufri Jyoti    | 0.35  | 53.00  | 0.80 | 119.90  | 1.64  | 273.50  | 3.60   | 560.00   | 6.39   | 1006.40  |
| Kufri Giriraj  | 0.05  | 5.10   | 0.12 | 18.10   | 0.25  | 40.50   | 0.60   | 63.50    | 1.02   | 127.20   |
| Kufri Kanchan  | 0.02  | 2.30   | 0.03 | 3.25    | 0.03  | 7.00    | 0.10   | 7.70     | 0.18   | 20.25    |
| Kufri Himalini | 0.01  | 2.30   | 0.02 | 3.55    | -     | -       | -      | -        | 0.03   | 5.85     |
| Kufri Shailja  | 0.01  | 1.85   | 0.05 | 6.85    | 0.03  | 8.00    | 0.10   | 8.30     | 0.19   | 25.00    |
| Kufri Girdhari | 0.015 | 1.40   | -    | -       | -     | -       | -      | -        | 0.015  | 1.40     |
| Kufri Himsona  | 0.015 | 0.84   | -    | -       | -     | -       | -      | -        | 0.015  | 0.84     |
| Total B:       | 0.47  | 66.79  | 1.02 | 151.65  | 1.95  | 329.00  | 4.40   | 639.50   | 7.84   | 1186.94  |
| Total A+B      | 3.956 | 443.09 | 1.74 | 1462.31 | 23.80 | 4973.17 | 102.81 | 20051.80 | 140.56 | 26930.37 |

**CPRI**





**Table 52. Station, variety and stage wise area (ha) planted and production (q) obtained during 2008-09**

| Station/variety  | Stage-I      |               | Stage-II    |                | Stage-III   |                | Stage-IV     |                 | Total         |                 |
|------------------|--------------|---------------|-------------|----------------|-------------|----------------|--------------|-----------------|---------------|-----------------|
|                  | Area         | Prod.         | Area        | Prod.          | Area        | Prod.          | Area         | Prod.           | Area          | Prod.           |
| <b>A.Plains</b>  |              |               |             |                |             |                |              |                 |               |                 |
| <b>Modipuram</b> |              |               |             |                |             |                |              |                 |               |                 |
| Kufri Anand      | 0.10         | 11.20         | 0.45        | 87.75          | 0.60        | 122.20         | 4.00         | 1213.57         | 5.15          | 1434.72         |
| Kufri Badshah    | 0.05         | 8.30          | 0.44        | 86.00          | 0.40        | 93.50          | 1.00         | 266.94          | 1.89          | 454.74          |
| *Kufri Bahar     | 0.53         | 63.85         | 2.52        | 512.95         | 5.00        | 1148.50        | *23.85       | *6206.10        | 31.90         | 7931.40         |
| Kufri Chip.-1    | 0.08         | 11.35         | 0.71        | 131.25         | 0.70        | 143.70         | 2.25         | 646.48          | 3.74          | 932.78          |
| Kufri Chip.-2    | -            | -             | -           | -              | -           | -              | 0.25         | 60.40           | 0.25          | 60.40           |
| Kufri Chip.-3    | 0.10         | 15.00         | 0.37        | 67.05          | 0.45        | 116.30         | 1.00         | 285.35          | 1.92          | 483.70          |
| Kufri Himsona    | 0.02         | 2.05          | 0.07        | 12.95          | 0.08        | 21.50          | -            | -               | 0.17          | 36.50           |
| Kufri Pukhraj    | 0.10         | 16.45         | 0.24        | 43.90          | 0.90        | 243.10         | 3.00         | 582.75          | 4.24          | 886.20          |
| Kufri Sadabahar  | 0.05         | 9.35          | 0.04        | 8.05           | -           | -              | -            | -               | 0.09          | 17.40           |
| Kufri Surya      | 0.20         | 25.45         | 0.20        | 38.00          | 0.70        | 169.00         | 1.95         | 563.05          | 3.05          | 795.50          |
| Kufri Sutlej     | 0.05         | 8.50          | 0.40        | 80.80          | -           | -              | 1.75         | 238.00          | 2.20          | 327.30          |
| MP/98-71         | 0.02         | 2.65          | 0.03        | 4.80           | -           | -              | -            | -               | 0.05          | 7.45            |
| MP/01-916        | 0.02         | 1.20          | -           | -              | -           | -              | -            | -               | 0.02          | 1.20            |
| <b>Total</b>     | <b>1.32</b>  | <b>175.35</b> | <b>5.47</b> | <b>1073.50</b> | <b>8.83</b> | <b>2057.80</b> | <b>39.05</b> | <b>10062.64</b> | <b>54.67</b>  | <b>13369.29</b> |
| <b>Jalandhar</b> |              |               |             |                |             |                |              |                 |               |                 |
| KCM              | 0.012        | 1.11          | 0.04        | 6.35           | 0.20        | 59.10          | 1.40         | 407.85          | 1.652         | 474.41          |
| *Kufri Jyoti     | 0.454        | 33.80         | 0.71        | 116.00         | 2.50        | 612.50         | *11.70       | *2864.14        | 15.364        | 3626.44         |
| Kufri Badshah    | 0.016        | 2.31          | 0.04        | 7.47           | 0.50        | 104.70         | 1.10         | 237.51          | 1.656         | 351.99          |
| Kufri Pukhraj    | 0.016        | 2.09          | 0.04        | 8.65           | 0.50        | 135.50         | 1.10         | 369.62          | 1.656         | 515.86          |
| Kufri Pushkar    | -            | -             | -           | -              | -           | -              | 2.00         | 832.60          | 2.00          | 832.60          |
| Kufri Sutlej     | 0.013        | 1.30          | 0.02        | 4.02           | 0.10        | 25.90          | 0.40         | 105.35          | 0.533         | 136.57          |
| <b>Total</b>     | <b>0.511</b> | <b>40.61</b>  | <b>0.85</b> | <b>142.49</b>  | <b>3.80</b> | <b>937.70</b>  | <b>17.70</b> | <b>4817.07</b>  | <b>22.861</b> | <b>5937.87</b>  |
| <b>Gwalior</b>   |              |               |             |                |             |                |              |                 |               |                 |
| KCM              | 0.21         | 12.35         | 0.40        | 25.50          | 0.86        | 94.00          | 2.65         | 385.03          | 4.12          | 516.88          |
| Kufri Jyoti      | 0.41         | 22.26         | 0.62        | 40.50          | 1.01        | 105.60         | 5.32         | 580.23          | 7.36          | 748.59          |
| Kufri Sindhuri*  | 0.12         | 8.26          | 0.36        | 38.00          | 1.00        | 109.00         | 9.20         | 1122.74         | 10.68         | 1278.00         |
| Kufri Lauvkar*   | 0.36         | 19.59         | 0.55        | 23.50          | 0.60        | 52.75          | 3.35         | 616.51          | 4.86          | 712.35          |
| Kufri Chip.-1    | 0.18         | 9.76          | 0.45        | 37.50          | 0.51        | 72.00          | 3.51         | 418.26          | 4.65          | 537.52          |
| Kufri Chip.-2*   | 0.13         | 7.05          | 0.38        | 26.50          | 0.84        | 96.00          | 1.55         | 150.41          | 2.90          | 279.96          |
| Kufri Chipsona-3 | -            | -             | -           | -              | 0.15        | 11.54          | -            | -               | 0.15          | 11.54           |
| Kufri Arun       | 0.09         | 6.91          | 0.24        | 22.80          | 0.13        | 14.00          | 0.33         | 36.86           | 0.79          | 80.57           |
| Kufri Kanchan    | -            | -             | -           | -              | -           | -              | 0.31         | 19.78           | 0.31          | 19.78           |
| Kufri Pukhraj    | -            | -             | -           | -              | -           | -              | 0.36         | 51.97           | 0.36          | 51.97           |
| Kufri Surya      | -            | -             | -           | -              | 0.12        | 10.22          | -            | -               | 0.12          | 10.22           |
| <b>Total</b>     | <b>1.50</b>  | <b>86.18</b>  | <b>3.00</b> | <b>214.30</b>  | <b>5.22</b> | <b>565.11</b>  | <b>26.58</b> | <b>3381.79</b>  | <b>36.30</b>  | <b>4247.38</b>  |

**Patna**

|                  |              |               |               |                |              |                |              |                 |                |                 |
|------------------|--------------|---------------|---------------|----------------|--------------|----------------|--------------|-----------------|----------------|-----------------|
| Kufri Arun       | 0.033        | 3.60          | 0.080         | 16.50          | 0.20         | 38.00          | 0.85         | 62.55           | 1.163          | 120.65          |
| Kufri Ashoka     | -            | -             | 0.100         | 23.00          | 0.40         | 87.06          | 1.05         | 170.67          | 1.550          | 280.73          |
| Kufri Pukhraj    | 0.034        | 5.20          | 0.210         | 57.50          | 0.60         | 114.74         | 2.75         | 550.40          | 3.594          | 727.84          |
| Kufri Jyoti*     | 0.033        | 2.80          | 0.100         | 17.00          | 0.50         | 88.00          | *2.00        | *413.00         | 2.633          | 520.80          |
| Kufri Kanchan    | -            | -             | 0.170         | 28.00          | 0.40         | 60.60          | 2.10         | 330.15          | 2.670          | 418.75          |
| Kufri Lalima     | -            | -             | 0.007         | 13.00          | -            | -              | -            | -               | 0.007          | 13.00           |
| Kufri Chipsona-1 | -            | -             | 0.005         | 1.90           | -            | -              | -            | -               | 0.005          | 1.90            |
| Kufri Chipsona-2 | -            | -             | 0.008         | 10.30          | -            | -              | -            | -               | 0.008          | 10.30           |
| Kufri Surya      | -            | -             | 0.004         | 8.00           | -            | -              | -            | -               | 0.004          | 8.00            |
| <b>Total</b>     | <b>0.10</b>  | <b>11.60</b>  | <b>0.684</b>  | <b>175.20</b>  | <b>2.10</b>  | <b>388.40</b>  | <b>8.75</b>  | <b>1526.77</b>  | <b>11.634</b>  | <b>2101.97</b>  |
| <b>Total A:</b>  | <b>3.431</b> | <b>313.74</b> | <b>10.004</b> | <b>1605.49</b> | <b>19.95</b> | <b>3949.01</b> | <b>92.08</b> | <b>19788.27</b> | <b>125.465</b> | <b>25656.51</b> |

**B. Hills****Kufri/Fagu**

|                 |             |              |             |               |             |               |             |               |             |               |
|-----------------|-------------|--------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|
| Kufri Jyoti     | 0.25        | 27.00        | 0.90        | 110.70        | 1.35        | 177.70        | 3.90        | 350.00        | 6.40        | 665.40        |
| Kufri Giriraj   | 0.03        | 4.25         | 0.10        | 11.90         | 0.24        | 31.00         | **0.55      | **22.00       | 0.92        | 69.15         |
| Kufri Kanchan   | 0.02        | 0.98         | 0.03        | 4.75          | 0.12        | 15.65         | 0.15        | 2.40          | 0.32        | 23.78         |
| Kufri Himalini  | 0.02        | 4.96         | 0.01        | 6.10          | 0.06        | 15.97         | -           | -             | 0.09        | 27.03         |
| Kufri Shailja   | 0.01        | 1.48         | 0.03        | 10.65         | 0.18        | 29.07         | **0.10      | **2.70        | 0.32        | 43.90         |
| Kufri Giridhari | 0.02        | 3.45         | 0.02        | 6.00          | -           | -             | -           | -             | 0.04        | 9.45          |
| Kufri Himsona   | 0.02        | 2.05         | 0.01        | 5.40          | -           | -             | -           | -             | 0.03        | 7.45          |
| <b>Total:</b>   | <b>0.37</b> | <b>44.17</b> | <b>1.10</b> | <b>155.50</b> | <b>1.95</b> | <b>269.39</b> | <b>4.70</b> | <b>377.10</b> | <b>8.12</b> | <b>846.16</b> |

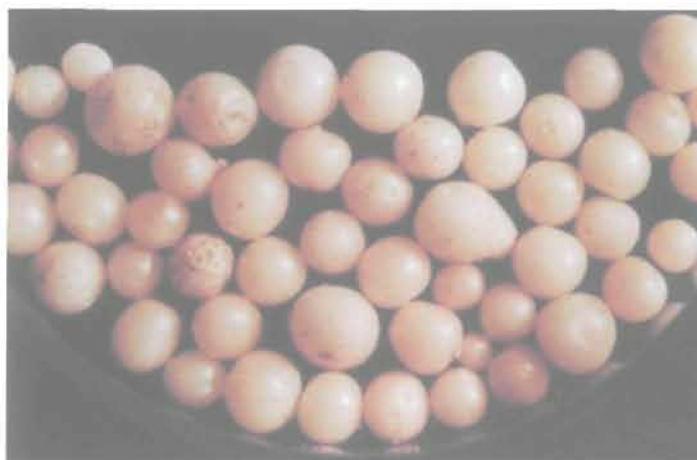
\* = Area under NSP at Jalandhar is 2ha and production is 489.53q of Kufri Jyoti.

Area under NSP at Gwalior is 4.40ha (3.10, 0.65 & 0.65) and Production is 629.85q (513.80, 63.55 and 52.50) of Kufri Sindhuri, Kufri Lauvkar and Kufri Chipsona-2 respectively.

Area under NSP at Modipuram is 3.85ha and production is 883q of Kufri Bahar.

Area under NSP at Patna is 2ha and production is 413q of Kufri Jyoti.

\*\*= Area under mini mission at Kufri is 0.65 ha (0.55 and 0.10) and production is 24.70q (22.00 and 2.70) of Kufri Giriraj and Kufri Shailja respectively.





CPRI





# *Division of Social Sciences*



# Impact of Potato Production Technologies Developed by the Institute



## Economic impact of potato production technologies in India

A survey was conducted to assess the area and productivity of different potato varieties on 126 farmers field in 3 districts of Gujrat i.e. Banaskantha, Anand and Khera. Kufri Badshah was the leading potato variety covering 48% of potato area followed by Kufri Lauvkar and Kufri Pukhraj covering 23% and 18% potato area, respectively. Average potato yield in the state was 337 q/ha. Kufri Pukhraj was the most productive potato variety in the state with an average yield of 364 q/ha followed by Kufri Badshah (322 q/ ha) and Kufri Lauvkar (284 q/ha).

A weighted index of farmers' responses on Kufri Badshah and Kufri Pukhraj was designed to evaluate the quality attributes of there potato varieties. Yield was assigned the highest weight of 3 followed by price received for the produce (2); keeping quality in cold store and disease resistance (1.5 each); keeping quality outside cold store and fitment in cropping system (1 each). The percent weighted score for Kufri Badshah and Kufri K. Pukhraj was 88 and 71, respectively. This explained the farmers' preferrance for Kufri Badshah in Gujarat.

The mean seed replacement rate in the state was very high (50%) due to warm climatic conditions. This rate ranged between 58% for K. Pukhraj and 46% for K. Badshah. Out of the overall 50% seed replacement in the state 37% was contributed by Punjab and Western UP seed while the remaining 13% was contributed by the local progressive farmers. The annual seed potato demand for the state was estimated to be 1.37 lac tonnes. Nearly 0.51 lac tonnes of seed potato in the state is required from Punjab and Western UP every year.

Price and supply elasticities of potato were calculated. Price elasticity of potato was estimated to be 0.32, indicating lower response of the commodity demand to change in its price. Cross elasticity of potato was relatively high at 0.57, while its income elasticity was negative (-0.21). Supply elasticity of potato was also calculated and was found very high at 0.84.



## Quick survey on potato outlook

A survey was conducted in the states of Gujarat, MP and Chhattisgarh. Influenced by prevailing high temperature and severe late blight infection during the year, the potato yields were estimated to be lower by 35%, 30% and 25% in the states of Gujarat, Chhattisgarh & MP, respectively. Kufri Sindhuri was pre-dominant and occupying about 40% area in the Surguja district of Chattisgarh followed by Kufri Jyoti (10%). The Devas district in M.P. recorded drastic 2.5 times reduction in area during 2008-09. This might be due to shortage of irrigation water in this district.

## Efficiency analysis of potato cultivation under different production systems

Farmers' field survey was conducted in four districts of Hooghly, Bankura, Burdwan and Howrah in West Bengal to compare the *economics and efficiency level under ordinary and contract farming*. The detailed analysis of 283 ordinary potato growers revealed that the contract farmers were more experienced in terms of schooling and social participation. Varietal preference and yield difference of different potato varieties between two groups of farmers' i.e. ordinary farmers and contract farmers were compared. The comparison showed that Atlantic variety was cultivated by the contract farmers and it occupied about 42% of their potato area, whereas Kufri Jyoti was predominant variety for both the category of farmers. The cost of cultivation of Atlantic and Kufri Jyoti was also compared. It was found that the benefit cost ratio was almost double in case of Atlantic. The yield of Atlantic was poor as compared to most popular variety Kufri Jyoti. Cost of cultivation of Atlantic variety (contract farmers) and Kufri Jyoti (Ordinary farmers) was also compared. Atlantic gave

higher net return of Rs. 30173/ha than of Kufri Jyoti (Rs. 20148/ha).

## Seed rate and its sources

Seed is the major investment in potato cultivation. The applied seed rate was very low in case of ordinary farmers as compared to other potato growing states. However, the contract farmers applied more seed of Kufri Jyoti (Table 53).

The survey also revealed that ordinary farmers sourced seed from traders, whereas contract farmers' used almost 50% seed from their own produce. The seed is purchased from Punjab every year and multiplied for next year.

## Assessment of Potato Technologies through Farmers' Participatory Research

### Technological gap at farmers' field

The data regarding the technological gap at the farmers' fields were collected in Shimla district of HP, and Muzaffarpur and Vaishali districts of Bihar. The survey indicated that there was 45 per cent gap in adoption of potato technologies in Shimla and 64 per cent in Muzaffarpur and Vaishali w.r.t. cultural practices, pest management and healthy seed potato production. Maximum knowledge gap (87%) was found in case of integrated pest management at Patna. Unavailability of good quality seed was perceived as the biggest constraint for potato production.

### Assessment of selected potato technologies

As per the technological gap assessment, 15 demonstrations, 5 each on late blight

Table 53. Seed rate and its sources

| Category         | Seed (q/ha) |       | % sources for K. Jyoti |                |         |        |
|------------------|-------------|-------|------------------------|----------------|---------|--------|
|                  | K. Jyoti    | ATL   | Own                    | Fellow farmers | Traders | Others |
| Ordinary farmer  | 13.69       | -     | 57.42                  | 7.19           | 35.15   | 0.24   |
| Contract farmers | 15.92       | 16.14 | 67.60                  | 2.68           | 29.60   | 0.13   |

management, white grub management, and healthy seed potato production, were conducted on 200 sq. m. area each in Kharapathar village of Shimla district in HP during 2008. The demonstrations were compared with the farmers' practice plots and the results revealed that the incidence of late blight and white grubs in farmers' plots were 50% and 1%, whereas that in demonstration plots were 40% and 0.6%, respectively. The results of the demonstrations indicated that the farmers were able to harvest on an average 258 q/ha yield from demonstration plot as against the yield of 115.5 q/ha from farmers' own control plot.

In Muzaffarpur and Vaishali also 15 demonstrations on 200 sq. m. area each were laid out at Baniya and Lalpura villages during 2008-09 on use of high yielding variety and late blight management. The varieties of potato used were Kufri Ashoka, Kufri Pushkar and Kufri Arun. These demonstrations were compared with the farmers' practice and the results revealed that maximum increase in yield was there in potato variety Kufri Ashoka (33.33%) followed by Kufri Pushkar (30.9%). In case of late blight

management, there was an yield advantage of 26.43 per cent.

### Impact of Extension Training

Model Training Course on "Potato Improvement, Production & Utilisation in the Current Indian Scenario" from 16-23 September, 2008 was organised at CPRI, Shimla to improve the knowledge and skill of extension officers working in state departments of agriculture/horticulture. A total of 16 participants from 9 states attended the training course. A variety of training methods were used to provide rich learning experience to the trainees. These included lecture-cum-discussions, practical sessions, field visits and video film shows. Pre-and post-training evaluations of the trainees were conducted to assess the impact of the training. It was found that after the training, the overall knowledge of the participants was improved by 13 per cent. Maximum gain in knowledge was in Plant pathology (23.1 per cent), followed by Physiology & PHT (17.1 per cent) and Plant breeding (15.9 per cent).





# Transfer of Technology



## Training of Extension Officers

### Model Training Course

The Division of Social Sciences organized 8-days Model Training Course on "Potato Improvement, Production & Utilisation in the Current Indian Scenario" from 16-23 September, 2008 at Shimla, which was sponsored by the Directorate of Extension, Ministry of Agriculture, Govt. of India. The objectives of the training course were improving the knowledge of the trainee officers regarding seed potato production and certification, improving the skill of the trainee officers regarding seed potato production, and to get the feedback from the trainee officers regarding field problems in the adoption of potato production technologies and in the seed certification. A total of 16 participants from 9 states attended the training course. The training included lecture-cum-discussions, practical sessions, skill demonstrations, field visits and video film shows. In all, 24 lectures were delivered and a field visit to CPRI farm at Kufri was organised during the training course.

### Winter School at CPRIC, Modipuram

CPRIC, Modipuram organized Winter School on Modern Techniques of Potato Research & Development during 2-22 Jan., 2009 which was attended by 18 participants from 8 states from AICRP (Potato), State Agriculture Universities, NGOs engaged in seed production and ICAR Institutes of the country. At the outset of the course, an evaluation was done on relevance of subject covered, extent of usefulness of the topic and overall satisfaction of the course. As many as 50% participants opined that seed plot

technique was very important area. About 50% gain in knowledge was observed.

## Training of Farmers

### Farmers' Training at CPRI, Shimla

A farmers' training on "Improved Techniques of Seed Potato Production and Post-harvest Technologies" was organized during 8-10 July, 2008 by the Division of Social Sciences at CPRI, Shimla. Although the research Institute like CPRI



has been entrusted with conducting trainers' training, but this approach has borne limited success in effecting technology transfer to the farmers owing to inefficiency and lack of professional approach at the state level. Hence, the Institute has started direct farmers' training activity to reduce the distortion in technology dissemination.

The training was organized for the farmers of Himachal Pradesh in which 16 farmers from 6 major potato-growing districts of the state, namely Shimla, Mandi, Sirmour, Solan, Kullu & Hamirpur participated. During this training course, farmers were given series of lectures consisting of late blight management, PTM & white grub management, healthy seed potato production, seed certification, marketing and strategies for adoption of potato technologies. A field visit to CPRS, Kufri was also organized for the farmers on this occasion.

#### Farmers' Training at CPRS, Patna

Under the celebrations of International Year of Potato, about 600 farmers from various potato-growing districts of Bihar were trained by the scientists of CPRS, Patna on scientific potato cultivation, healthy seed potato production, plant protection, use of farm implements and potato production through TPS. The trainings of these farmers were sponsored by NHRDF, ATMA, NAIP and other agencies.

#### Farmers' Training at CPRS, Shillong

An on-station farmers' training on "Improved Potato Production and Protection Technologies" was organized at CPRS, Shillong on August 12, 2008 in which 50 farmers participated. Two training programmes for farmers on "Improved Potato Production, Protection and Post-harvest technology" under MM-1 were organized during 17-18 October, 2008 at ICAR Research Complex for North-eastern region, Manipur Centre, Imphal and during 21-22 October, 2008 at ICAR Research Complex for North-eastern region, Tripura Centre, Agartala in which 60 farmers participated. A one-day training programme for 41 farmers on "Improved Potato Production, Protection and Post Harvest technology" under MM-1 was also organized on 12<sup>th</sup> November, 2008 at ITI, Nalbari, Assam.

#### Farmers' Training at CPRIC, Modipuram

About 900 farmers from various potato-growing districts of UP, Haryana and Rajasthan were trained by the scientists of CPRIC, Modipuram on scientific potato cultivation, healthy seed potato production, plant protection and use of high yielding varieties of potato. The trainings of these farmers were sponsored by State agriculture departments and other agencies.

#### Training to Tribal farmers of MP at CPRIC, Modipuram

Training was imparted to 20 scheduled tribe farmers of Alirajpur of Jhabua district of MP. The farmers were exposed on various aspects of potato cultivation includes ware seed and processing potato production.

#### Live Phone-in Programme on Doordarshan

The Shimla Doordarshan telecasts *live phone-in* programme of 'Krishi Darshan' in collaboration with various organizations concerned with agricultural development. The programmes of various organizations are discussed in the monthly meetings and are telecast every Monday and Thursday as per schedule. In this programme burning issues related to crop, animal husbandry, fishery, etc. are discussed by the studio-invited experts and the viewers (farmers) can ask questions from the experts by dialling the phone number announced just before the start of the programme. Drs. VK Dua, Manoj Kumar and Vinod Kumar of CPRI, Shimla participated in the programme during the year to discuss various aspects of potato production. Field recording on Organic Potato production was also done at farmers' field in Talai village (near Fagu) of Shimla district, which was subsequently telecast on Shimla Doordarshan. Drs. RP Rai, Shambhu Kumar, SK Singh and Barsati Lal of CPRS, Patna participated in similar programme telecast by Patna Doordarshan.

#### Potato School on AIR

Aloo Pathshala (Potato School) on All India Radio, Shimla was aired to commemorate the International Year of Potato 2008. In this

programme, 20 talks on "Recent potato technologies were broadcast from 15 March to 26 July, 2008. Out of 20 episodes, 3 were broadcast in the month of March, 2008 and the remaining during April-July, 2008. At the end of each talk, a question related to that talk was asked from the farmers, who were supposed to send their answers on a postcard. An overwhelming response from the farmers was obtained, which also provided feedback about the programme and about various potato technologies developed by the Institute. During this programme, a Jingle on potato was also broadcast at the beginning and end of each talk, which highlighted the nutritive value of potato and also educated the public on the popular misconception about potato.

## Kisan Mela/ Field Days

### Awareness Camp on PTM Management

An awareness camp on management of potato tuber moth (PTM) was organized at Block Office, Nagrota in Kangra district of Himachal Pradesh on 12 May, 2008. Nagrota block is known for supplying good quality potatoes to the processors during off-season. This area is also a hot-spot for PTM infestation during maturity and harvesting of potato crop. The infestation gets aggravated during the storage of potato in non-refrigerated stores. The camp was aimed at educating the farmers and potato traders on the latest package of practices for controlling PTM during crop period and storage. About 50 farmers and traders of the neighbouring villages participated in the camp. The scientists namely Drs. VK Chandla, Brajesh Singh and Anil Kumar from CPRI, Dr. RS Chandel from CSKV, Palampur, and Dr. Sanjay Kumar from PepsiCo India Pvt. Ltd. addressed the farmers on various issues related to PTM control. A potato exhibition was also put up by CPRI on this occasion.

## Potato Exhibits

**Exhibition in Kisan Mela at Solan:** An exhibition stall of potato technologies were put up at the Kisan Mela organized by National Research Centre for Mushroom, Chambaghat, Solan on 10th Sept., 2008. The stall was visited by more than 250 farmers from different parts of the states and they were briefed about the

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

**Agro-tech Exhibition at GPC-2008:** During Global Potato Conference-2008, an agro-tech exhibition including potato was also organized to showcase the status of potato based industries and trade, food value chain, food services and retailing, biotechnology and public private partnership in technology transfer. More than 60 organizations of national and international repute put up their stall to depict the latest trend in agriculture technologies. The CPRI stall provided the glimpses of potato research in India and demonstrated the technologies of potato chips, French fries and delicious pickle. The new developed varieties of the Institute attracted large number of farmers.

## Activities of ATIC

A total of 411 farmers visited the Institute at Shimla during the year to get first-hand information about potato technologies. In addition, 60 scientists/teaching staff, 954 UG and PG students were attended by the ATIC staff at Shimla. They were shown potato film and museum besides briefing from the extension scientist about the programmes and activities of the Institute.

The ATIC staff maintains the record of Institute's technical/extension bulletins and CDs. During the year, an income of Rs. 33600/- was generated from sale of publications & CDs to the visitors. Besides, a number of extension bulletins were also supplied free of cost to the visiting farmers, students and extension officers.





## Externally Funded Projects



1. Implementation of protection of plant varieties and farmer's rights legislation (funded by Govt. of India)

Characterization of reference varieties:

Trial with all CPRI released varieties were conducted at Kufri and Modipuram and data recorded for various descriptors including the quantitative ones.

Conservation of reference varieties:

Reference collection of 178 varieties/numbers was maintained; 121 in vitro and 141 in fields. These included 44 CPRI released varieties, 3 state varieties, 5 Indian numbers released elsewhere, 20 exotic varieties cultivated or in cultivation in India, 57 indigenous varieties/numbers, 29 UPOV example varieties and 20 miscellaneous cultures. These were also tested for their freedom from viruses with the help of Plant Protection Division. Except CPRI varieties, which are presently in seed production, most of the remaining were found to be infected with one or more viruses.

Finalization of descriptors:

The descriptors developed by the CPRI were discussed in the Task Force meeting. These were revised as per suggestions of the task force and final copy submitted to the secretary, Task Force.

2. Project: Engineering late blight resistance in susceptible Indian potato cultivars (ICAR-ABSP II collaborative project)

The race non-specific late blight resistance gene *RB* cloned from the wild potato species *Solanum bulbocastanum* is being used to develop potato varieties with durable resistance under the collaborative project between ICAR and ABSP II. The *RB* is being introgressed by conventional breeding using the transgenic lines (SP904/951) of Katahdin and it is also being transferred into the commercial Indian potato cultivar by *Agrobacterium*-mediated genetic transformation.



Introgression of RB gene by crossing with RB-transgenic Katahdin:

Twenty-two selected  $F_1C_3$  clones from the cross Kufri Bahar x SP904/951 were evaluated under controlled environment chamber at Shimla and under contained field condition at Modipuram. All the selected lines performed better than the maternal parent Kufri Bahar in terms of late blight field resistance both at Shimla and Modipuram. Based on performance at both the locations, 11 clones (KP/SP-951-9, KP/SP-951-26, KP/SP-904-12, KP/SP-904-22, KP/SP-904-23, KP/SP-904-46, KP/SP-904-50, KP/SP-904-56, KP/SP-904-62, KP/SP-904-66, KP/SP-904-77) have been selected for further evaluation.

One hundred three  $F_1C_1$  clones of the cross Kufri Jyoti X SP951, that tested positive for RB gene, were screened for late blight resistance under controlled environment chamber. All the clones except three (KJ 15, KJ 52, and KJ 54) showed better resistance than the maternal parent Kufri Jyoti (Fig. 35). Fifty four clones that produced 5 or more tubers in the pot were screened at CPRI Campus, out of which 50 clones performed better both at Shimla and Modipuram. Similarly, 55 clones obtained from the cross Kufri Bahar x SP951 and positive for RB gene were screened under controlled environment chamber at Shimla. Though most of the clones showed resistance to late blight, the degree of field resistance in most of the clones was inferior to that of Kufri Jyoti hybrids. Twenty four clones producing 5 or more tubers were screened at CPRI Campus, Modipuram. Based on performance of the clones at both the locations, 11 promising clones (KB-23, 24 27 28, 29, 30, 31, 32, 37, 38, and 45) have been selected for further evaluation.



Fig. 35. Hybrids of Kufri Jyoti x SP 951 after completion of screening under controlled environment chamber. The pot at the left corner shows control Kufri Jyoti.

Development of RB-transgenic Kufri Bahar and Kufri Jyoti by direct transformation:

Kufri Bahar and Kufri Jyoti were transformed with the RB gene by *Agrobacterium*-mediated genetic transformation. In Kufri Jyoti, a total of 86 shoots were regenerated out of which 60 developed roots in presence of 50 mg/L kanamycin and 16 were rooting-positive in presence of 100 mg/L kanamycin. In Kufri Bahar, 98 shoots were regenerated, out of which 57 developed roots in medium containing 50 mg/L kanamycin and 31 were rooting-positive in presence of 100 mg/L kanamycin. Eight putative transgenic lines of Kufri Jyoti positive for the RB gene were screened under controlled environment chamber. All the eight transgenic lines showed better resistance than that of non-transgenic Kufri Jyoti. Late blight resistance of the clone KJRBE-58 after screening under controlled environment chamber is shown in the Fig. 36. Similarly, 10 putative transformed lines of Kufri Bahar were screened under controlled environment chamber. Although seven lines showed late blight resistance better than non-transgenic control, the degree of field resistance was not desirable in most of the clones. Four of them, i.e. KB-RBL-23, KBRBL-12, KBRBL-22, and KBRBE-23 were selected for further evaluation.



Fig. 36. Late blight infection in non-transgenic Kufri Jyoti and RB-transgenic Kufri Jyoti line KJRBE -58.

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

Late blight caused by the fungus-like organism, *Phytophthora infestans*, is the major limiting factor of potato cultivation. Breeding for late blight resistance began nearly 100 years ago with the introgression of resistance from *S. demissum*, a wild hexaploid species indigenous to Mexico. Resistance in *S. demissum* is determined by dominant R genes inducing hypersensitive (HR) response. This type of resistance often called vertical resistance was introgressed extensively into the cultivated potato. However, *P. infestans* rapidly overcomes such resistance and now-a-days such gene-for-gene resistance is abandoned. Race non-specific resistance also called horizontal resistance to late blight has been located in several wild potato species and genetic studies suggested their quantitative nature. Such quantitative resistance to late blight has been reported from the wild species *S. berthaultii*, *S. bulbocastanum*, *S. demissum*, *S. microdontum*, and *S. phureja*. The present work was undertaken to map the major QTL governing late blight horizontal resistance in the wild diploid potato species *S. chacoense* and *S. spegazinii*. For linkage mapping, a  $F_1$  progeny of the cross *S. spegazinii* x *S. chacoense* consisting of 126 individuals was developed and is being maintained in tissue culture. Phenotyping of the population was done both by detached leaf method and whole plant screening under controlled environment

chamber. The population showed a normal distribution in terms of late blight infection both under detached leaf and whole plant screening (Fig. 37). Genotyping of the population was done using 12 selective AFLP primer pairs. A total of 268 loci were amplified from male parent *S. chacoense* that were absent in *S. spegazinii*. The expected segregation ratio of 1:1 was tested for all these loci in the population by Chi-square analysis using JoinMap 0.4 software and only 89 (33%) loci segregated as per the expected ratio. A molecular linkage map of *S. chacoense* has been prepared using those 89 markers (Fig. 7, page 48). Similarly, 379 loci were amplified from the female parent *S. spegazinii* that were absent in the male parent. Out of them 162 alleles segregated in 1:1 ratio and were used for developing a linkage map for the species *S. spegazinii* (Fig. 38). Major QTLs governing the late blight horizontal resistance in both the species are being determined.

#### Marker assisted selection of PVY extreme resistance

A SCAR marker validated earlier was used to develop parental lines having PVY extreme resistance gene (*Ryadg*) in triplex/quadruplex state. Test crosses were attempted using five putative multiplex clones and PVY susceptible commercial cultivars/hybrid (nulliplex). The progeny thus obtained were analyzed for presence of the SCAR marker. One clone i.e. YY-6/3 C11 appeared to be a putative triplex clones as the segregation ratio in its progeny was 30:1, quite close to the expected segregation ratio of 27:1 in the progeny of a nulliplex x triplex cross following random chromatid assortment (Table 54). To confirm its

**Table 54. Segregation ratios obtained in test crosses based on SCAR marker analysis**

| Sr. No. | Cross combination          | Seedlings evaluated | Band    |        | Segregation ratio |
|---------|----------------------------|---------------------|---------|--------|-------------------|
|         |                            |                     | Present | Absent |                   |
| 1       | K Chipsona-3 X YY-6/3 C10  | 23                  | 17      | 6      | 2.83:1            |
| 2       | K Chipsona-3 X YY-13/3 C76 | 11                  | 9       | 2      | 4.50:1            |
| 3       | K Girdhari X YY-6/13 C30   | 13                  | 8       | 5      | 1.60:1            |
| 4       | QB/A 9-120 X YY-6/3 C11    | 31                  | 30      | 1      | 30.00:1           |
| 5       | K Girdhari X YY-13/3 C96   | 41                  | 32      | 9      | 3.56:1            |

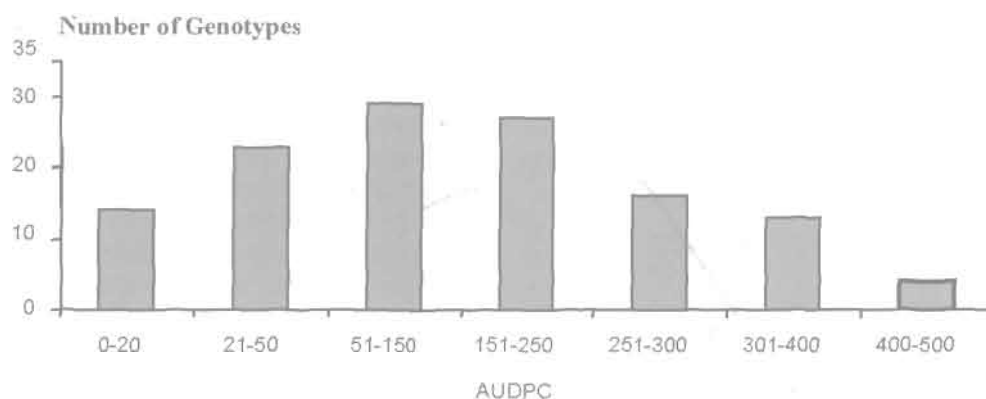


Fig. 37. Distribution of  $F_1$  progeny in terms of area under disease progress curve under controlled environment chamber.

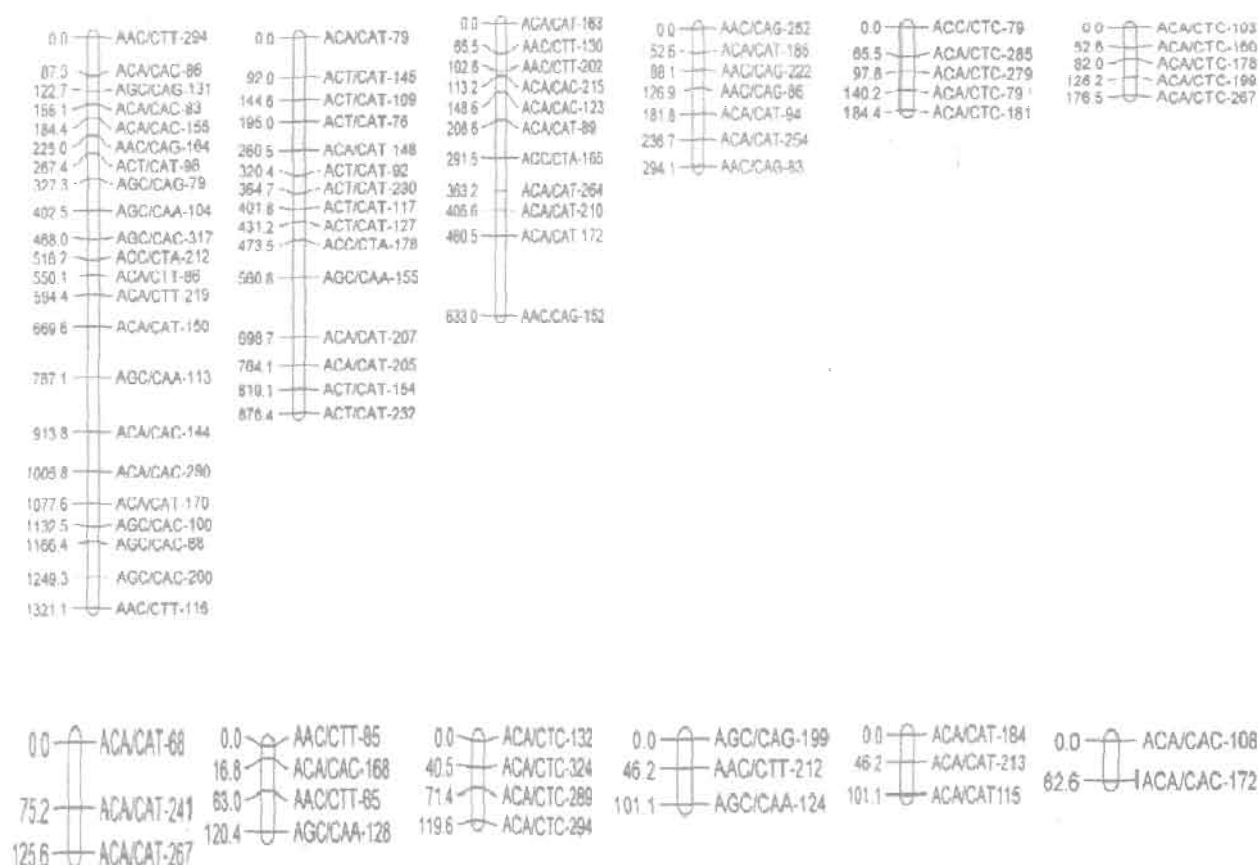


Fig. 38. Linkage map of *Solanum spegazinii*

triplex status, a larger progeny having 151 individuals was raised from the cross (QB/A 9-120 x YY-6/3 C11) and checked for presence of the marker. A segregation ratio of 25:1 was obtained in the progeny of this cross thus confirming triplex status of the clone YY-6/3 C11. The clone was challenge inoculated by PVY and confirmed to have extreme resistance to the virus by ELISA and IEM.

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

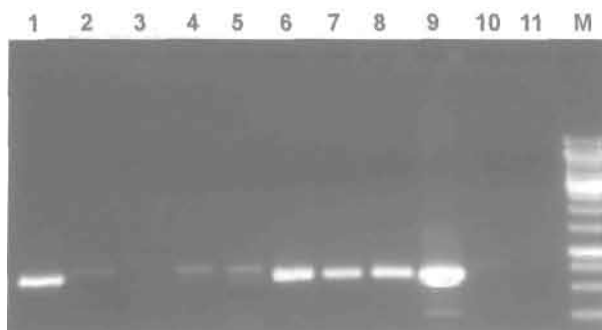
In recent years, geminiviruses are emerging as serious threats to many crops including potato in the tropics and subtropics. Potato apical leaf



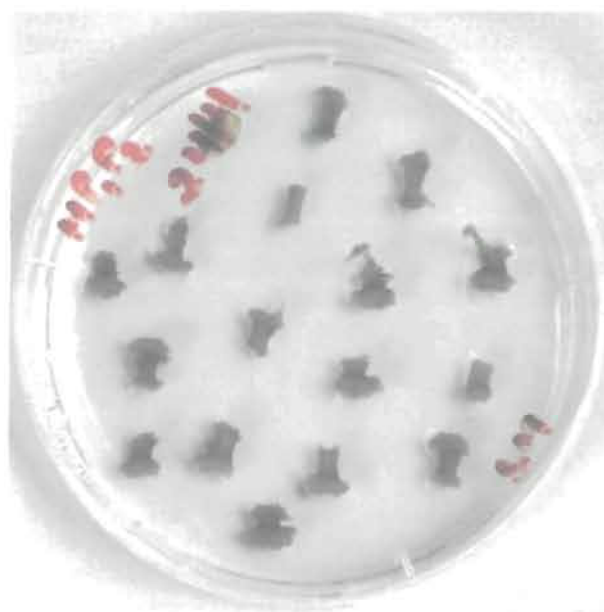
curl virus is one such example that has been reported for the first time from northern states of India in the year 1999. The emergence of this virus in potato is primarily due to early planting when temperature is slightly higher and the vector (white flies) population is high. Most of the popular cultivars of the region are susceptible to this virus causing significant yield loss. The popular variety Kufri Badshah and the early maturing variety Kufri Pukhraj were chosen for genetic transformation with the replication-associated protein gene (*AC1*) of the virus to obtain pathogen-derived resistance. The *AC1* gene was PCR amplified from field infected potato leaves, cloned and sequenced. It showed 93% sequence similarity with the *AC1* gene of TOLCV-NDe (DQ169056). The gene was sub-cloned in the binary vector pBinAR in antisense orientation and as hairpin loop to derive the transformation vectors pGTLC1 and pGTLC2 respectively. The transformation vectors were mobilized into the *Agrobacterium tumefaciens* strain EHA105 by freeze thaw method and used for genetic transformation.

The internodal stem segments of Kufri Badshah microplants were used for genetic transformation. Approximately 200 explants were cocultivated with EHA105 harboring the binary vector pGTLC1 (containing replicase gene in antisense orientation). One hundred sixty nine putative transgenic shoots were regenerated out of which 16 lines produced roots in presence of 100 mg/L kanamycin. Those plants were checked by PCR for gene integration. Eight lines were positive for integration of replicase gene in antisense orientation (Fig. 39). The positive lines were grown inside a transgenic green house and tubers have been obtained from the first clonal generation.

Similarly, the variety Kufri Badshah was transformed with the replicase gene as hairpin loop to confer resistance by post transcriptional gene silencing. Approximately 200 internodal cuttings were cocultivated and 150 putative transgenic shoots were regenerated (Fig. 40). Thirty shoots developed roots in presence of 100 mg/L kanamycin. The rooting positive lines were tested by PCR for gene integration and 4 positive lines have been identified so far.



**Fig. 39. PCR amplification of replicase gene in positive transgenic lines.** Lane # 1: GTLC1-159; 2: GTLC1-45; 3: GTLC1-122; 4: GTLC1-34; 5: GTLC1-126; 6: GTLC1-115; 7: GTLC1-67; 8: GTLC1-17; 9: positive control, 10: negative control; 11: water; M: marker. Note: The non-transgenic plant and the negative transgenics showed a faint band slightly higher than desired band. The lines GTLC1-159, GTLC1-115, GTLC1-67, and GTLC1-17 are positive for gene integration.



**Fig. 40. Regeneration of replicase hairpin loop transgenic shoots of Kufri Badshah after cocultivation.**

In another attempt, the early variety Kufri Pukhraj has been transformed with the antisense construct of the replicase gene and 74 putative transgenic shoots have been regenerated so far. Rooting in presence of kanamycin was observed in 36 lines. Three lines have so far been identified with positive gene integration. Molecular analysis of the remaining lines and fresh transformation is in progress.

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

Attempt has been made for integration of both approaches of post-transcriptional silencing of invertase expression by introduction of invertase inverted repeat gene construct and overexpression of tobacco invertase inhibitor gene.

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

Transcriptional silencing of potato *UGPase* gene by introduction of intron containing inverted repeat gene construct has been attempted for refuction of cold-induced sweetening in potato.

## 7. Development of dwarf potato cultivars suitable for cultivation in hills and eninsular India through recombinant DNA technology (DBT funded project).

Potato plants when grown under long days or high temperatures conditions accumulate gibberellic acid and grow tall leading to reduced partitioning of dry matter to the tubers. To reduce internal gibberellic acid content and consequently excessive vegetative growth, we have silenced *GA20-oxidase1* gene (involved in the synthesis of gibberellic acid) through post transcriptional gene silencing (PTGS) to obtain transgenic plants of variety Kufri Giriraj with reduced

height. Glass house trials were conducted during 2005, 2006 and 2007 with 75 Inverse Repeat *GA20 oxidase1* (IRGA), 35 sense and 34 antisense plants. Based on the yield performance as well as plant height for three years, 10 IRGA lines have been selected for field trial. During 2008 only the ten selected lines were planted in pots in the glass house. Plants height was in the range of 41-58 cm. The average control plant height was 78 cm. During 2008 selected IRGA lines yielded in the range of 119-227 g/plant compared to 129g/plant for controls.

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

- A total of 83 plant species were tested against fungal pathogens and sprouting of potato
- Mazufal was found effective against late blight
- Shikakai and Malkangani were found effective as sprout inhibitors

## 9. Mega Seed Project (National Seed Project)

The main motive of the project is to put efforts towards fast spread of high yielding new varieties/hybrids by providing more and more seed to seed producing agencies to enhance the production of healthy seed to meet the need of the country. A total production of 3366.88q (2415.38 in stage-IV and 951.50 in Generation-2) was achieved in 16.40ha (12.25 in stage-IV and 4.15 in Gen.-2) area under NSP during 2008-09.

A production of 1482.64q of quality seed in an area of 9.43 ha has been achieved. In addition 14.0q quality seed through tissue culturally developed material was also produced.

## 10. Survey of virus vectors and pathogen pressure in potato production regions of North-East India (CIP-CPRI)

Sites were identified for undertaking the virus vectors (aphids) and pathogen pressure study in five North Eastern states of India. In all the above selected sites work was undertaken to monitor the vector population both in the crop and also from the installed water and sticky trap at weekly intervals. The survey was conducted by the state department collaborators throughout the duration of the crop till maturity by visiting the sites. Periodic samples from the standing potato crop from all the sites have also been taken for identification of viruses prevalent in the locality.

Aphid population monitored in different identified sites has been collated and the brief results of the different sites are presented below.

- Aphids were counted in upper, middle and lower leaves
- Weekly aphid count was obtained through visual observation of 100 compound leaves
- Water and sticky traps also used for monitoring aphids
- Weather data was collected from the nearest state meteorological department

### Meghalaya

Weekly survey of the Aphid monitoring and virus incidence at the different sites in Meghalaya State viz. Govt Ag.farm, Tyrsad, Shillong peak, Kyrdekhlā, Laitlyngkot and Nongkynrih was done from 19 April to 21 June 2008. Aphid spp. specially *Myzus persicae* was found beyond the critical level at some places like Nongkynrih

| Locations          | PVX | PVS | PVM | PLRV |
|--------------------|-----|-----|-----|------|
| Govt.Ag.Farm       | "   | "   | X   | X    |
| Shillong Peak      | "   | "   | X   | X    |
| Tyrsad             | "   | "   | X   | X    |
| Laitlyngkot        | "   | "   | X   | X    |
| Mowkodok/Kyrdekhlā | "   | "   | X   | X    |
| Nongkynrih         | "   | "   | X   | X    |

(third & last week) followed by Tyrsad (last week). The counts ranged from 22-34/ 100 compound leaves in the month of April where as at some other sites like Govt. Ag. Farm (first & second week of May) and at Shillong Peak (second & third week of May) the population ranges from 22-50/100 compound leaves. The plants showing mild and severe mosaic symptoms were found to be infected by PVX and PVS viruses detected by using ELISA technique.

### Sikkim

Weekly observation of Aphid monitoring and virus incidence was done at different sites of Sikkim viz. Potato seed Farm (Ravangala), New Sada, Bakkhim, Okhrey and Ribdi from 7th April to 29 May. It was observed that the Aphid population was more than that of critical level i.e.20-26/100 compound leaves at the Potato Seed Farm, Ravangla (1st & 2nd week of April) followed by New Sada (Last week of Mar). The virus infected plants showing mosaic and mottling symptoms at potato seed farm were found to be infected with PVX but on the other hand the plants showing mild and severe mosaic symptoms at Okhrey and Ribdi was found infected with PVS and PVM respectively by using ELISA detection technique.

| Locations              | PVX | PVS | PVM | PLRV |
|------------------------|-----|-----|-----|------|
| Govt.Potato Farm       |     |     |     |      |
| Ravangla               | "   | X   | X   | X    |
| Ribdi                  | X   | "   | "   | X    |
| Bakkhim                | X   | X   | X   | X    |
| Hille Govt. Potao Farm | X   | "   | "   | X    |
| New Sada               | X   | X   | X   | X    |
| Okhrey                 | X   | "   | "   | X    |

| Locations             | PVX | PVS | PVM | PLRV |
|-----------------------|-----|-----|-----|------|
| Kigwema Village       | "   | "   | "   | X    |
| Lower Ukule Kigwema   | "   | X   | X   | X    |
| Khuzama Vill NH-39    | "   | X   | X   | X    |
| Khuzama Village       | X   | X   | X   | X    |
| Ukule Kigwema Village | "   | "   | X   | X    |



## Nagaland

Weekly survey of Aphid population and virus incidence was done at different sites in Nagaland viz. Kigwema Vill, Ukule Kigwema, Khuzama, Khuzama Vill. NH 39 and Lower Ukule Kigwema from April 8 to May 19, 2008. It was found that the Aphid population was below the critical level from 0-12/100 compound leaves in all the locations. The infected plants showing the viral symptoms were found to be infected with PVX, PVS and PVM, respectively, using ELISA technique.

| Locations      | PVX | PVS | PVM | PLRV |
|----------------|-----|-----|-----|------|
| Upper Wanghoo  | "   | "   | X   | X    |
| Lower Wanghoo  | "   | X   | "   | X    |
| Warjung        | "   | "   | "   | X    |
| Pedung Village | "   | "   | "   | "    |

## Arunachal Pradesh

Weekly observation of Aphids as well as virus incidence data was collected from the different sites of Arunachal Pradesh viz. Upper Wanghoo, Lower Wanghoo, Pedung Vill; Nafra and Warjung. The data showed that the Aphid population was less than that of critical level except in Pedung, where 31/100 compound leaves has been recorded in the last month of April 2008 but ELISA detection technique revealed that the infected plants showing viral symptoms like mosaic mottling and stunting were found to be PVX and PVS at Upper Wanghoo, PVX, PVS and PVM were recorded from Warjung, and plants showing severe mosaic leaf roll symptoms were found infected with PVX, PVS, PVM as well as PLR from the Pedung Vill. PVX and PVM were recorded from Lower Wanghoo.

## Mizoram

Since there were no potato crops in the identified sites in Mizoram there were no record of aphid population and virus incidence done at the locations selected for the study. During June first week a new site was

identified and the observation taken but the data is not reliable and hence not presented but for the virus detection.

| Locations | PVX | PVS | PVM | PLRV |
|-----------|-----|-----|-----|------|
| Ngur Zo   | "   | "   | "   | "    |

## Relationship between weather parameters and aphid count

The weather data collected from the observatory in Shillong was used to look at the relationship between the aphid counts and the weather parameters. The graphs presented show that the relationship between temperature, humidity and sunshine hours was there. The aphid count went up with decrease in temperature, increase in humidity and decrease in sunshine hours. Similar kind of results were seen in autumn crop also as is revealed by the graphs, though the population counts were very low.

## Degeneration trials

Degeneration trials were conducted at one site in each of the Meghalaya, Nagaland, Arunachal Pradesh and Sikkim districts in 2008. The planting material as basic seed for both seed and ware potato production practices was supplied by CPRI. The seed plot technique was practiced for seed production plots, whereas for ware crops, farmers' practices were followed. The field trials were harvested in July- August and produce has been stored separately for next generation studies. The tuber yield and average tuber weight were recorded.

In all states, improved practices gave little higher tuber yield than traditional practice. The highest yield of 22.0 t/ha was obtained from the Kufri Jyoti variety using improved practices. In general, Kufri Jyoti gave a higher yield than Kufri Giriraj. Tuber weight was greater from improved practice than traditional practices. The differences between the two treatments will be more when 2<sup>nd</sup> and 3<sup>rd</sup> generation material produced through farmers' practices is planted.

11. Strengthening of tissue culture laboratory at Central Potato Research Institute Campus, Modipuram for production of Nucleus Seed of Potato through Micro-tubers (funded by Uttar Pradesh State Horticulture Mission, Lucknow (UP))

It was a non project based programme under this project Caster racks and media dispenser have been procured and are being utilized for the production of micropropagules in Tissue Culture Lab.

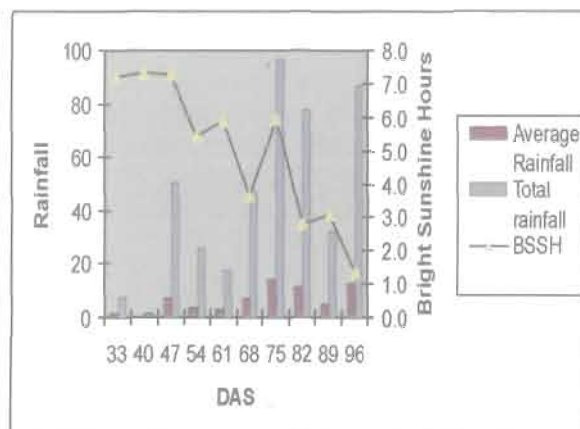
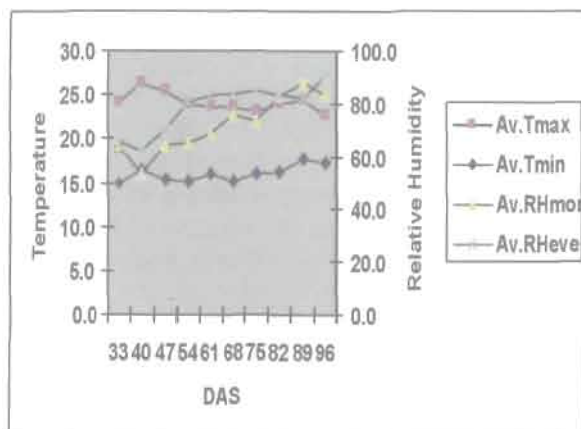
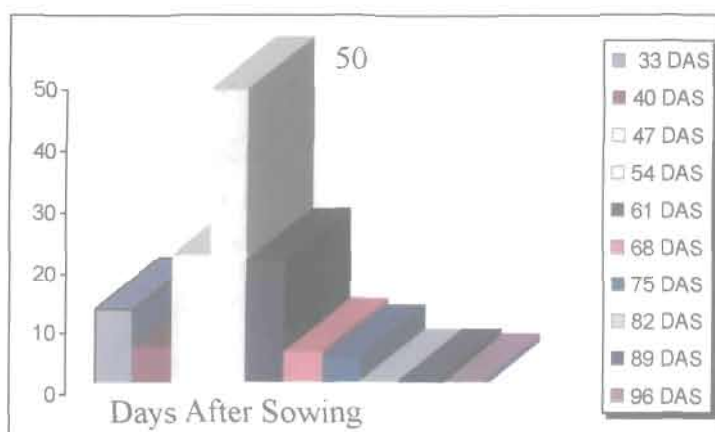
12. Popularising of low cost storage technology for table potato and potato seed (NABARD RIF)

Household level storage for table potatoes

The project is being implemented since January 2008. Sixteen farmers were selected five each from Myllem, Mawnianglah, four from Nongpyiur and two from Mawklot. Households level storage structures were constructed in all the nominated farmers households. The capacity of a households storage structures is 10 quintals. The farmers who plant the crop in the paddy field start harvesting in the beginning

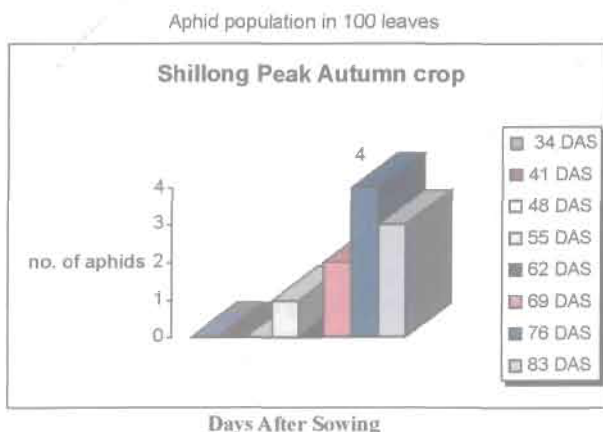
#### Summer crop Shillong Peak

Aphid population in 100 leaves

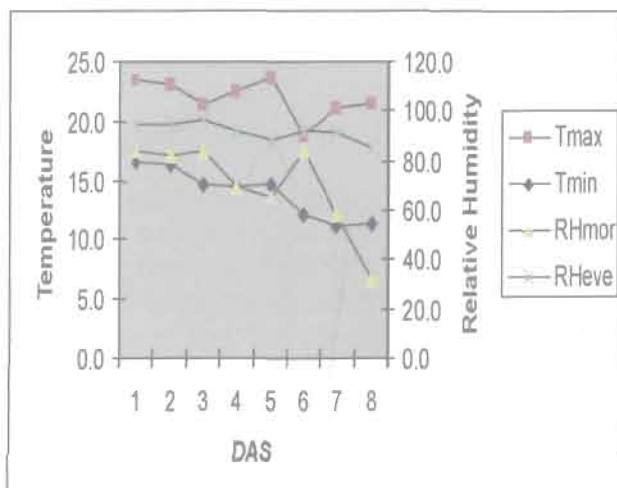


Weather parameters

## Shillong Peak Autumn crop



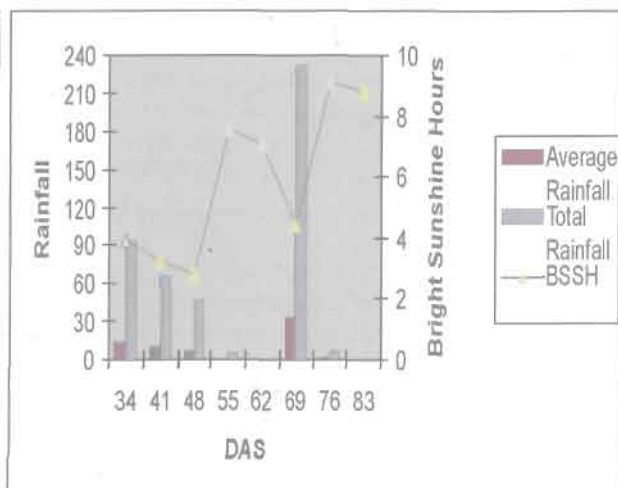
## Weather parameters



of potatoes in this new technique of storage is less. The loss in traditional stores was very high, the rottage loss (no. basis) being 69% to 75% and weight loss 82 to 72% In household storage structures, the tuber sprouting was very less 90 days after storage. The disease infestation was also less.

## Community Level Seed Storage Structures

The Community Level Seed Storage Structures was constructed at Myllem Madan Ing Syiem with a capacity of 32 quintals of seeds. Twenty one farmers kept the seeds in the seed storage structures of which 17 were from Myllem, 2 from Mawklot and 2 from Nongpyiur.



of June as paddy planting will be started and farmers who plant the crop in the hilly areas start harvesting by the end of June and continue till August. These structures will help them to store the potatoes for about three months and sell them at a time when the price is high enabling them to make a profit. The market rate of table potato was monitored at fortnightly interval upto 15<sup>th</sup> December 2008. The market rate of table potato is presented in Table 54.

The farmers who sold their produce in the month of November got a better price after 3 months of storage. They got a profit of Rs 200 to 625. The total loss in household structures ranged between 2% to 5% only (i.e. rottage and weight loss), which shows that the rottage

The total quantity of seeds kept by the different farmers this year in the stores was 23.5 quintals.

The seeds in the seed storage structures looked healthy as there was proper circulation of air and less infestation of PTM. The seeds were having healthy sprouts, small to medium in sized, with less to medium shrinkage. There was less infestation of diseases and also no infestation of PTM as the window in the stores is properly fixed with a net and lantana leaves was properly spread. Disease infestation was also less with dry rot between 10% to 30%, soft rot between 10 to 30% and PTM infestation being very less. Following are the observation taken in the Seed storage structures (Table 55).



**Table 54. Wholesale market rate of potato in Shillong during the storage period**

| Period                          | Rate (Rs./Kg) |        |       |
|---------------------------------|---------------|--------|-------|
|                                 | Large         | Medium | Small |
| 1 <sup>st</sup> July 2008       | 6.5           | 4.5    | 2.0   |
| 15 <sup>th</sup> July 2008      | 7.0           | 5.0    | 2.0   |
| 1 <sup>st</sup> August 2008     | 7.5           | 5.5    | 2.5   |
| 15 <sup>th</sup> August 2008    | 7.0           | 5.0    | 2.5   |
| 1 <sup>st</sup> September 2008  | 7.5           | 5.5    | 3.5   |
| 15 <sup>th</sup> September 2008 | 8.0           | 6.0    | 5.0   |

| Period                         | Rate (Rs./Kg) |        |       |
|--------------------------------|---------------|--------|-------|
|                                | Large         | Medium | Small |
| 1 <sup>st</sup> October 2008   | 8.0           | 6.5    | 5.5   |
| 15 <sup>th</sup> October 2008  | 8.0           | 5.5    | 4.5   |
| 1 <sup>st</sup> November 2008  | 9.0           | 6.5    | 5.5   |
| 15 <sup>th</sup> November 2008 | 10.0          | 7.5    | 6.0   |
| 1 <sup>st</sup> December 2008  | 7.0           | 5.5    | 4.0   |
| 15 <sup>th</sup> December 2008 | 8.0           | 6.5    | 5.0   |

### 13. Integrated Development of Horticulture in NEH Region funded by Technology Mission on Horticulture (Mini-Mission-I)

Under the Mini-mission-1 running at the station following activities were undertaken and those are being presented programme-wise in the following paragraph.

#### Component I: Production of Nucleus/Basic seed and planting material

The activities under this programme were aimed at production of micro plants by micro propagation of various potato varieties especially

K. Giriraj, K. Jyoti and also newly released varieties (K. Himsona, K. Girdhari and K. Himalini) for production of mini tubers under controlled conditions in poly houses. The mini tubers obtained from the polyhouses were multiplied for production of basic seed/quality planting materials in different field generations. Disease free quality seeds of K. Jyoti, K. Giriraj, K. Megha and K. Kanchan were supplied to various states in the NE region (Table 56).

A total of 3000 microplants of K. Giriraj, K. Jyoti, K. Kanchan, K. Himalini and K. Girdhari were produced from the fresh cultures procured from CPRI, Shimla. During the same year a total of 178.47q quality seed from various field generations were obtained and out of total quantity 105.00 q seed was given for demonstrations to farmers in Meghalaya.

**Table 55. Seed quality in the community level storage structure at the end of storage period**

| Sl. No. | Village   | No. of Farmers | Percent sprouting | Percent Greening (Avg) | Rottage loss (Avg) | Weight loss (Avg) | Disease (Avg) |
|---------|-----------|----------------|-------------------|------------------------|--------------------|-------------------|---------------|
| 1       | Mylliem   | 17             | 100%              | 2%                     | 0.05%              | 357g              | 0.29%         |
| 2       | Mawklot   | 2              | 100%              | 3%                     | 0                  | 175g              | 0             |
| 3       | Nongpyiur | 2              | 100%              | 2%                     | 0                  | 150g              | 0             |

Remaining quantity will be multiplied during 2009-10.

## Component II: Standardization of Production and Protection

Under this programme, the Use of EPN for management of white grubs was planned. The trial was laid out with seven treatments consisting of soil treatment of carbofuran at the time of planting and other treatments which include drenching with chlorpyrifos and imidacloprid and a combination of the two. The trial also includes soil treatment with EPN, *Steinernema carpocapase* and *Heterorhabditis indica* at the time of appearance of the pest. Observations on the incidence of white grubs was recorded by uprooting 5 plants and recording.

### Treatment combinations:

- T0: Control (no treatment)
- T1: Soil treatment at planting with Phorate 10 G @ 15 kg/ha
- T2: Drenching of ridges with Chlorpyrifos 20 EC @ 2.5 ml/litre of water on the appearance of the pest
- T3: Drenching of ridges with Imidacloprid 17.8 SL @ 0.004% (2 ml/10 litre of water) on the appearance of the pest
- T4: T1 + T2
- T5: T1 + T3
- T6: soil treatment with *Steinernema*

*carpocapase* on the appearance of the pest.

### Multiplication of microplants of potato at Tissue culture laboratory



Table 56. Status of micro plants and different field generations during 2008-09.

| Variety     | Microplants (Numbers) | Field Generation II (q) | Field Generation III (q) | Field Generation IV (q) | Total of all Field generations (q) |
|-------------|-----------------------|-------------------------|--------------------------|-------------------------|------------------------------------|
| K. Giriraj  | 2000                  | 46.00                   | 60.78                    | 56.78                   | 163.56                             |
| K. Jyoti    | 100                   | -                       | -                        | -                       | -                                  |
| K. Kanchan  | -                     | 14.91                   | -                        | -                       | 14.91                              |
| K. Girdhari | 100                   | -                       | -                        | -                       | -                                  |
| K. Himalini | 300                   | -                       | -                        | -                       | -                                  |
| K. Himsona  | 500                   | -                       | -                        | -                       | -                                  |
| Total       | 3000                  | 60.91                   | 60.78                    | 56.78                   | 178.47                             |

**Table 57. Pest incidence (White grub) per 5 plants/plot/replication/treatment at 45, 60, 75 days after planting and at harvest**

| Treatment | At 45 days | Mean | At 60 days | Mean |
|-----------|------------|------|------------|------|
| T0        | 2/20       | 0.1  | 9/20       | 0.45 |
| T1        | 0/20       | 0    | 1/20       | 0.05 |
| T2        | 1/20       | 0.05 | 5/20       | 0.25 |
| T3        | 3/20       | 0.15 | 2/20       | 0.1  |
| T4        | 1/20       | 0.05 | 3/20       | 0.15 |
| T5        | 0/20       | 0    | 3/20       | 0.15 |
| T6        | 11/20      | 0.55 | 5/20       | 0.25 |
| T7        | 5/20       | 0.25 | 4/20       | 0.2  |
| Treatment | At 75 days | Mean | At harvest | Mean |
| T0        | 9/20       | 0.45 | 9/20       | 0.45 |
| T1        | 1/20       | 0.05 | 5/20       | 0.25 |
| T2        | 10/20      | 0.5  | 5/20       | 0.25 |
| T3        | 5/20       | 0.25 | 3/20       | 0.15 |
| T4        | 1/20       | 0.05 | 5/20       | 0.25 |
| T5        | 2/20       | 0.1  | 3/20       | 0.15 |
| T6        | 6/20       | 0.3  | 4/20       | 0.2  |
| T7        | 4/20       | 0.2  | 1/20       | 0.05 |

T7: soil treatment with *Heterorhabditis indica* on the appearance of the pest.

In trials for the management of white grubs treatment with the EPN, *Heterorhabditis indica* recorded the least infestation at harvest of 0.05 grubs per 5 plants at harvest and per cent tubers damaged of 0.37 followed by imidacloprid (0.15 grubs/5 plants and 0.30% tubers damaged) drenching at the time of appearance of the pest (Table 57). The same treatments also recorded a yield of 19.99 and 19.33 tonnes/ha as compared to 16.40 tonnes/ha in untreated control (Table 58).

### Component III: Technology assessment & refinement and imparting training

It was planned to conduct on-farm demonstration with K. Giriraj, training for potato farmers in NE states and on-farm farmers' meetings, training, etc.

#### I. On-farm demonstration and training on improved potato technologies

A total of 70 on-farm demonstrations were carried out in the farmers' field in East Khasi

**Table 58. Potato yields recorded in different treatments at harvest**

| Treatments | Average yield (kg/plot) | Average yield (t/ha) |
|------------|-------------------------|----------------------|
| T0         | 9.82                    | 16.40                |
| T1         | 11.05                   | 18.45                |
| T2         | 10.31                   | 17.21                |
| T3         | 11.58                   | 19.33                |
| T4         | 11.42                   | 19.06                |
| T5         | 10.55                   | 17.62                |
| T6         | 9.38                    | 15.67                |
| T7         | 11.97                   | 19.99                |

Hills district of Meghalaya on potato through seed tuber (K.Giriraj).

Kufri Giriraj used for the demonstration recorded an average yield of 18 t/ha, while the local variety used by the farmers recorded only 2.2 t/ha. An average 292 % yield increase was achieved over the farmers' practice in these demonstrations. The farmers expressed their desire to follow the improved methods of potato cultivation (Table 59).



A field day was organized on 12<sup>th</sup> June 2008 at Mawklot village of East Khasi Hills district in Meghalaya. Three on-farm trainings were organized on Integrated disease Management of Potato in Umyingka, Mylliern and Nongpiur villages of East Khasi Hills district on 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> May, 2008 (Table 60).

One on-station farmers' training on "Improved potato production, protection and storage technologies" was organized on 12<sup>th</sup> August 2008 at Central Potato Research Station, Shillong. A

total of 50 farmers participated in the training.

Three farmers' training on "Improved potato production, protection and storage technologies" was also organized at three different locations of NEH region. The details are furnished below (Table 61).

Thirty eight on-farm demonstrations on TPS 92-PT-27 in Meghalaya and Arunachal Pradesh were conducted.

**Table 59. Details of on-farm demonstration conducted in East Khasi Hills district of Meghalaya**

| Sl. No | Name of the farmers     | Village   | Farmers Yield (t/ha) | Demonstration Yield (t/ha) |
|--------|-------------------------|-----------|----------------------|----------------------------|
| 1.     | Smt.Triolian Myrthong   | Sanmer    | 2.5                  | 6.75                       |
| 2.     | Smt.Britilian Myrthong  | -Do-      | 2.0                  | 8.5                        |
| 3.     | Smt.Shridamon Kurkalang | -Do-      | 2.1                  | 7.25                       |
| 4.     | Smt.Judialin Nongkhlaw  | -Do-      | 2.0                  | 6.75                       |
| 5.     | Smt. Prabon Marbaniang  | -Do-      | 1.5                  | 6.5                        |
| 6.     | Smt. Iahunlang Lyndoh   | Nongpyiur | 0.5                  | 2.5                        |
| 7.     | Smt.Wesbilin Lyngdoh    | -Do-      | 0.8                  | 4.0                        |
| 8.     | Smt.Shida Thawmuit      | -Do-      | 1.3                  | 3.5                        |
| 9.     | Smt.Therina Kharluki    | -Do-      | 2.1                  | 7.5                        |
| 10.    | Smt.Klenibel Lyngdoh    | -Do-      | 0.5                  | 3.0                        |
| 11.    | Mr.Press Thawmuit       | Myrkhan   | 3.5                  | 12                         |
| 12.    | Mr.Rul Thawmuit         | -Do-      | 4.0                  | 15.5                       |
| 13.    | Mrs. Grestina Kurkalang | -Do-      | 2.0                  | 8.5                        |
| 14.    | Mrs.Klaidor Thawmuit    | -Do-      | 2.1                  | 5.0                        |
| 15.    | Mrs.Thewmon Muiirian    | -Do-      | 3.2                  | 12.5                       |
| 16.    | Smt. Tusbina Mawlong    | Umyingka  | 3.5                  | 11.5                       |
| 17.    | Smt.Verydalyne Kharin   | -Do-      | 2.9                  | 5.9                        |
| 18.    | Smt. Patricia Nongkhlaw | -Do-      | 3.2                  | 11                         |
| 19.    | Smt.Idonis Mawlong      | -Do-      | 2.5                  | 7.5                        |
| 20.    | Shri. Kampher Kharir    | -Do-      | 1.3                  | 2.5                        |
| 21.    | Smt. Shammon Dkhar      | Laitmysaw | 2.0                  | 8.0                        |
| 22.    | Smt.Jhaibok Pyrtuh      | -Do-      | 2.6                  | 5.5                        |
| 23.    | Smt.Youtis Thawmit      | -Do-      | 3.9                  | 7.5                        |
| 24.    | Smt. Kesmina Kharkrang  | -Do-      | 1.5                  | 5.0                        |
| 25.    | Smt. Basantina Khakrang | -Do-      | 0.8                  | 2.5                        |
| 26.    | Edolis Nongneng         | Mawklot   | 0.9                  | 4.0                        |
| 27.    | Krecybel Lyngdoh        | -Do-      | 1.5                  | 7.5                        |
| 28.    | Bardalin War            | -Do-      | 2.5                  | 13                         |
| 29.    | Thrillin Tariang        | -Do-      | 3.2                  | 12.5                       |

Contd...

Contd...

| Sl. No | Name of the farmers        | Village   | Farmers Yield (t/ha) | Demonstration Yield (t/ha) |
|--------|----------------------------|-----------|----------------------|----------------------------|
| 30.    | Baphira Nongkhlaw          | -Do-      | 3.5                  | 12                         |
| 31.    | Smt.Drimasila Nongneng     | -Do-      | 0.5                  | 3.0                        |
| 32.    | Smt.Bilinda Nongneng       | -Do-      | 1.5                  | 8.4                        |
| 33.    | Mr.Firstborn Kharbangar    | Mylliern  | 12.4                 | 21                         |
| 34.    | Mr.Pyndaplang Khyriem      | -Do-      | 10.3                 | 15                         |
| 35.    | Mr. Loren Kharkongor       | -Do-      | 2.3                  | 10                         |
| 36.    | Mr. Ribor Khyriem          | -Do-      | 1.5                  | 5.0                        |
| 37.    | Mr. Welin Nongkhlaw        | -Do-      | 2.0                  | 7.5                        |
| 38.    | Mr.Loin Nongkhlaw          | -Do-      | 2.9                  | 8.0                        |
| 39.    | Smt Bluebell K.sohnoh      | -Do-      | 1.5                  | 3.4                        |
| 40.    | Smt.Banrihun Syiem         | -Do-      | 2.1                  | 8.5                        |
| 41.    | Mr.Octobernes Kharkongor   | -Do-      | 3.6                  | 11.25                      |
| 42.    | Mr.Ondro Nongkhlaw         | -Do-      | 10.6                 | 21.3                       |
| 43.    | Smt. Meris Langstieh       | -Do-      | 3.8                  | 17                         |
| 44.    | Smt.Kdis Nongsteng         | -Do-      | 3.3                  | 13.6                       |
| 45.    | Smt. Leona Kurkalang       | -Do-      | 0.9                  | 5.5                        |
| 46.    | Smt.Siralin Pathaw         | -Do-      | 2.1                  | 7.5                        |
| 47.    | Smt.Siphina Khyriem        | -Do-      | 1.2                  | 4.25                       |
| 48.    | Smt. Iniew Langstieh       | -Do-      | 3.4                  | 17                         |
| 49.    | Smt.Marydalin Syiem        | -Do-      | 0.8                  | 3.4                        |
| 50.    | Smt. Batsila Kharmawphlang | -Do-      | 1.6                  | 7.5                        |
| 51.    | Smt. Shailinda Kurkalang   | -Do-      | 2.1                  | 4.25                       |
| 52.    | Smt.Bis Kharkongor         | -Do-      | 1.9                  | 11.9                       |
| 53.    | Smt. Tiop Kurkalang        | -Do-      | 2.1                  | 11.9                       |
| 54.    | Smt. Smirian Sohtun        | -Do-      | 4.9                  | 21.25                      |
| 55.    | Smt. Sweety Syiem          | -Do-      | 0.6                  | 2.85                       |
| 56.    | Smt. Philinda Kurkalang    | -Do-      | 1.6                  | 6.0                        |
| 57.    | Smt. Vitcelbin Langstieh   | -Do-      | 10.8                 | 22.2                       |
| 58.    | Shri. K. Kharbudnah        | Sanmer    | 3.8                  | 20                         |
| 59.    | Smt.Wanmon Kharbudnah      | -Do-      | 1.7                  | 6.5                        |
| 60.    | Shri.Qdsingli Nongkhlaw    | -Do-      | 2.6                  | 7.5                        |
| 61.    | Smt. Droi Nongkhlaw        | -Do-      | 1.6                  | 7.5                        |
| 62.    | Shri Donkumar Kurkalang    | -Do-      | 2.5                  | 6.25                       |
| 63.    | Shri Kwell Nongbri         | Mylliern  | 3.2                  | 6.0                        |
| 64.    | Smt.Tngency Thawmuit       | Nongpyiur | 1.9                  | 11.05                      |
| 65.    | Smt. Kerlin Dkhar          | -Do-      | 0.8                  | 6.4                        |
| 66.    | Shri Kedarwell Dkhar       | -Do-      | 1.6                  | 5.0                        |
| 67.    | Shri. Eveningstar Dhkar    | -Do-      | 1.3                  | 8.0                        |
| 68.    | Smt.Intimai Pathaw         | Mylliern  | 0.8                  | 5.0                        |
| 69.    | Smt. Etreny Langstieh      | -Do-      | 1.7                  | 3.5                        |
| 70.    | Phaitimai Kharbudnah       | Sanmer    | 2.8                  | 5.5                        |

**Table 60. Details of on- farm farmers' training on Disease Management of potato**

| S. No | Date of training | No. of farmers attended training | Venue             |
|-------|------------------|----------------------------------|-------------------|
| 1.    | 07/05/08         | 46                               | Umyingka Village  |
| 2.    | 08/05/08         | 50                               | Mylliem Village   |
| 3.    | 09/05/08         | 37                               | Nongpyiur Village |

**Table 61. Details of farmers' training on "Improved potato production, protection and storage technologies**

| S. No | Date of training         | No. of farmers | Venue                                                           |
|-------|--------------------------|----------------|-----------------------------------------------------------------|
| 1.    | 17th - 18th October 2008 | 76             | ICAR Research complex for NEH Region, Manipur centre, Imphal.   |
| 2.    | 20th -21st October 2008  | 32             | ICAR Research complex for NEH Region, Tripura centre, Agartala. |
| 3.    | 12th November 2008       | 17             | Nalbari, Assam.                                                 |



**On-farm training on Integrated disease Management of Potato , May 7<sup>th</sup>-9<sup>th</sup> 2008**



**Field day on Harvesting & Post-harvest Technologies in Potato held at Shillong, June 13<sup>th</sup> 2008**



**On- station farmers' training on "Improved potato production, protection and storage technologies", August 12<sup>th</sup> 2008**



14. National project on organic farming (funded by Ministry of Agriculture, Department of Agriculture and Cooperation, Govt. of India, New Delhi)

The work on national project on organic farming has been initiated from January, 2009 for increasing availability of bio-resources and improving their quality for use as nutrients sources under potato based cropping system in order to develop manurial and cultural practices for nutrients, water, weed and insect-pest management. The programme also includes training on production and quality control of organic inputs, organic farming systems and field demonstration on organic inputs to farmers/extension workers. The long term input of organic farming practices on soil health, crop productivity,

profitability and quality will also be evaluated. At present, ten demonstrations on use of organic inputs under potato based cropping has been laid out at Theog and Mashobra in Shimla district.

15. *In vitro* mass micropropagation and protected production of Micro/Mini tubers of processing and common potato varieties suitable for hills

Mass micropropagation and multiplication of processing and common potato varieties suitable for hills and protected minitubers production was under taken and a total of 36440 microplants of eight varieties have been produced for mini tuber production.

#### On farm training on Improved Potato Production, Protection & Post Harvest Technology



Lembucherra, Tripura



Nalbari, Assam



Lamphelpat, Manipur

## 16. Sustainable livelihood improvement through need based integrated farming system models In disadvantaged districts of Bihar -Sub - project: Scientific cultivation of seed and ware (processing) potato

The above work was divided into two major components viz., i) production of quality seed employing seed plot technique and, ii) cultivation of processing varieties using improved agronomic practices.

- I. Under the first component i.e. production of quality seed; a group of thirteen farmers were selected. These farmers were provided with breeder seed of high yielding variety, Kufri Pukhraj to produce foundation seed at their fields. In the beginning, farmers were imparted training on seed plot technique and given live demonstrations at CPRI farm. In variable plot size, thirteen farmers grew the seed crop covering an area of 2.0 ha. The agronomic practices were supervised at farmer's fields by scientists and technical staff at very regular intervals. The seed crop was got certified by seed certification agency of state government. A total of 337.4 q seed was produced.
- II. Under second component of project i.e. use of improved agronomic practices for cultivation of processing potatoes, a total of twenty-five

farmers were selected. Twelve farmers were given the breeder seed of variety, Kufri Chipsona-I and thirteen farmers were given the seed of another variety, Kufri Kanchan. The farmers were imparted with know-how of growing ware crop for processing purpose through live demonstrations and made aware of different salient points. In the farmers' fields the crops were fully protected against late blight and the yields achieved were 177.4 and 97.0 q respectively in Kufri Chipsona-I and Kufri Kanchan. A quantity of 147.0 q of Kufri Chipsona-I was sold by farmers @ Rs 1000 per quintal.

## 17. Enhanced food and income security in SWCA through potato varieties with improved tolerance to abiotic stress (CIP-CPRI collaborative project)

**Seedling rising: (Dr S V Singh):** The highest clones were selected in the CIP family 305069 (41%), followed by CIP families 305108 (26%), 305111 (23%), 305138 (22), 305086 (20) and 305118 (20%).

**Evaluation and multiplication of CIP late blight/virus resistant clones (SK Luthra) :** Twenty CIP clones (Late blight/virus resistant) were evaluated along with four control varieties (K. Anand, K. Bahar, K. Pukhraj and K. Sadabahar).





**Plant vigour and Foliage maturity:** The results showed that most of genotypes possessed good to very good plant vigour and foliage maturity was in between medium to very late.

**Tuber yield:** None of the CIP clone produced significantly higher marketable and total tuber yield than the best control at 75 and 90 days crop duration.

**Total tuber yield:** CP4047 (385 g/plant at 75 DAP) and CP4050 (507 g/plant at 90 DAP) produced at par total tuber yield with best control K Pukhraj (404 g/plant at 75 DAP) and K Anand (497 g/plant at 90 DAP), respectively.

**Chip colour score:** The results on chip colour score indicated that none of the CIP clone is suitable for chipping purposes

**Multiplication of CIP parental lines through in-vitro plants in net house (SK Luthra):** 425 nodal cutting recovered from 136 test tubes of in-vitro plants of 18 CIP parents received from Shimla were planted in the net house for multiplication.

18. Enhanced food and income security in SWCA through potato varieties with improved tolerance to abiotic stress (CIP, Peru; IST, Germany and CPRI (Funded by GTZ, Germany).



**Multiplication of CIP advance clones through in-vitro plants in net house:** 784 nodal cutting recovered from 235 test tubes of in-vitro plants of 31 CIP advance clones (under GTZ) received from Shimla were planted in the net house for multiplication. The high average tuber weight (g) was recorded in CP4209 (38g) followed by CP4187 (36), CP4193 (33), CP4206 (33), CP4212 (31), CP4199 (30 g). The tuber material of these genotypes has been supplied (Kufri for late blight screening) or kept for supply to Ladol (20 genotypes for heat stress). The leftover tuber material of these genotypes has been kept for next year multiplication at Modipuram

Yield maintenance was highest CIP clone 395109.29 followed by CIP clone 396037.15 under reduced irrigation treatments, these two clones seems to be promising for drought prone agro-ecologies. CIP clone 395109.29 possesses resistance to late blight as well.

19. Understanding vermicompost technology: Analysis, experimentations and standardization of practices (DST funded project)

In this multilocal project local specie of earth worm were collected and their efficiencies of converting dung into vermicompost were compared with standard species *Eisina*





foetida Nutrient status of fresh dung with 45 days old compost is being carried out for macro, micro and heavy metal estimation

20. Standardization of conventional storage technology for potatoes using CIPC (Funded by Uttar Pradesh Council of Agricultural Research)

**Experiment 1:** Effect of Ca fertilization on quality of potatoes stored at 10-12 °C with CIPC

- Ca application tended to slow down senescence in cv Kufri Bahar at 105 days
- Ca (200 kg/ha) increased total tuber yield significantly in cv Kufri Bahar (27.7%) and Kufri Chipsona-3 (14.4%); but Kufri Sindhuri did not follow the trend
- Ca dose (200 kg/ha) significantly increased specific gravity of tubers in cv K. Bahar and K. Sindhuri over control, however K. Chipsona-3 remained uninfluenced
- Chip colour score improved and glucose content decreased with increased Ca level (200 kg/ha) in cv K. Chipsona-3 in comparison to control

**Experiment 2:** To find out the effect of organic nutrition and homeopathic product on quality of potatoes during storage

- Senescence hastened in organically fertilized plots in comparison to inorganic one in all the three varieties
- Marketable and total tuber yield was higher in inorganic treatment compared to organic + homeopathic source of nutrition during first year
- Specific gravity responded positively to inorganic source over organic + homeopathic nutrition in all the three cultivars
- Chip colour deteriorated with inorganic nutrition, while it improved significantly in organic + homeopathic treatment

21. Symmetric and Asymmetric somatic hybridizations for potato improvement (AP Cess funded)

Symmetric somatic hybridization

Symmetric somatic hybridization through protoplast electrofusion was carried out between androgenic dihaploid C-13 and 1 EBN diploid *Solanum* wild species *S. bulbocastanum*, *S. commersonii*, *S. circaecifolium*, *S. etuberosum* and *S. pinnatisectum*. Of several independent electrofusion experiments, in total 188 putative somatic hybrids, 14 for C-13 + *S. pinnatisectum*, 40 for C-13 + *S. etuberosum*, 24 for C-13 + *S. bulbocastanum* and 110 for C-13 + *S. commersonii*, were developed and regenerated using the protocol developed in our laboratory. Fusion cultures between C-13 + *S. circaecifolium* could not be regenerated into plantlets till date.

Characterization of somatic hybrids

RAPD fingerprinting analysis using random decamer primers (OPERON) was performed for characterization of these putative somatic hybrids. A total of 15 decamer primers, 4 from OPAC series (OPAC-06, OPAC-09, OPAC-13 and OPAC-14), 5 from OPAQ series (OPAQ-02, OPAQ-14 to 16 and OPAQ-20), 3 from OPAT series (OPAT-03, OPAT-06 and OPAT-09), and one each from OPD (OPD-03), OPG (OPG-09) and OPK (OPK-06), were used for RAPD analysis. DNA was isolated from in vitro plantlets of putative somatic hybrids and all the parental genotypes following CTAB procedure. The isolated pure DNA was subjected to PCR amplification using individual decamer primer following standard protocol. Amplified DNA was resolved on 1.6% agarose gel, stained with ethidium bromide and photograph of fingerprint pattern was taken by multiimager. Fingerprint pattern of all the putative somatic hybrids, respective parental genotypes separately and in combination by pooling DNA of both the parental genotypes were analyzed for confirmation of somatic hybrids. Presence of the same DNA fingerprint pattern generated by combined parents and individual putative somatic hybrids was looked for, and based on similarity of

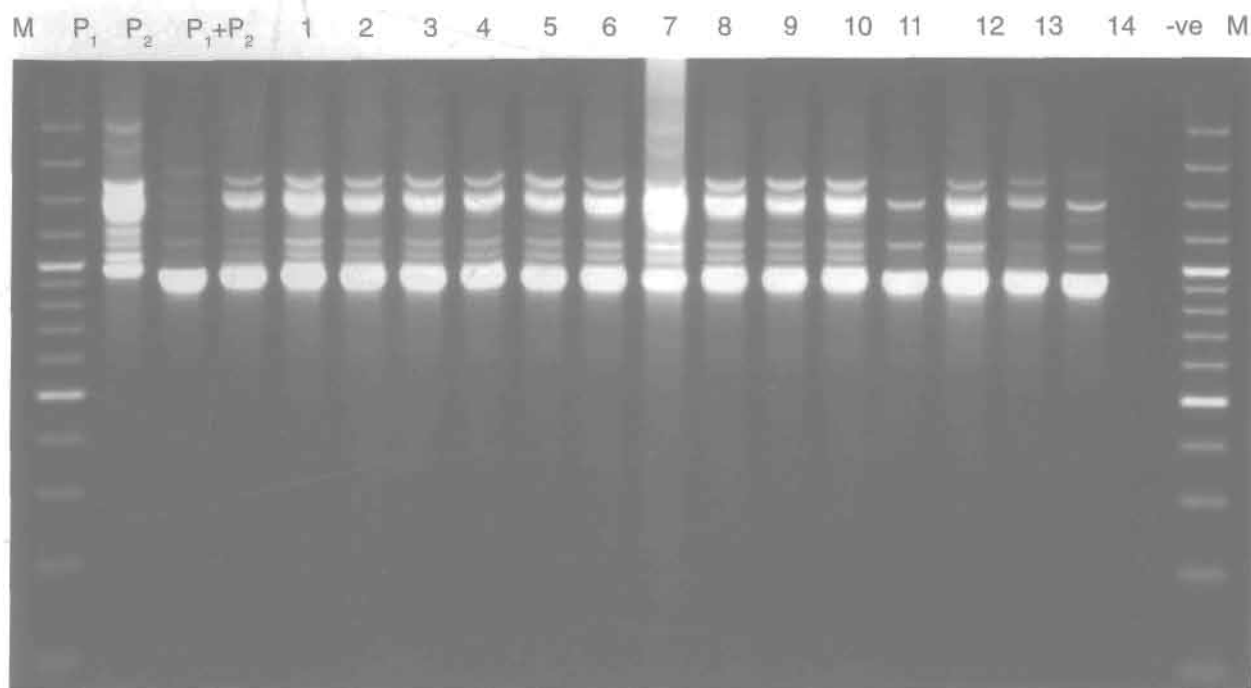


Fig. 41. DNA fingerprint profile (RAPD) of somatic hybrid clones of C-13 + *S. pinnatisectum* using primer OPAC-14. M = 100 bp ladder, P<sub>1</sub> (Parent 1) = C-13, P<sub>2</sub> (Parent 2) = *S. pinnatisectum*, P<sub>1</sub>+P<sub>2</sub> = Combined parental DNA and -ve (negative control) = distilled water. Twelve somatic hybrid clones No. 1 to 10, 12 and 13 were identified as true somatic hybrid. Whereas, 2 somatic hybrid clones No. 11 and 14 were not true somatic hybrids.

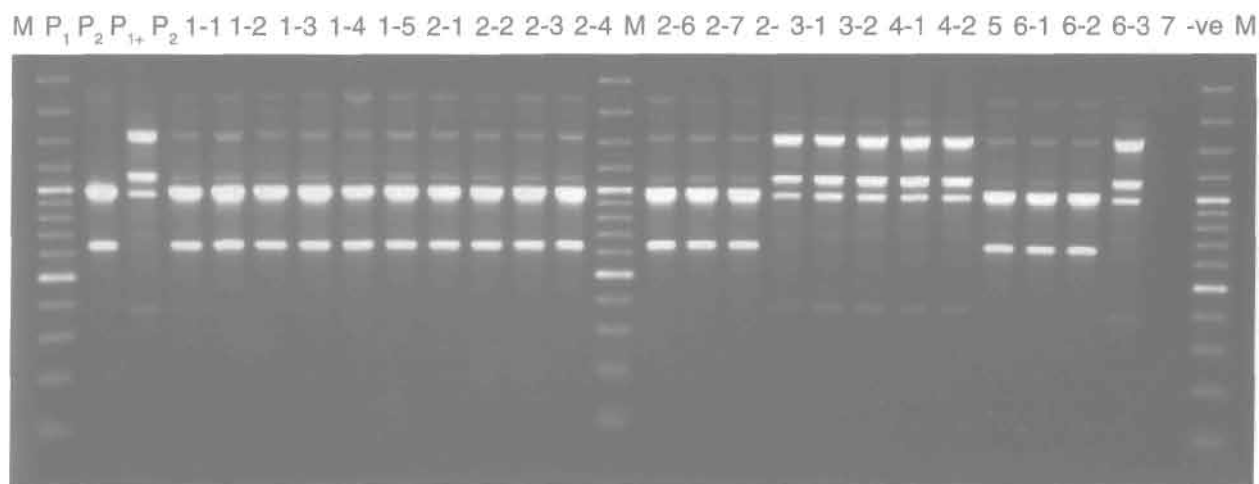


Fig. 42a. DNA fingerprint profile (RAPD) of somatic hybrid clones of C-13 + *S. etuberosum* using primer OPAC-13. M = 100 bp ladder, P<sub>1</sub> (Parent 1) = C-13, P<sub>2</sub> (Parent 2) = *S. etuberosum*, P<sub>1</sub>+P<sub>2</sub> = Combined parental DNA and -ve (negative control) = distilled water. Fifteen somatic hybrid clones No. 1-1 to 1-5, 2-1 to 2-4, 2-6 to 2-8, 6-1 to 6-3 were identified as true somatic hybrids. Whereas, 6 somatic hybrid clones No. 3-1, 3-2, 4-1, 4-2, 5 and 7 were not true somatic hybrids (Continued on Fig. 42b).

M P<sub>1</sub> P<sub>2</sub> P<sub>1</sub>+P<sub>2</sub> 8 9 10 11 12 13 14-1 14-2 M 15 16 17-1 17-2 19-1 19-3 19-7 20-2 20-5 20-7 20-8 -ve M

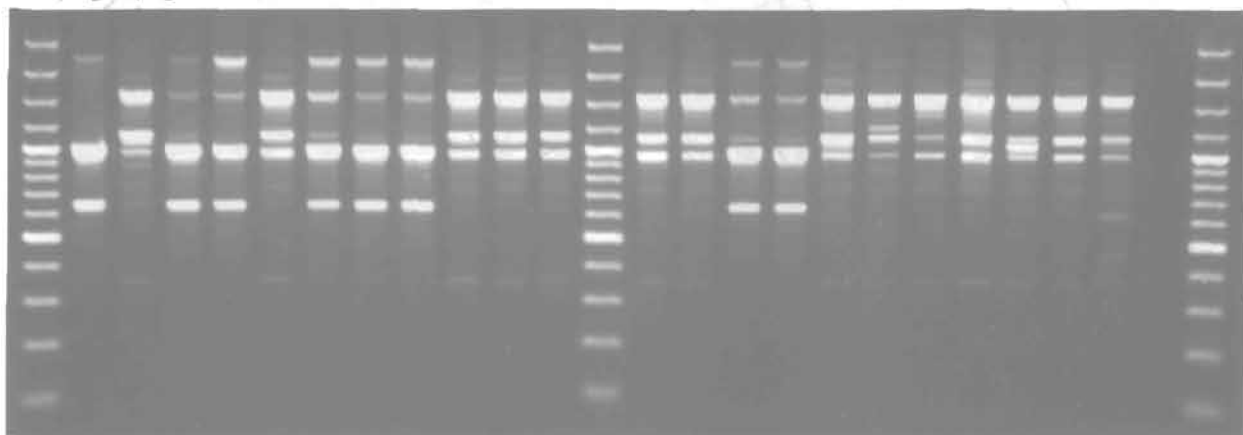


Fig. 42b. (Continued from Fig. 6a) DNA fingerprint profile (RAPD) of somatic hybrid clones of C-13 + *S. etuberosum* using primer OPAC-13. M = 100 bp ladder, P<sub>1</sub> (Parent 1) = C-13, P<sub>2</sub> (Parent 2) = *S. etuberosum*, P<sub>1</sub>+P<sub>2</sub> = Combined parental DNA and -ve (negative control) = distilled water. Six somatic hybrids clones No. 8, 10 to 12, 17-1 and 17-2 were identified as true somatic hybrids. Whereas, 13 somatic hybrids clones No. 9, 13, 14-1, 14-2, 15, 16, 19-1, 19-3, 19-7, 20-2, 20-5, 20-7 and 20-8 were not true somatic hybrids.

fingerprint pattern individual clone was confirmed as somatic hybrid or not.

Twelve out of fourteen clones of C-13 + *S. pinnatisectum* generated DNA fingerprint pattern similar to the fingerprint of combined parents as revealed by 15 above mentioned random decamer primers. These twelve clones are No. 1 to 10, 12 and 13. Whereas, fingerprint pattern of two clones, No. 11 and 14, differed from that of the combined parents. Fingerprint pattern, generated by OPAC-14, was shown in Fig. 41. Three distinct DNA fragments of 987, 1579 and 1743 bp were amplified for combined parents using the random decamer primer, OPAC-14, which were present in clones No. 1 to 10, 12 and 13, but absent in clone No. 11 and 14 (Fig. 41). Similar trend was observed for the other 14 decamer primers used for analysis. Therefore, based on the RAPD fingerprinting pattern the twelve clones (No. 1 to 10, 12 and 13) were identified as true somatic hybrids. Clone No. 11 and 14 were not true somatic hybrids, and might be homokaryon of either of the parents.

Twenty one out of forty clones of C-13 + *S. etuberosum* generated DNA fingerprint pattern similar to the fingerprint of combined parents as revealed by 15 above mentioned random decamer primers. These 21 clones are No. 1-1 to 1-5, 2-1 to 2-4, 2-6 to 2-8, 6-1 to 6-3, 8, 10 to 12, 17-1 and 17-2. Whereas, fingerprint

pattern of 19 clones No. 3-1, 3-2, 4-1, 4-2, 5, 7, 9, 13, 14-1, 14-2, 15, 16, 19-1, 19-3, 19-7, 20-2, 20-5, 20-7 and 20-8 differed from that of the combined parents. Fingerprint pattern, generated by OPAC-13, was shown in Fig. 42a and 42b. Five distinct DNA fragments of about 626, 975, 1134, 1564 and 2319 bp were amplified for combined parents using the random decamer primer, OPAC-13, which were present in 21 clones No. 1-1 to 1-5, 2-1 to 2-4, 2-6 to 2-8, 6-1 to 6-3, 8, 10 to 12, 17-1 and 17-2 but absent in 19 clone No. 3-1, 3-2, 4-1, 4-2, 5, 7, 9, 13, 14-1, 14-2, 15, 16, 19-1, 19-3, 19-7, 20-2, 20-5, 20-7 and 20-8 (Fig. 42a and 42b). Similar trend was observed for the other 14 decamer primers used for analysis. Therefore, based on the RAPD fingerprinting pattern the 21 clones (No. 1-1 to 1-5, 2-1 to 2-4, 2-6 to 2-8, 6-1 to 6-3, 8, 10 to 12, 17-1 and 17-2) were identified as true somatic hybrids. Clone No. 3-1, 3-2, 4-1, 4-2, 5, 7, 9, 13, 14-1, 14-2, 15, 16, 19-1, 19-3, 19-7, 20-2, 20-5, 20-7 and 20-8 were not true somatic hybrids, and might be homokaryon of either of the parents.

Twenty four clones of C-13 + *S. bulbocastanum*, and 110 clones of C-13 + *S. commersonii* were fail to generate DNA fingerprint pattern similar to the fingerprint of their combined parents by 15 above mentioned random decamer primers. These all the clones were produced the DNA fingerprint of only one parent. Therefore, these



twenty four clones of C-13 + *S. bulbocastanum*, and 110 clones of C-13 + *S. commersonii* were not true symmetric somatic hybrids.

## 22. Value chain of potato and potato products (NAIP funded)

- A total of 5000 micro plant/microtuber produced in tissue culture laboratory which were further multiplied in net house leading the 40,000 minitubers.
- FYM and Vermi compost were found to be the best medium for production of minitubers under net house.
- Yield of 159 gm/plant were achieved under Vermi compost followed by FYM (141 gm/plant) and Cocopit (123 gm/plant).
- Optimal NPK dose for produce of minitubers under net house was found to be 90 kg N, 60 kg P and 70 kg K.
- Aseptic culture of seven potato varieties were established and role of various factor such as growth hormone, light intensity, sucrose concentration etc, is being studied.
- Recombinant protein of virus PVX & PLRV were developed and over expressed in presence of IPTG. However, the problem was encountered in detection of recombinant protein. The efforts are on in this direction.
- Results of the multilocation trial on evaluation of advanced hybrid for their suitability for French fries making revealed that hybrid MP/98-71 was the best in terms of French fry grade yield and processing attributes specially French fry texture. There was no oil soaking and no sogginess was observed up to 3 minutes. The laboratory tests were validated at industrial scale testing.
- Cumulative tuber damage after harvesting was 26.6% which increased to 48.09% after heaping. The peeling losses increased by 1.9%, 12.9% and 9.1% in de skinning, shatter bruised and cracked tuber respectively as compared to undamaged tuber.
- French fry grade and total tuber yield was not influenced by soil fertility.
- Across the fertilizer regimes, total and French fry grade tuber yield was highest in hybrid MP/98-71 (378.2 and 143.3 q/ha respectively) as compared to variety Kufri Surya and Kufri Chipsona-1.
- Crop geometry of 67.5x27.5 cm was optimum for getting higher proportion of French fry grade tuber yield.
- Long term storage studies revealed that hybrid MP/98-71 can be stored up to 150 days for making French fry.
- Amongst all the variety tested least acrylamide content was recorded in Kufri Chipsona-1 (53 ug/kg) as compared to 694 ug/kg in Kufri Ashoka. A positive correlation was recorded between acrylamide content and reducing sugar.
- Out of 16 cultivars evaluated for antioxidant richness, Kufri Surya contained highest ascorbic acid and carotenoids (20.4 mg/100 g FW and 44.4 ug/100g FW respectively) with moderate content of phenols (78.1 mg/100 g FW).
- In salad category cv. Kufri Pukhraj was adjudged the best as its tuber had waxy texture, shallow eyes, oval shape and golden yellow flesh colour. In the baby potato segment cv Kufri Chipsona-1, Kufri Chipsona-2, Kufri Lauvkar and Kufri Himsona were found suitable.
- Studies on production technology of salad potatoes revealed that cv. Kufri Pukhraj produced significant higher salad size tuber yield (282 q/ha). The 90 days crop duration was adjudged best and the recommended level of NPK (180:80:100 kg/ha) was found ideal for salad potato production.
- Studies on baby potato production revealed that 50% of recommended dose of NPK was most ideal for baby potato production. Besides crop duration of 60 days was identified the best for this purpose.
- Proximate composition of raw potato, mash potato and potato peel has been determined. The crude fibre content of raw potato, mash potato and dry potato peel is 0.9 and 7.49 to 18.8% respectively.
- The average bulk density of potato pulp was between 820-911 kgm<sup>-3</sup>. The average bulk density of potato peel was between 759 to 764 kgm<sup>-3</sup>.
- 67% of ground potato peels and pulp particles have an average size in the range of 111.74-384.09  $\mu$ m.
- Three sets of questionnaire were developed and baseline surveys were carried out in two States (UP and Punjab). Questionnaire on estimation of demand for French fries and specially potato in NCR and the results are awaited.

# Library and Documentation Services



**I**ntroduction: 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 55 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 1010 documents were purchased, procured and added to library resources. The total collection at Shimla stand at 34666 documents comprised of 13208 books, 14366 back volumes of journals, 2430 serials, 2125 annual reports, 582 theses, 251 standards, 41 maps/atlasses and 1663 reprints. The libraries at six regional stations and one campus at Modipuram are having their own library collection of 26089 books; journals back volumes and other documents i.e. AR/Reprints and Bulletins etc as per the details below (Table 62).

## Periodicals and Serials Management

Twenty-nine serials title i.e. advances, annual reviews, reference annuals, yearbooks and

statistical data publications etc. were purchased. A total of 229 current journals comprising of 67 foreign and 162 Indian have been subscribed at Shimla. Out of which 48 foreign and 136 Indian journals were subscribed on payment basis and rest on exchange or gratis. In all 1247 issues of such journals were received, marked and kept in library for use. Besides 107 titles of different journals were subscribed at CPRS libraries. 2680 entries of library documents were made in Library Automation Software and 25 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 62. Library Collection of CPRIC & CPRS.**

| Regional Stations  | Books        | Back vols.<br>of Journals | Other<br>Documents<br>(AR/Rpr/Bull) | Total        | Current Journals<br>subscribed |           |
|--------------------|--------------|---------------------------|-------------------------------------|--------------|--------------------------------|-----------|
|                    |              |                           |                                     |              | Indian                         | Foreign   |
| 1 CPRIC, Modipuram | 3863         | 5490                      | 2196                                | 11549        | 27                             | 3         |
| 2 CPRS, Jalandhar  | 2856         | 1401                      | 1078                                | 5335         | 30                             | 3         |
| 3 CPRS, Patna      | 1826         | 1199                      | 13                                  | 3038         | 18                             | 3         |
| 4 CPRS, Gwalior    | 567          | 4                         | 326                                 | 897          | 1                              | 3         |
| 5 CPRS, Ooty       | 1333         | 1838                      | 533                                 | 3704         | 13                             | 3         |
| 6 CPRS, Shillong   | 1289         | -                         | 133                                 | 1422         | -                              | 3         |
| 7 CPRS, Kufri      | 144          | -                         | -                                   | 144          | -                              | -         |
| <b>TOTAL</b>       | <b>11878</b> | <b>9932</b>               | <b>4279</b>                         | <b>26089</b> | <b>89</b>                      | <b>18</b> |

### Computerized & Net Based Services

New library web portal has been designed integrating all library resources and services. The institute scientists were facilitated with online full text access to 48 foreign subscribed journals and more than 2000+ 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 other services like Recent Articles on Potato (RAP) and Current Journals Received Last Week were regularly updated and maintained on library web page. Now scientists are making use of mostly library resources online from their desktop. Many relevant web sites were visited and information and data were downloaded therefrom for scientists' use.

### Readers and Reference Service

A total of 1924 documents were circulated (borrowed and returned) for home studies and 6150 readers consulted 23609 documents within the library. Besides 41 outside scientists and research scholars of various research organizations consulted the library resources. A total of 1729 job requests were received for 1,70,343 copies of photocopying and printing work of different official documents. 4 new members were enrolled and 15 old members withdrew their library membership due to their transfer or retirement. At present 154 readers are active members of library excluding RAs/SRAs. Library received 9405 reference queries from the users of the library and responded to them satisfactorily.

### Documentation and Information Services

1247 issues of journals (725 issues of national and 522 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. 1,17,829.00 which include the amount charged on account of rendering CDROM searching & photocopying services (Rs. 7,349.00), IGNOU computer practical (Rs. 26,200.00) and library discount (Rs. 84,280.00) in addition to normal 10% GOC discount saved on purchase of library books and journals through CPRI Book Store. A total of Rs. 24,37,202.00 was spent (under Plan Rs. 15,00,000.00 and Non-Plan Rs. 9,37,202.00) on library resources and services developments like purchase of books (Rs. 5,31,212.00), binding of books/journals (Rs. 92,920) and subscription of journals (Rs. 18,13,070.00).

### CDS/ISIS Practical Training

As per MOU between CPRI and IGNOU, New Delhi, 15 days computer, IT, and database creation and operation practical session was organized during 4<sup>th</sup> - 16<sup>th</sup> and 19<sup>th</sup> -20<sup>th</sup> May 2008 for 14 MLIS and 22 BLIS students of IGNOU Study Center, Shimla.

### Infrastructure Development

Ten numbers of book cases, 6 number of double faced book stacks and 16 number addition units thereof, 5 stepping stools, 2 number of online UPS, 10 number of library chairs. 6 number scholar cubicles and 2 number of CD Library- II storage have been procured and added to library facilities.



# Institute Research Council Meeting



The Institute Research Council (IRC) Meeting, 2008 was held at CPRI, Shimla on 23<sup>rd</sup>-25<sup>th</sup> July, 2008. It was attended by 57 scientists from the Headquarters, Institute's Campus at Modipuram and regional stations. The basic objective of this meeting was to review the achievements of 2007-08 and formulate future plan of work for 2008-09 of different research programmes.

Dr. SS Lal, Secretary, IRC welcomed the participants. After the opening remarks by Dr. SK Pandey, Director, CPRI and Chairman, IRC, Heads of Divisions presented action taken report on the decisions and recommendations taken in the last IRC Meeting. All Programme Leaders and participating scientists highlighted the major activities and achievements during 2007-08. Thorough discussions were held on each of the above items and various recommendations have been included in the IRC Proceedings of the Institute.

The important recommendations of IRC Meeting, 2008 are:

1. Pre-breeding and molecular breeding will be done by the concerned breeders in respective breeding programmes for the respective traits as per the requirement of the programme.
2. Storage behavior of advanced hybrids (8-10 hybrids per year) will be studied by surface morphology of the tuber skin with scanning electron microscopy keeping Kufri Pushkar, Kufri Surya and Kufri Chipsona-1 as controls.
3. Advanced hybrids will be selected at crop durations of 65, 75 and 80 days at Jalandhar, Patna and Modipuram, respectively.
4. Advanced hybrids *i.e.* J/99-48, J/99-242, MS/02-1741, MS/02-3964 and 2000P55 will be introduced into AICRP (P) for multi-location trials.
5. More emphasis should be put on development of processing varieties maturing in about 75 days having high dry matter of about 21%.
6. Advanced hybrids MP/2K-516 and MP/01-916 will be introduced into AICRP (P) for multilocation trials mainly in *kharif* centers to start with for 75 and 90 DAP crop duration keeping Kufri Jyoti, Kufri Lauvkar and Atlantic as controls.
7. Genetic coefficients of newly released/processing varieties *viz.* Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3 should be worked out at Modipuram for use in INFOCROP-POTATO model.

8. Nutrient and water use efficiency of all popular varieties may be worked out and physiological and morphological traits related with input use efficiency should be identified.
9. The work on carbon sequestration is to be initiated at Modipuram. The appropriate methodology is to be adopted for this work in long term manurial experiments.
10. Drawing of all the equipments/implements developed by the institute must be completed. The implements for small and marginal farmers should be developed on priority basis.
11. Aero hydroponics system for disease free seed production be developed within 3-4 years for Jalandhar and Modipuram.
12. A brain storming session is to be organized at Jalandhar for design and development of implements suitable for potato production.
13. There should be greater emphasis on storage of potatoes in heaps for processing so that the potato processing industry can also benefit. The relationship between dry matter content and texture of French fries to be studied.
14. Trial with heat tolerant variety Kufri Surya need to be conducted in Goa, Kerala and Karnataka states.
15. Late blight pathogen profiling is presently being done using biological markers – metalaxyl resistance, mating types races *etc.* It should be shifted to the molecular markers (mt haplotypes, microsatellites) for which required facilities may be developed on priority.
16. The meiotic tetraploids deriving resistance from *Solanum verrucosum*, *S. phureja*, *S. microdontum* and *S. chacoense* will be used in hybridization programme.
17. Twenty parental lines including released varieties may be sent to CIP, Lima for knowing the R-gene status of these lines.
18. Capsules for the IPM of white grubs and potato tuber moth to be tested at farmers' fields/stores involving extension scientists.
19. *Trichoderma viride* + Boric Acid combine treatment may be tested at different locations under AICRP on Potato.
20. Buffer stocks of potato varieties maintained in the Division of Seed Technology may be checked once in a year by electron microscopy for virus freedom.
21. Reasons behind low multiplication rate of < 3 g mini tubers of Kufri Chipsona-3 in spite of good rates of multiplication through microplants/microtubers may be looked into along with Kufri Sindhuri and Kufri Kanchan.
22. The Quick survey on Potato Outlook should be conducted in Gujarat, MP, Assam and Chhatisgarh states of India where area and production estimation through remote sensing and GIS is not carried out.
23. Besides economic impact, the effect of technologies on employment generation, industry and consumers should also be studied.



# Research Advisory Committee



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

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



The fifteenth meeting of the Research Advisory Committee (RAC) was held at Central Potato Research Institute, Shimla on 12<sup>th</sup> and 13<sup>th</sup> of June, 2008 under the chairmanship of Dr. M. Mahadevappa, Ex. Chairman, ASRB, New Delhi. The following RAC members were present:

Dr. P.C. Gaur, Dr. A. N. Maurya, Mr. Prakash Lohia, Sh. Devadatta J. Nikam and Chaudhary Mann Singh

## RECOMMENDATIONS OF RAC

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

- *Andigena* is a reservoir of a number of desirable genes. To use them in breeding programmes, it is necessary to develop a novel *Andigena* population which does not have undesirable characters like poor tuber shape and poor bulking, but has high heterogeneity for economic characters like tuber yield and disease resistance. This new population may be used by breeders in breeding programmes for developing new varieties.

Programme 2. Breeding potato cultivars for Indo- Gangetic plains

- Percentage rejection at F1 and F1C1 stages are very high and this could result in loss of valuable material. Percentage rejection may be reduced by not taking yield into consideration at this stage.

Programme 3. Development of varieties and technology for processing

- The RAC recommended the release of hybrid MP/98-71, as no variety suitable for French fries has been released so far.
- Besides Indo-Gangetic plains and the plateau region, the hybrid MP/98-71 should be tried in mid and higher hills also for year round supply of raw material.

Programme 4. TPS technology for potato production

- JEX-722 and JEX-732 are two *Andigena* cultures, which produce large number of small size tubers, and are good combiners. They may be used for developing populations/ varieties for baby potatoes.

Programme 5. Biotechnology in potato improvement

- Biotechnology programme may be strengthened further to have a strong basic research component in the Institute.

Programme 6. Cell biology and somatic cell genetics in potato improvement

No recommendation

Programme 7. Physiological response of potatoes to heat stress

- The information being collected may be disseminated effectively so that users can make decisions based on scientifically estimated area and production, instead of speculating.

Programme 8. Develop sustainable potato based cropping systems

No recommendation

Programme 9. Low input technology for potato production

- Situations/areas where growing bajra before potato will be beneficial and where it will not be beneficial, may be identified.

Programme 10. Integrated nutrient and water management in potato

- Drip irrigation may be tried in flat beds.

Programme 11. Studies on long term manurial and fertilizer application and organic farming in potato production

No recommendation

Programme 12. Mechanization of potato cultivation

- Two scientists from CPRI may visit CIAE, Bhopal and see whether any of the equipments developed by them can be useful for potato, as such or with little improvement.

Programme 13. Management of potato late blight

No recommendation

Programme 14. Diagnostics and detection of pathogens

No recommendation

Programme 15. Integrated disease management

- Increase of 27.3-32.6% in yield of paddy due to *Bacillus subtilis* B5 application appears to be quite high. This may be checked by repeating the experiment.

Programme 16. Integrated pest management

- Whether the plant extracts being used on potato for disease and pest control are safe for human consumption may be checked.

Programme 17. Management of potato nematodes

No recommendation

Programme 18. Storage behaviour and processing quality of potatoes under controlled temperature and non-refrigerated storage systems

- The economics of using volatile compounds as sprout suppressants on potato may be worked out.
- The technology of storing potatoes in heap with CIPC treatment may be popularized for the benefit of small and marginal farmers.

Programme 19. Diversified utilization of potatoes

No recommendation

Programme 20. Seed Technology

No recommendation

Programme 21. Impact of potato technologies developed by CPRI

- A strong link may be developed with KVKs and other extension agencies for quick and effective transfer of technology to farmers.



# Publications



## A. Books:

Annual Report 2007-08

Annual Report Mini Mission-I

Newsletter Vol. No.38 (June, 2008)

Newsletter Vol. No. 39 (December, 2008)

Samahit 2008-09 (Hindi)

Key note Address of Brain Storming session on impact assessment of climate change for research priority.

Impact assessment of climate change for research priority in Horticulture crops.

Potato Workers Directory

Twenty steps towards hidden treasures technologies that triggered potato revolution in India

Indian farming 2008

Indian Horticulture 2008

Phal Phool 2008

Kheti 2008

Proceedings of workshop on Global Climate change and Indian Horticulture : current status and future priorities

Potato - A wholesome Food (*In Telugu*).

Seed and Ware Potato Production Technology for Southern Hills (*In Tamil*).

Potato cyst nematodes and their management in Nilgiris (*In Tamil*).

A Compendium of Climate Based Potato Zones in India.

## B. Folders:

Folder- CIPC (Chloropham) for control of potato tuber Moth in country stores

Folder- On farm storage of potato in heap

## C. Technical Bulletions:

Technical Bulletin No. 86- Inventory of potato Germplasam collection

Technical Bulletin No. 87- Infocrop potato A Model for Simulating growth and yield of pototo in Sub-Tropics

Technical Bulletin No. 88- A compendium of climate based potato zones in India.

Technical Bulletin No. 89-Chipsona Varieties: A success story



Technical Bulletin No. 90-Nutrient Management in Potato

Technical Bulletin No. 91- Soil and Plant Tests for Judicious Use of fertilizers in Potato

Technical Bulletin No. 92- Low Input Technology for Potato Production

Technical Bulletin No. 93- Farm Equipment and Machines for Potato Production

Technical Bulletin No. 94- Status of Dry Matter and Reducing Sugar Content of Potatoes Grown in Major Potato Growing States of India

#### D. Extension Folder:

Extension Folder No. 39- Cultural Management of crops in potato based cropping systems in India

#### E. Software developed

Govindakrishnan, PM, Shashi Rawat, SK Pandey, JP Singh, SS Lal and VK Dua. 2008. "Computer Aided Advisory System for Potato Crop Scheduling (CAASPS)". Central Potato Research Institute, Shimla, Beta Version released on 10.12.2008 in Global Potato Conference, New Delhi.

#### F. Papers published in referred journals:

Arora, R.K. 2008. Management of black scurf of potato with the integrated use of *Trichoderma viride* and boric acid. *Potato J.* **35**:130-33.

Chandel R.S., Brajesh Singh, V.K. Chandra and P.K. Sharma. 2008. Use of CIPC (Isopropyl N-(3-chlorophenyl) Carbamate) for the control of potato tuber moth in country stores. *Potato J.* **35**: 66-71.

Chimote, V.P., Raj Kumar, N. Sharma and S. Kamal. 2008. Nuclear-cytoplasmic diversity in parental genotypes used for Indian early bulking potato (*Solanum tuberosum* ssp. *tuberosum*) breeding programme. *Indian J. Genet.* **68**: 171-76.

Dua, V.K., R.C. Jaiswal, S.C. Khurana, D. Kumar, D.N. Nandekar, M. Raghav, Sanjay Rawal, G.V. Sasani, S.P. Trehana, S.K. Trivedi, M.K. Jatav, S.S. Lal, K.C. Thakur, S.K. Pandey and P.S. Naik. 2008. Manipulation of agronomic

practices for tuber- size distribution in potato (*Solanum tuberosum*) seed crop. *Indian Journal of Agron.* **53**: 210-16.

Ezekiel, R. and Brajesh Singh. 2008. Effect of cooking and processing on CIPC residue concentrations in potatoes and processed potato products. *Potato Research* **50**: 175-84.

Ezekiel, R. Brajesh Singh and P.S. Datta. 2008. Effect of low dose of gamma irradiation on the chipping quality of potatoes stored at 8 and 12°C. *Potato J.* **35**: 31-40.

Ezekiel, R. Brajesh Singh, Dinesh Kumar and Arvind Kumar. 2008. Effect of growing location on the processing quality of two potato cultivars stored at low temperature. *Indian J. Hort.* **65**: 52-59.

Garg, I.D., P. Kaundal, N. Kaushal and S.J. Gawande. 2008. A novel method of storage for potato viruses. *Indian J. Virol.* Vol. No. 36-40.

Gopal, J. 2008. Use of *in vitro* cultures to predict drought tolerance of potato. *Agricell Report* **50**: 13.

Gopal, J., K. Iwama and Y. Jitsuyama. 2008. Effect of water stress mediated through agar on *in vitro* growth of potato. *In Vitro Cellular & Developmental Biology-Plant* **44**: 221-28.

Gopal, J., Vinod Kumar and S.K. Luthra. 2008. Top cross vs. poly-cross as alternative to test cross for estimating the general combining ability in potato. *Plant Breeding* **127**: 441-45.

Gopal, J., V. Kumar, S.K. Pandey, R. Kumar, P.C. Pande and S.V. Singh. 2008. Morphological descriptors for DUS testing of potato varieties. *Plant Genetic Resources Newsletter* **154**: 40-47.

Kashyap, S., S.K. Chakrabarti, D. Pattanayak, K.P. Chandran, D.C. Gautam, V.K. Chandra and P.S. Naik. 2008. A modified artificial diet for rearing potato tuber moth, *Phthorimea operculella* (Zeller). *Potato J.* **35**: 141-46.

Kumar R., G.S. Kang and S.K. Pander. 2008. Estimation of genetic parameters and combining ability for characters related to potato propagation by true potato seed. *Potato J.* **35**: 12-18.

Kumar, N. R., N. K. Pandey, and Rajesh K. Rana. 2008. Production and Marketing of Potato

- in Banaskantha district of Gujarat. *Indian Journal of Agricultural Marketing*. **22**: 99-110.
- Kumar, Parveen, S.K. Pandey, S.V. Singh, B.P. Singh, S. Rawal and Dinesh Kumar. 2008. Evaluation of nutrient management options for potato processing cultivars. *Potato J.* **35**: 46-52.
- Kumar, R. 2007. The canon of potato science: 42. Flowering. *Potato Research* **50**: 383-85.
- Kushwah, V.S. and S.P. Singh. 2008. Effect of intra-row spacing and date of haulm cutting on production of small size tubers. *Potato J.* **35**: 88-90.
- Luthra, S.K., J. Gopal, S.K. Pandey and B.P. Singh. 2008. Evaluation of potato germplasm for adaptability under west-central plains. *Indian J. Hort.* **65**: 446-51.
- Luthra, S.K., J. Gopal, Vinod Kumar, B.P. Singh and S.K. Pandey. 2008. Evaluation of potato germplasm for frost tolerance. *Indian J. Hort.* **65**: 344-46.
- Marwaha, R.S., Dinesh Kumar, S.V. Singh, and S.K. Pandey. 2008. Influence of blanching of slices of potato varieties on chipping quality. *J. of Food Science & Techno.* **45**: 364-67.
- Mehta, A., Brajesh Singh, R. Ezekiel and D. Kumar. 2008. Storage of table and processing potatoes (*S. tuberosum*) with isopropyl N-(3-chlorophenyl) carbamate fog under heap storage. *Indian J. Agric. Sci.* **78**: 343-46.
- Pande, P.C., S.K. Luthra, S.V. Singh, S.K. Pandey and B.P. Singh. 2008. Kufri Sadabahar: A potato variety for Uttar Pradesh. *Potato J.* **35**: 111-17.
- Pandey, S.K. J.P. Singh and J. Gopal. 2008. Potato varieties and cropping systems in India. *Potato J.* **35**: 103-10.
- Pandey, S.K., S.V. Singh, Dinesh Kumar, P. Manivel, R.S. Marwaha, Parveen Kumar, B.P. Singh and V.K. Gupta. 2008. Kufri Himsona: A chipping cultivar for hill regions of India. *Potato J.* **35**: 1-8.
- Pandey, S.K., S.V. Singh, P. Manivel, T.A. Joseph, R.S. Marwaha and Dinesh Kumar. 2009. Performance and stability of indigenous and exotic potato (*Solanum tuberosum* L.) cultivars for processing. *Indian J. Agric. Sci.* **79**: 8-11.
- Rana, Rajesh K., N. K. Pandey, Arun Pandit and N. R. Kumar. 2008. Brand wise expenditure estimates of processed potato products in Punjab. *Indian J. Agri. Market.* **22**: 196-205.
- Singh, Brajesh, R. Ezekiel, Dinesh Kumar and Suresh Kumar. 2008. Reducing sugar content and chipping quality of tubers of potato cultivars after storage and reconditioning. *Potato J.* **35**: 23-30.
- Singh, J.P., A. Salaria, K. Singh and B. Gangwar. 2008. Efficiency of diversified rice-wheat cropping systems including potato, vegetable peas and groundnut crops in trans-Gangetic plains. *Potato J.* **35**: 53-60.
- Singh, J.P., V.K. Dua, S.S. Lal and S.K. Pandey. 2008. Agro-economic analysis of potato-based cropping systems. *Indian J. Fertilisers* **4**: 31-40.
- Singh, R.K., J.P. Singh and S.S. Lal. 2008. Dry matter partitioning relative to development in high yielding Indian potato cultivars under short day tropical conditions. *Potato J.* **35**: 161-66.
- Singh, S.N., S.P. Trehan and M. Kumar. 2008. Response of potato cultivars to nitrogen in the plains of Bihar. *Potato J.* **35**: 158-60.
- Singh, S.P. and V.S. Kushwah. 2008. Effect of prolonged use of small sized tubers on mosaic incidence, yield and other growth parameters. *Potato J.* **35**: 91-93.
- Singh, S.V., S.K. Pandey, D. Kumar, R.S. Marwaha, Parveen Kumar and P. Manivel. 2008. Potential of advanced potato (*Solanum tuberosum*) hybrids for processing in Agra and Indore region of west-central plains. *Indian J. Agri. Sci.* **78** : 198-202.
- Somani, A.K. 2008. Resistance in potato against charcoal rot and incidence of tuber rot. *Potato J.* **35**: 94-96.
- Trehan, S.P., R.C. Sharma and S.K. Roy. 2008. Recycling of crop residues for efficient and optimum use of mineral fertilizers in potato-onion-groundnut rotation. *Advances in Hort. Sci.* **22**: 191-96.
- V.K Chandra and R.S. Chandel. 2007 (published in 2008). Integrated management of soil pest of potato in higher hills of Himachal Pradesh. *Natl. Acad. Sci. Lett.* **30**: 221-22.

# Institute Activities



## On-farm farmers' training under NABARD RIF Project at Shillong

On-farm farmers' training programme on "Low Cost Storage Technology for Table Potatoes and Potato Seeds" was organised by Central Potato Research Station, Shillong at Madan Ing Syiem village of Myllem block in East Khasi Hills district on 9<sup>th</sup> April 2008. The training programme was organised as part of the NABARD RIF project. The inaugural session was presided by Dr. S Ramani, Head, CPRS, Shillong. Dr. Brajesh Singh, Senior Scientist, CPRI, Shimla and Dr. R Roy Burman, Scientist, Central Potato Research Station, Shillong were the resource persons for the programme. A total of thirty farmers were present in the training.

## Potato farmers' club promoted in Meghalaya

Central Potato Research Station, Shillong promoted the "Myllem Potato Farmers' Club" in East Khasi Hills district of Meghalaya in collaboration with the Myllem branch of Meghalaya Rural Bank with financial assistance from NABARD, Meghalaya Regional Office. The Farmers' Club is a grassroot level informal forum and is organised by Meghalaya Rural Bank with the support and financial assistance from NABARD for the mutual benefit of the banks and rural people. The broad functions of the Farmers' Club include coordination with banks to ensure credit flow among its members and forge better bank borrower relationship, arranging interface with subject matter

specialists in the fields of agriculture and allied activities, fostering liaison with corporate



Farmers training on storage of potatoes



input suppliers to purchase bulk inputs on behalf of members, organising joint activities like value addition, processing, collective farm produce marketing for the benefit of members, sponsoring Self Help Groups (SHGs), undertaking socio-economic and community developmental activities and marketing rural produce and products. The Launch Meeting of Myllem Potato Farmers' Club was organised at Central Potato Research Station, Shillong on 6<sup>th</sup> December 2007 and Ms. MHK Marak, Secretary (Agriculture), Government of Meghalaya was the Chief Guest and representatives from NABARD, the State Department of Horticulture and other officers were present. The club has a membership of 15 persons at present. The launch meeting was followed by a Base Level Orientation & Training Programme in which the resource persons from NABARD, Meghalaya Regional Office trained the farmers about the maintenance and functioning of the club, activities to be undertaken and the procedures to be followed at different stages by the club members. The training programme ended with a positive note from the members of the club and they pledged for dynamism and enthusiasm in carrying out the club activities.

#### On-farm training on disease management

On-farm Training on "Disease Management in Potato" was organized by Central Potato Research Station, Shillong during 7<sup>th</sup> to 9<sup>th</sup> May 2008 at three villages viz., Umlyngka, Myllem and Nongpiur in East Khasi Hills district of Meghalaya. Dr. PH Singh, Principal Scientist, Central Potato Research Institute, Shimla and Dr. RK Arora, Principal Scientist, Central Potato Research Station, Jalandhar were the resource persons for the training. The training programmes were organised as a part of MM-I project on "Integrated Development of Horticulture in NE States including Sikkim". Resource persons imparted training and practical sessions on identification, prevention and control measures of major potato diseases prevalent in this region. A total of 150 farmers (50 farmers each at three different locations) participated in the training programme.

#### PTM awareness camp at Nagrota

An awareness camp on potato tuber moth (PTM) was organized at Block Office, Nagrota in Kangra district of Himachal Pradesh on 12<sup>th</sup> May 2008.

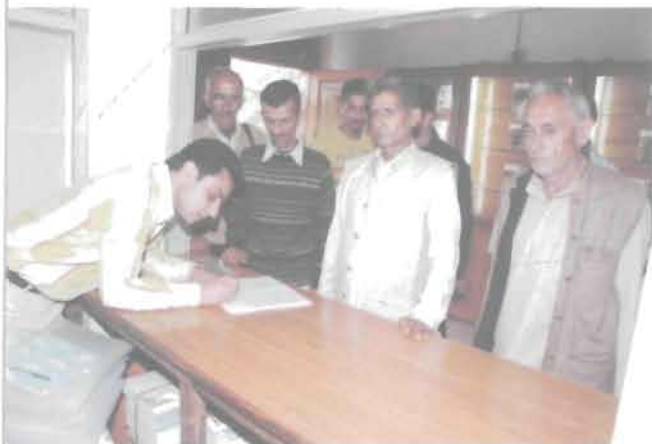
About 50 farmers and traders of the neighbouring villages, viz., Malan, Pathiyar, Ambari, Lakha Mandal, Hatwas and Arla participated in this camp. The scientists, viz., Drs. VK Chandla, Brajesh Singh, Anil Kumar, from CPRI, Dr. RS Chandel, from CSKVV and Dr. Sanjay Kumar, from Pepsico addressed farmers on the various issues related to crop husbandry, PTM control, storage and quality aspects in potatoes. All the farmers were keen to understand the latest PTM control strategies and they also saw the potato exhibition put up by CPRI on this occasion.



Discussion with farmers at PTM camp

#### Farmers' training at CPRI, Shimla

A farmers' training on "Improved Techniques of Seed Potato Production and Post-harvest Technologies" was organized during 8-10 July, 2008 by the Division of Social Sciences at CPRI, Shimla. Although the research Institute like CPRI has been entrusted with conducting trainers' training, this type of arrangement has borne limited success in effecting technology transfer to the farmers owing to inefficiency and lack of professional approach at the state level. Hence, the Institute has started this type of activity to reduce the distortion in technology dissemination.



**Registration of farmers for training at Shimla**

The training was organized for the farmers of Himachal Pradesh in which 16 farmers from 6 major potato growing districts of the state, namely Shimla, Mandi, Sirmaur, Solan, Kullu & Hamirpur participated. During this training course, farmers were given series of lectures consisting of late blight management, PTM & white grub management, healthy seed potato production, seed certification, marketing and strategies for adoption of potato technologies. A field visit to CPRS, Kufri was also organized for the farmers on this occasion.

### Model Training Course

A model training course on "Potato Improvement, Production & Utilization in the Current Indian Scenario" was organized during 16-23 Sept., 2008 at CPRS, Shimla. The training course was sponsored by Directorate of Extension, Ministry

of Agriculture, Govt. of India. The objectives of the training course were, improving the knowledge of the trainee officers regarding seed potato production and certification, improving the skill of the trainee officers regarding seed potato production, and obtaining the feedback from the trainee officers regarding field problems in the adoption of potato production technologies and in the seed certification.

Sixteen (16) extension officers from 9 state departments of agriculture/ horticulture, namely Himachal Pradesh, Haryana, Uttar Pradesh, Gujarat, Jharkhand, West Bengal, Assam, Sikkim and Maharashtra participated in this training course. The training included lecture-cum-discussions, practical sessions, skill demonstrations, field visits and video film shows. In all, 22 lectures were delivered and a field visit to CPRS farm at Kufri was organized during the training course. Pre- and post-training evaluation of the trainees was conducted which revealed 13 per cent improvement in knowledge of the participants.

### Monitoring of NABARD RIF Project at CPRS, Shillong

Central Potato Research Station, Shillong is implementing NABARD Rural Innovation Fund (RIF) project on "Popularising of Low Cost Storage Technology for Table Potato and Potato Seeds" in four villages of East Khasi Hills district of Meghalaya. A team from NABARD headquarter Mumbai visited the station on 17<sup>th</sup> September, 2008 to monitor the project. The team comprised of Mr. B. Jayaraman, General Manager (DEAR); Mr. A. D. Javalekar, Manager; Mr. R. K. Shelar, Manager from NABARD, Mumbai; Mr. N. J. Mupid, AGM; and Mr. S. D. Waghmare, AGM, NABARD from Meghalaya Regional Office, Shillong and Dr. T. Haque, Ex-Chairman, Agriculture Cost & Price Commission and Consultant, Swiss Development Corporation (SDC). Dr. S. Ramani, Head of Station apprised the visitors about the station and its various activities and the activities undertaken in the project. The team alongwith the Head of station and the principal investigator of the project visited the community level seed storage structure and household level storage structure for table potatoes in the project villages. They also interacted with the farmers nominated in this project by the respective village heads and received positive feedback. The work done in this project was highly appreciated by the



**State Extension Officers attending MTC at Shimla**



visitors. The monitoring team met the members of Myllem Potato Farmers' Club, a farmers' club promoted by Central Potato Research Station, Shillong.

### Training to PepsiCo Staff

2-days training course on 'Recent Techniques in Quality Seed Potato Production' for the staff of PepsiCo India Holding Pvt. Ltd. (FritoLay Division, Gurgaon) was organized at CPRI, Shimla during July 31-1 Aug., 2008. In this training course, the trainees were delivered lectures on quality seed potato production, integrated nutrient management for processing potatoes, agronomic practices for potato production for processing purpose and post-harvest technology. The training was attended by 16 participants who were also exposed to a field visit to CPRS, Kufri/Fagu during training course.

### Aloo Pathshala on AIR, Shimla completed

The Division of Social Sciences organized Aloo Pathshala (Potato School) on All India Radio, Shimla to commemorate the International Year of Potato 2008. In this programme, 20 talks on "Recent potato technologies were broadcast from 15 March to 26 July, 2008. At the end of each talk, a question related to that talk was asked from the farmers who were supposed to send their answers on a postcard. An overwhelming response from the farmers was obtained who also provided feedback about the programme and about various potato technologies developed by the Institute. During this programme, a Jingle on potato was also broadcast at the beginning and end of each talk which highlighted the nutritive value of potato and also educated the public on the popular misconception about potato.

An on-station farmers' training on "Improved Potato Production and Protection Technologies" was organized at CPRS, Shillong on August 12, 2008 in which 50 farmers participated. Two training programmes for farmers on "Improved Potato Production, Protection and Post-harvest technology" under MM-1 were organized during 17-18 October, 2008 at ICAR Research Complex for North-eastern region, Manipur Centre, Imphal and during 21-22 October, 2008 at ICAR Research Complex for North-eastern region, Tripura Centre, Agartala in which 60 farmers participated.



Farmers' training at CPRS, Shillong

### Training programme in Lembucherra, Tripura

A one-day training programme for 41 farmers on "Improved Potato Production, Protection and Post Harvest technology" under MM-1 was also organized on 12<sup>th</sup> November, 2008 at ITI, Nalbari, Assam.

### Participation in Kisan Mela

CPRS, Patna participated and put up an exhibition stall in "Krishi evam krishak vikas karmshala-sah-pradarshani rabi 2008" inaugurated by Sh. Nitish Kumar, Hon'ble Chief Minister of Bihar and organized by Govt. of Bihar at Gandhi Maidan, Patna during 16-20 October, 2008. Drs. RP Rai, Barsati Lal, TK Sinha, Sh. Yogesh and Sh. Arjun Kumar Sharma participated in the programme.

### Live Phone-in programme on Doordarshan

Drs. RP Rai and Shambhu Kumar of CPRS, Patna participated in Live phone-in programme on "Aloo ki kheti ki mukhya batein" on October 21, 2008 at Doordarshan, Patna. Dr. Barsati Lal, Scientist (SS) of CPRS, Patna participated in Doordarshan Programme, "Satya aloo beej ki kheti se labh" and "Krishi vikas mein krishi vaigyanikon ki bhumika" under the programme "Krishi Darshan and Gaon Ghar".

### Global Potato Conference-2008

Indian Potato Association, Shimla along with Central Potato Research Institute, Shimla and



Indian Council of Agricultural Research, Govt. of India, New Delhi celebrated the "International Year of the Potato" by organizing the Global Potato Conference in New Delhi during 9-12 December, 2008. The year 2008-09 also happens to be the Diamond Jubilee year of CPRI, Shimla. The conference was sponsored by a group of 24 public and private institutions from India and abroad. It was attended by over 550 delegates from more than 30 countries like USA, UK, Germany, The Netherlands, Canada, Australia, Japan, Sweden, Hungary, Argentina, Peru, Chile, Uganda, Bangladesh, Sri Lanka, Pakistan, Bhutan, Nepal, central Asian countries, etc. Besides, a mega exhibition was held at the conference venue to showcase the strength of technologies and inputs in facilitating sustainable agriculture with special emphasis on potato.

#### Inaugural session of GPC-2008 at Vigyan Bhavan

The conference was inaugurated by the Hon'ble Union Minister of Agriculture and Consumer Affairs, Food & Public Distribution Sh. Sharad Pawar on 9<sup>th</sup> December, 2008 in the Plenary Hall of Vigyan Bhavan, New Delhi. Dr. Mangala Rai, Secretary, DARE & DG, ICAR; Sh. Nanda Kumar, Secretary, DAC, GOI; Dr. Pamela Anderson, DG, CIP; Dr. Gavin Wall, FAO Representative in India; Dr. H.P. Singh, DDG (Hort.), ICAR and Dr. S.K. Pandey, Director, CPRI were also present in the inaugural function. The Hon'ble Union Minister of Agriculture emphasized on the role of horticulture as the best option for crop diversification. He also elaborated the success of potato research & development in India and challenges ahead. Dr. Mangala Rai, DG, ICAR

stressed the importance of developing varieties with novel traits, application of biotechnology for breaking the yield barrier, production of quality planting materials, efficient management of natural resources, and better utilization of potato. Dr. Gavin Wall, FAO Representative in India elaborated the purpose of declaring the year 2008 as the International Year of the Potato. Dr. Pamela Anderson, DG, CIP emphasized on the role of potato as a vehicle for poverty alleviation and as an antidote for global food price crisis.

#### Release of CPRI bulletins by Hon'ble Union Agriculture Minister, Sh. Sharad Pawar

There were nine technical sessions, viz., (i) genetic resource management for crop improvement, (ii) potato genomics and biotechnology, (iii) resource management for sustainable production, (iv) potato health management, (v) late blight- the perpetual challenge, (vi) seed production and management, (vii) post-harvest management and value addition, (viii) technology transfer and social concerns, (ix) potato trade and industry, and one satellite meeting on *RB* gene technology for late blight management. There were 75 invited lectures in different sessions out of which about 50 were from outside India. Besides, there were 284 research papers presented as posters during the conference. The technical sessions were held during 10-12 December, 2008 at National Agricultural Science Centre Complex, Dev Prakash Shashtri Marg, New Delhi. The major recommendations of the conference are as follows:



- Commercial potato varieties throughout the world suffer from narrow genetic base, thereby seriously endangering them from unpredictable biotic and abiotic stresses. A long-term global commitment is needed to broaden the genetic base of potato varieties through conventional and/or molecular breeding approaches.
- Transgenics for resistance to late blight, bacterial wilt, tuber moth and for better nutritional and processing quality have been developed by several countries. Food and environment safety of promising transgenic lines should be studied on priority as per national regulatory requirements of different countries.
- The potato genome sequencing is being done by a multinational consortium and hopefully the entire sequence of 840 Mbp potato genome will be available by 2010. Gene annotation for potato genome should be initiated as soon as draft sequence is prepared followed by functional validation of each gene by an international community.
- Preliminary results indicate that there will be significant yield loss with increase in temperature due to global climate change. Proper assessment of climate change should be done and emphasis should be given on adaptation and mitigation research.
- Application of space technology along with the geographical information system has emerged as powerful tool and must be exploited for site suitability analysis, crop assessment and monitoring, providing information on cropping system and post-harvest management planning to support the decisions in potato production.
- The late blight pathogen *Phytophthora infestans* is known to adapt very quickly to changing environment. Global warming may lead to development and selection of pathogen strains to higher temperature regimes which may further risk the outbreak of late blight in warmer areas. Therefore, there is need to monitor and study *P. infestans* population structure on a regular basis using modern molecular tools and disease reaction.
- Several developing countries including India have developed region specific 'decision rules' for forecasting late blight. It would be appropriate to convert them into web-based late blight forecasting systems using regional weather data.
- Emerging potato diseases like Zebra chip disease in North and Central America, and Yellow vein virus in Andes may pose serious threats to global potato sector. Strict quarantine should be enforced to curtail their international movement.
- Cold storage involves substantial cost and farmers of the poor Asian countries cannot afford the high storage cost. There are a number of traditional low-cost and non-refrigerated storage structures that do not require electric energy and are suitable to store potatoes for 3-4 months. These traditional structures with or without CIPC treatment and other modifications should be popularized and encouraged.
- For increasing the international trade of potato, there is need for enhanced knowledge sharing among the countries and barriers to be broken. There is need for evolution of a mechanism for easier movement of potato and potato products among SAARC countries.

During the Plenary Session of Global Potato Conference 2008, awards were given to 10 best potato growers and 8 best potato entrepreneurs of the country. The Regional Vice-Presidents of IPA identified the names of the progressive potato growers from major potato growing states to be nominated for the award. The awardee farmers were Sh. HS Sangha (Punjab), Tek Chand (HP), Arvind Bhargava (UP), Yogender Pal Singh (UP), Sita Ram Singh (Bihar), Anant Dev Nayek (West Bengal), Dhirender Sarkar (Tripura), MM Gehlot (Gujarat), Sadanand Shivalli (Karnataka) and T Vasu (Tamil Nadu).

The entrepreneurs were selected for the award on the basis of their contribution to the development of potato industries in India. The awardee entrepreneurs were Sh. Rajesh Garg, Rudra Pratap Singh, B. Mazoomdar, Ramanjit Singh, Prakash Lohia, TPS Tomar, Rahul Chaturvedi and SK Tibrewal. Besides, 9 Best Poster Paper Awards were conferred to the presenters during each of the poster sessions of the GPC 2008.

In the evening December 12, 2008, an annual general body meeting of Indian Potato Association was held in the symposium hall of NASC complex, New Delhi in which about 100



members of IPA participated. In the meeting, the Association conferred Honorary Fellowship to 4 distinguished potato scientists of the world viz. Dr. Pamela Anderson, DG, CIP; Dr. JE Bradshaw, Head (Potato Breeding), SCRI, UK; Dr. SM Paul Khurana, VC, Rani Durgavati University, Jabalpur; and Sh. HS Sanga, farmer of Punjab. The Association also conferred Best Paper Award to a total of 27 recipients for the Years 2004, 2005 and 2006.

### Agro-Tech Exhibition at GPC-2008

On the sidelines of the Global Potato Conference-2008, an agro-tech exhibition was also organized to showcase the status of potato-based industries and trade, food value chain, food services and retailing, biotechnology, and public-private partnership in technology transfer. Shri Anil Kumar Upadhyay, Additional Secretary, DARE and Secretary, Indian Council of Agricultural Research inaugurated the agro-tech exhibition. Sh. Upadhyay lauded the role of exhibition in enhancing the exposure of farming community to new and relevant technologies ready for adoption.

Secretary, DARE and DG (ICAR), Dr. Mangala Rai, DDG(Hort.), ICAR, Dr. HP Singh, Chairman, ASRB, Dr. CD Mayee, and Former DG (ICAR), Dr. RS Paroda also visited the agro-tech exhibition 2008 at the NASC Complex. While appreciating the efforts made by the organizers, Dr. Mangala Rai said that India has the required potato production technologies and the produce is free from major diseases, which provide significant opportunity for export of potato products. He told that the celebration of

International Year of the Potato started in India with the organization of *India International Potato Expo* at Kolkata during 9-11 January, 2008 and concluded with the Global Potato Conference and Agro-tech Exhibition 2008 at New Delhi. Delegate scientists from India and abroad and large number of farmers from adjoining cities also visited the exhibition every day and interacted with the stall officials.

### Dignitaries visiting exhibition of potato varieties at CPRI stall

More than 60 organizations of national and international repute put up their stalls to depict the latest trends in agricultural technologies from modern irrigation methods to processing techniques, and quality seeds to value-added products. All the sponsors and co-sponsors of the Conference, and several other private institutions displayed their technologies and products through the exhibition stalls. Important among them were the Indian Council of Agricultural Research, International Potato Center, National Seed Corporation, National Horticulture Mission of UP, Pepsico India Holdings Pvt. Ltd., Syngenta, Vegit Potato Specialties, Haldiram's, etc. The exhibitions were organized under the guidance of Dr. TP Trivedi, Project Director, DIPA (ICAR) and Dr. PS Naik, Project Coordinator, AICRP (Potato) who took keen interest in this event.

The stall of CPRI was the biggest attraction which provided a glimpse of potato research in India and demonstrated the technologies for production of potato chips, French fries and delicious pickles. The new developed varieties of Central Potato Research Institute attracted large number of farmers. At the stall of ICAR, popular books and CDs were displayed and made available for sale. The newly released book on potato cultivation (*Aloo ki kheti*) attracted large number of farmers. As an added attraction, a mini-theater was created at the exhibition to show informative and motivational films on ICAR's technologies and success stories. The exhibition offered an international platform for different corporate and farming community from India and abroad to come together at the world's largest agri-based market to negotiate business deals and secure linkages.





## Brain Storming Session on Impact Assessment of Climate Change

A brain storming session on "Impact assessment of climate change for research priority, planning in horticultural crops" was organized during 6-7 September, 2008 at Central Potato Research Institute, Shimla. The session started with invocation ceremony by lighting the lamp by Hon'ble Governor of Himachal Pradesh Her Excellency Smt. Prabha Rau followed by other dignitaries and singing of the invocation song. Dr SK Pandey, Director, CPRI, Shimla extended a warm welcome to the chief guest Hon'ble Governor of Himachal Pradesh Her Excellency Smt. Prabha Rau; the president of the inaugural function, Dr HP Singh, DDG (Hort), ICAR, New Delhi; the Guest of Honour, Dr Mathura Rai, Director, IIVR, Varanasi and distinguished delegates and participants of the brain storming session. In his address he briefed the dignitaries and participants about the activities and achievements of CPRI. The importance of climate change and its impact on horticultural crops in future with implications for food and social security was underlined.

In the inaugural address Hon'ble Governor of Himachal Pradesh Her Excellency Smt. Prabha Rau highlighted that i) climate change impacts and adaptation should be considered in all major development activities, ii) develop new infrastructure, policies and institutions to support the new land use arrangements identified by science and technology, iii) consider financial incentives and package for improved land management including resource

conservation/enhancement (water, carbon, energy and fertilizer use efficiency), iv) consider incentives for industry and farming community for developing and adopting Green House Gases inhibiting technologies, v) establish Green Research Fund for strengthening research on adaptation, mitigation and impact assessment.

The Hon'ble DDG (Horticulture) Dr. H. P. Singh In his presidential address provided an overview of climate change, its impacts and also adaptation and mitigation strategies and emphasized upon research needs to face the future challenges including assessment of climate change impacts on horticultural crops, development of crop-based adaptation strategies, identification of gaps in vital information, prioritize research issues from the point of view of farmers, policy planners, scientists, trade and industries. He urged to address i) priority of education, research and development and policy implications for enhancing adaptive capacity of Indian horticulture to climate change, ii) capacity assessment of Indian horticulture for mitigation of GHG, iii) appropriate short-term and long-term action plans to mitigate the impact of climate change in horticulture which included development of heat and drought tolerant cultivars with the use of innovative technologies including biotechnology, technology for productive use of water and nutrients, production system management adjustable to climate change, strategic management of insect-pests and diseases, protected cultivation, plant architectural management and augmentation for quality.

The Guest of Honour, Dr Mathura Rai, Director, IIVR, Varanasi highlighted the need to understand and assess the vulnerability of horticultural crops to emerging climate change scenarios and emphasized to evolve adaptation measures through research and development.

On this occasion the chief guest Hon'ble Governor of Himachal Pradesh Her Excellency Smt. Prabha Rau released a book on 'Impact assessment of climate change for research priority, planning in Horticultural crops followed by the release of a technical bulletin 'Infocrop-Potato : A Model for Simulating Growth and Yield of Potato in the Sub-Tropics'. Thereafter another Technical bulletin 'A Compendium of



**Hon'ble Governor of HP Smt. Prabha Rau delivering inaugural address at the Brain Storming Session**



**Release of Technical Bulletins of CPRI**

Climate Based Potato Zones in India was released by Hon'ble DDG (Horticulture) Dr. H. P. Singh. This was followed by the release of another technical bulletin 'Cultural Management of Crops in Potato Based Cropping Systems' in India by the Guest of Honour Dr Mathura Rai, Director, IIVR, Varanasi.

On this occasion Dr S. Ramanujam Award for block year 2004-2007 in the memory of the founder Director of CPRI, Dr S. Ramanujam was presented by the Hon'ble Governor of Himachal Pradesh Her Excellency Smt. Prabha Rau to Drs. SV Singh, SK Pandey, RS Marwaha, BP Singh, Dinesh Kumar and Praveen Kumar for their outstanding Research/ Leadership in potato improvement and production.

The inaugural session ended with the vote of thanks proposed by Dr. SS Lal, Head, Division of Crop Production, CPRI, Shimla. After the inaugural function, the technical sessions were held under the chairmanship of Dr. HP Singh, DDG (Horticulture), ICAR on 6-7 September, 2008 and presentations were made by the scientists on different aspects of climate change on various crops. It was attended by 80 scientists/delegates including directors of different ICAR Institutes/NRCs of Horticulture Division.

## Training of Extension Officers

### Model Training Course

The Division of Social Sciences organized 8-days Model Training Course on "Potato Improvement, Production & Utilisation in the

Current Indian Scenario" from 16-23 September, 2008 at Shimla, which was sponsored by the Directorate of Extension, Ministry of Agriculture, Govt. of India. The objectives of the training course were improving the knowledge of the trainee officers regarding seed potato production and certification, improving the skill of the trainee officers regarding seed potato production, and to get the feedback from the trainee officers regarding field problems in the adoption of potato production technologies and in the seed certification. A total of 16 participants from 9 states attended the training course. The training included lecture-cum-discussions, practical sessions, skill demonstrations, field visits and video film shows. In all, 24 lectures were delivered and a field visit to CPRI farm at Kufri was organised during the training course.

### Winter School at CPRIC, Modipuram

CPRIC, Modipuram organized Winter School on Modern Techniques of Potato Research & Development during 2-22 Jan., 2009 which was attended by 18 participants from 8 states from AICRP (Potato), State Agriculture Universities, NGOs engaged in seed production and ICAR Institutes of the country. At the outset of the course, an evaluation was done on relevance of subject covered, extent of usefulness of the topic and overall satisfaction of the course. 50% participants opined that seed plot technique was very important area. About 50% gain in knowledge was observed.

### Farmers' Training at CPRI, Shimla

A farmers' training on "Improved Techniques of Seed Potato Production and Post-harvest Technologies" was organized during 8-10 July, 2008 by the Division of Social Sciences at CPRI, Shimla. Although the research Institute like CPRI has been entrusted with conducting trainers' training, this type of arrangement has borne limited success in effecting technology transfer to the farmers owing to inefficiency and lack of professional approach at the state level. Hence, the Institute has started this type of activity to reduce the distortion in technology dissemination.

The training was organized for the farmers of Himachal Pradesh in which 16 farmers from 6 major potato-growing districts of the state, namely Shimla, Mandi, Sirmaur, Solan, Kullu & Hamirpur participated. During this training



course, farmers were given series of lectures consisting of late blight management, PTM & white grub management, healthy seed potato production, seed certification, marketing and strategies for adoption of potato technologies. A field visit to CPRS, Kufri was also organized for the farmers on this occasion.

#### Farmers' Training at CPRS, Patna

Under the celebrations of International Year of Potato, about 600 farmers from various potato-growing districts of Bihar were trained by the scientists of CPRS, Patna on scientific potato cultivation, healthy seed potato production, plant protection, use of farm implements and potato production through TPS. The trainings of these farmers were sponsored by NHRDF, ATMA, NAIP and other agencies.

#### Farmers' Training at CPRS, Shillong

An on-station farmers' training on "Improved Potato Production and Protection Technologies" was organized at CPRS, Shillong on August 12, 2008 in which 50 farmers participated. Two training programmes for farmers on "Improved Potato Production, Protection and Post-harvest technology" under MM-1 were organized during 17-18 October, 2008 at ICAR Research Complex for North-eastern region, Manipur Centre, Imphal and during 21-22 October, 2008 at ICAR Research Complex for North-eastern region, Tripura Centre, Agartala in which 60 farmers participated. A one-day training programme for 41 farmers on "Improved Potato Production, Protection and Post Harvest technology" under MM-1 was also organized on 12<sup>th</sup> November, 2008 at ITI, Nalbari, Assam.

#### Farmers' Training at CPRIC, Modipuram

About 900 farmers from various potato-growing districts of UP, Haryana and Rajasthan were trained by the scientists of CPRIC, Modipuram on scientific potato cultivation, healthy seed potato production, plant protection and use of high yielding varieties of potato. The trainings of these farmers were sponsored by State agriculture departments and other agencies.

#### Training to Tribal farmers of MP at CPRIC, Modipuram

Training was imparted to 20 scheduled tribe farmers of Alirajpur of Jhabua district of MP. The farmers were exposed on various aspects of potato cultivation includes ware seed and processing potato production.

#### Live Phone-in Programme on Doordarshan

The Shimla Doordarshan telecasts *live phone-in* programme of 'Krishi Darshan' in collaboration with various organizations concerned with agricultural development. The programmes of various organizations are discussed in the monthly meetings and are telecast every Monday and Thursday as per schedule. In this programme burning issues related to crop, animal husbandry, fishery, etc. are discussed by the studio-invited experts and the viewers (farmers) can ask questions from the experts by dialling the phone number announced just before the start of the programme. Drs. VK Dua, Manoj Kumar and Vinod Kumar of CPRI, Shimla participated in the programme during the year to discuss various aspects of potato production. Field recording on Organic Potato production was also done at farmers' field in Talai village (near Fagu) of Shimla district, which was subsequently telecast on Shimla Doordarshan. Drs. RP Rai, Shambhu Kumar, SK Singh and Barsati Lal of CPRS, Patna participated in similar programme telecast by Patna Doordarshan.

**Exhibition in Kisan Mela at Solan:** An exhibition stalls of potato technologies were put up at the Kisan Mela organized by National Research Centre for Mushroom, Chambaghat, Solan on 10th Sept., 2008. The stall was visited by more than 250 farmers from different parts of the states and they were briefed about the potato technologies. This endeavour proved worthy in getting first hand information from the farmers and transferring the potato technologies to them besides, a number of priced publications of the Institute were sold to the farmers and scientists visiting the stall.



## Activities of ATIC

A total of 411 farmers visited the Institute at Shimla during the year to get first-hand information about potato technologies. In addition, 60 scientists/teaching staff, 954 UG and PG students were attended by the ATIC staff at Shimla. They were shown potato film and museum besides briefing from the extension scientist about the programmes and activities of the Institute.

The ATIC staff maintains the record of Institute's technical/extension bulletins and CDs. During the year, an income of Rs. 33600/- was generated from sale of publications & CDs to the visitors. Besides, a number of extension bulletins were also supplied free of cost to the visiting farmers, students and extension officers.

### Participation in Farmers' Fair/ Exhibition

- Participated and set up a stall in Pride of India Exhibition along with other ICAR institutes of the NE region during the 96<sup>th</sup> Indian Science Congress at North Eastern Hill University, Shillong from 03-07 January, 2009. The ICAR stall was awarded a Special Recognition prize.



**CPRS stall at North East Agri Fair January 28-29, 2009 at College of Agriculture and Forestry, CAU, Pasighat, Arunachal Pradesh**

- Participated in North East Agri Fair 2009 & National Symposium on Strategies to combat emerging pests in the current scenario of climate change organised by Central Agricultural University, College of Agriculture and Forestry, Pasighat, Arunachal Pradesh during 28-39 January, 2009.

### A. Myllem Potato Farmers Club

Myllem Potato Farmer's Club was formed on 7<sup>th</sup> September 2007. Till date the Club has organised 5 Expert Meets and 1 Training Programme. The Club had only 15 members in the beginning but every month the Club has recruited new members and at present have 30 members. The Club has done many activities which include trial demonstration of Kufri Jyoti and Kufri Giriraj with seeds supplied by CPRS, Shillong; demonstration of Kufri Himsona a processing variety of potatoes with seeds supplied by PepsiCo India Holdings Pvt. Ltd., Kolkata. The Club has also looked after the Community level seed storage structure in a project funded by NABARD. The Club has applied to the Department of Horticulture, Government of Meghalaya and has been registered as a Registered Grower.



**CPRS stall in Pride of India Exhibition along with other ICAR institutes of the NE region during the 96<sup>th</sup> Indian Science Congress, January, 3<sup>rd</sup>-7<sup>th</sup> 2009 at NEHU, Shillong**

## Hindi Day Celebration at CPRS, Shillong

दिनांक 24 सितम्बर, 2008 को केन्द्रीय आलू अनुसंधान केन्द्र, शिलांग के परिसर में हिंदी दिवस समारोह का आयोजन किया गया। इस आयोजन में डॉ. एस.के. शर्मा, विभागाध्यक्ष, हिंदी विभाग उत्तर पूर्वी पर्वतीय विश्वविद्यालय, मुख्य अतिथि के रूप में उपस्थित थे।

कार्यक्रम का शुभारम्भ मुख्य अतिथि के सम्मान में किया गया। तत्पश्चात डॉ. एस. रमणी, अध्यक्ष, केन्द्रीय आलू



मुख्य अतिथि का सम्बोधन

अनुसंधान केन्द्र, शिलांग ने सभा को सम्बोधित किया। उन्होंने अपने सम्बोधन में मुख्य अतिथि को केन्द्र में होने वाले कार्यों तथा हिंदी के विकास हेतु उठाए जाने वाले कदमों से अवगत कराया। हिंदी दिवस के उपलक्ष्य में



पुरस्कार वितरण

केन्द्रीय आलू अनुसंधान केन्द्र, शिलांग में आलू के विषय पर नारा लेखन प्रतियोगिता का आयोजन किया गया था जिसमें केन्द्र के कर्मचारियों ने उत्साहपूर्वक भाग लिया। इस प्रतियोगिता में विपुल कुमार दास, संचिता राय तथा राम इकबाल राय ने क्रमशः प्रथम, द्वितीय तथा सातवना पुरस्कार प्राप्त किया। मुख्य अतिथि, डॉ. एस.के. शर्मा ने प्रतियोगिता के विजेताओं को पुरस्कार वितरित किया। मुख्य अतिथि ने अपने संबोधन में राजभाषा हिंदी तथा हिंदी दिवस के महत्व पर प्रकाश डाला। उन्होंने केन्द्र में हिंदी के विकास हेतु किये जाने वाले प्रयासों की सराहना की। उन्होंने केन्द्र के कर्मचारियों से अनुरोध किया कि वे कार्यालय के कार्यों में हिंदी का प्रयोग करें।



## Distinguished Visitors



1. Sh. Sharad Joshi, MP (Rajya Sabha), Sh. Prabodh Panda, MP (L.S.), Sh. Girdhari, MP, Sh. Vikram Verma, MP (Rajya Sabha) and Sh. Harish Rawat, MP (L.S.) visited CPRI, Shimla on Study visit of the Parliamentary Standing Committee on Agriculture from 21<sup>st</sup> to 22<sup>nd</sup> May, 2008.
2. Dr. Dindo M Campilan, Regional Leader, CIP-SWCA, New Delhi visited CPRI, Shimla on 13<sup>th</sup> August, 2008.
3. ADG (AP&B), of ICAR, New Delhi Dr. T.J. Rasool visited CPRS, Shillong on 21.11.2008.
4. ADG (PP), of ICAR, New Delhi Dr. T.P. Rajendran visited CPRS, Shillong on 21.11.2008.
5. Former Director, Central Potato Research Institute and currently Vice Chancellor, Rani Durgavati Vishwavidyalaya, Jabalpur, Madhya Pradesh, Dr. S.M. Paul Khurana visited CPRS Shillong on 5.1.2009.





# Awards, Honours and Foreign Visits

## Awards, Honours

1. **Dr. SK Pandey, Director**, CPRI, Shimla awarded Fellowship of National Academy of Sciences, Allahabad.
2. **Dr. Jai Gopal**, Head, Crop Improvement, CPRI, Shimla awarded the Recognition Award (2007-08) of National Academy of Sciences, New Delhi.
3. **Sh. Rupu**, SSG-III, CPRI, Shimla and **Sh. Madan Pal**, SSG-II, CPRI, Modipuram was jointly awarded the CPRI's Best Worker Award, 2005 in Supporting Staff Category on 26th January, 2009.
6. **Dr. Jai Gopal**, Principal Scientist, Central Potato Research Institute, Shimla (HP), visited FAO Hqs. in Rome, Italy, for participation in Task Force 2 for the Global Partnership Initiative for Plant Breeding Capacity Building (GIPB) and attend face-to-face meeting during April 23-24, 2008.
7. **Dr. S. Ramani**, Head, Central Potato Res. Station, Shillong, visited Bhutan to attend workshop on "Potato Development in Bhutan – Experience generated and the way forward" held during May 6-10, 2008.
8. **Dr. BP Singh, Jr.**, Director, CPRI Campus, Modipuram, visited Bhutan to attend workshop on "Potato Development in Bhutan – Experience generated and the way forward" held during May 6-10, 2008.

## Foreign Visits

1. **Dr. BP Singh**, Joint Director, Central Potato Research Institute Campus, Modipuram (UP), visited Beijing-China for presentation of his paper in 3<sup>rd</sup> International Conference on Late Blight during April 3-6, 2008.
2. **Dr. RK Arora**, Principal Scientist, Central Potato Research Station, Jalandhar (Pb.), visited Beijing-China for presentation of his paper in 3<sup>rd</sup> International Conference on Late Blight during April 3-6, 2008.
3. **Dr. Jai Gopal**, Principal Scientist, Central Potato Research Institute, Shimla (HP) visited Beijing-China for presentation of his paper in 3<sup>rd</sup> International Conference on Late Blight during April 3-6, 2008.
4. **Dr. SK Kaushik**, Senior Scientist, CPRI, Shimla, visited Agricultural Research Station, Sita Eliya, Nuwara Eliya, Sri Lanka during April 3-4, 2008, for oral presentation of his paper in International Potato Symposium – 2008.
5. **Dr. JS Minhas**, Principal Scientist, CPRI, Shimla, visited Agricultural Research Station, Sita Eliya, Nuwara Eliya, Sri Lanka during April 3-4, 2008, for oral presentation of his paper in International Potato Symposium – 2008.
9. **Dr. SK Pandey**, Director, CPRI, Shimla, visited (i) Bangkok to attend workshop "To commemorate the International Year of Potato, 2008, on May 06, 2008, and (ii) Bhutan to attend workshop on "Potato Development – Experience generated and the way forward" during May 7-10, 2008.
10. **Dr. SK Pandey**, Director, Central Potato Research Institute, Shimla(HP), visited Dundee, Scotland for participation in one day potato workshop on "Improving International Potato Production" and to present paper on "Policies and research priorities for sustaining potato production consumption in Asia-Pacific" on August 08, 2008.
11. **Dr. Dinesh Kumar**, Senior Scientist, Central Potato Research Institute Campus, Modipuram, visited New Zealand for participation in World Potato Congress during March 22-25, 2009.
12. **Dr. Jai Gopal**, Principal Scientist, Central Potato Research Institute, Shimla, visited New Zealand for participation in World Potato Congress during March 22-25, 2009.

13. Dr. Parveen Kumar, Senior Scientist, Central Potato Research Institute Campus, Modipuram, visited New Zealand for participation in World Potato Congress during March 22-25, 2009.
14. Dr. Devendra Kumar, Sr. Scientist, CPRI Campus, Modipuram, visited Michigan State University, East Lansing, Michigan, USA for 10 days training (between March 30, 2009 to April 8, 2009) on Anti-oxidant Enrichment Techniques, under NAIP project "Value chain on Potato and Potato Products".



# Education and Training



| Sl. No. | Name of trainee                                    | Name, Date & Place of the Training                                                                                                                                                                                                        |
|---------|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | Dr. NK Pandey, Principal Scientist, CPRI, Shimla   | NAIP learning and capacity building programme on "Management Development programme on PME- for agriculture research" from 7 <sup>th</sup> to 11 <sup>th</sup> July, 2008 at NAARM, Hyderabad.                                             |
| 2       | Dr. R. Muthuraj, Scientist (SS), CPRS, Ootacamund  | 21 days advance training on "Breeding and seed production of vegetable crops" from 5 <sup>th</sup> to 25 <sup>th</sup> August, 2008 at CAS Hort (Veg.), Dr. YS Parmar Univ. of Hort. & Forestry, Nauni, Solan (HP)                        |
| 3       | Dr. Barsati Lal, Scientist, CPRS, Patna            | Summer school on "Gender issues and empowerment in agriculture" during 28 <sup>th</sup> August to 18 <sup>th</sup> September, 2008 under CAS at IARI, New Delhi.                                                                          |
| 4       | Dr. RM Sharma, In-charge, Library, CPRI, Shimla    | Short term training programme on "Online WINSIS database design and development" organised by National Institute of Science Communication and Information Resources, New Delhi from 15 <sup>th</sup> to 19 <sup>th</sup> September, 2008. |
| 5       | Dr. Sanjay Rawal, Scientist (SG), CPRIC, Modipuram | Model training course on "Crop diversification in sugarcane production system" during 16 <sup>th</sup> -23 <sup>rd</sup> September, 2008 at IISR, Lucknow                                                                                 |
| 6       | Dr. BP Singh, Joint Director, CPRIC, Modipuram     | 3 <sup>rd</sup> Management programme on "Leadership Development" under NAIP from 3 <sup>rd</sup> -7 <sup>th</sup> November, 2008 organised by NAARM, Hyderabad at Indian Institute of Management, Lucknow                                 |



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| 7  | Dr. VK Gupta, Scientist (SS), CPRIC, Modipuram                                                                                                                                                    | 21 days ICAR-CAS training programme on "Trait based Genetic Enhancement in Crop Plants" from 30 <sup>th</sup> October, 2008 to 19 <sup>th</sup> November, 2008 at TNAU, Coimbatore.                                                        |
| 8  | Sh. CM Singh Bist, T-4, CPRI, Shimla                                                                                                                                                              | Training for technical person of accredited test laboratory on genetic fidelity testing at CDFD, Hyderabad during 20 <sup>th</sup> to 24 <sup>th</sup> October, 2008                                                                       |
| 9  | Dr. Vijay Kishore Gupta, Scientist (SS), CPRIC, Modipuram                                                                                                                                         | ICAR-CAS training on "Trait based genetic enhancement in crop plants" during 30 <sup>th</sup> October, 2008 to 19 <sup>th</sup> November, 2008 at TNAU, Coimbatore                                                                         |
| 10 | Dr.(Mrs.) V. Sunaina, Principal Scientist, CPRIC, Modipuram                                                                                                                                       | Training for Women Scientist & Technologist on "Intellectual Property Rights (IPRs) and Related WTO" at Consumer Unity & Trust Society (CUTS), Jaipur from 3 <sup>rd</sup> -7 <sup>th</sup> November, 2008.                                |
| 11 | Sh. Kana Singh Chauhan, TO & Sh. Dev Raj, T-1, CPRI, Shimla                                                                                                                                       | Training programme on Fabrication of LED Lights and Maintenance of Solar Devices" organised by Himalayan Research Group, DST Core Group, Chotta Shimla at CPRI, Shimla.                                                                    |
| 12 | Dr. R Ezekiel, Principal Scientist, CPRI, Shimla                                                                                                                                                  | Workshop-cum-training on "Post-harvest Technology, cold chain Management and Food Safety Issues" sponsored by Indi-US Science & Technology Forum from 14 <sup>th</sup> -20 <sup>th</sup> November, 2008 at Amity University Campus, Noida. |
| 13 | Dr. Barsati Lal, Scientist (SS), CPRS, Patna, Dr. Murlidhar J. Sadawarti, Scientist, CPRS, Gwalior, Dr. VK Gupta, Scientist (SS), CPRIC, Modipuram & Dr. AK Srivastava, Scientist, CPRS, Shillong | Winter School on "Modern Techniques of Potato Research & Development" from 2 <sup>nd</sup> -22 <sup>nd</sup> January, 2009 at CPRIC, Modipuram                                                                                             |
| 14 | Dr. Manoj Kumar, Sr. Scientist, CPRI, Shimla                                                                                                                                                      | Training on "IT based decision support system for spatial knowledge management for sustainable livelihood security" from 19 <sup>th</sup> -29 <sup>th</sup> January, 2009 at NAARM, Hyderabad                                              |
| 15 | Dr. Rajesh K. Rana, Sr. Scientist, CPRI, Shimla                                                                                                                                                   | Training programme on "Development winning Research proposals in Agricultural Research" from 11 <sup>th</sup> -16 <sup>th</sup> March, 2009 at NAARM, Hyderabad.                                                                           |
| 16 | Dr. Anil Kumar, Sr. Scientist, CPRI, Shimla                                                                                                                                                       | Evaluation of Training from 23 <sup>rd</sup> -27 <sup>th</sup> March, 2009 at ISTM, New Delhi                                                                                                                                              |

## Conferences/Symposia and Workshop

| Sl. No. | Name                                                                                                                                                | Title of the Conference/ Symposia/Workshop                                                                            | Dates & Venue                                                                                                                               |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 1.      | Dr. NK Pandey, Principal Scientist & Dr. Rajesh K Rana, Sr. Scientist, CPRI, Shimla                                                                 | Workshop on "Value chain of potato and potato products"                                                               | 15 <sup>th</sup> May, 2008 at CPRIC, Modipuram                                                                                              |
| 2.      | Dr. ID Garg, Principal Scientist & Dr. SK Chakrabarti, Principal Scientist, CPRI, Shimla                                                            | Workshop on "Standard operating procedure for export inspection and phytosanitary certification".                     | 28 <sup>th</sup> May, 2008 organised by Directorate of Plant Protection Quarantine & Storage, Faridabad (Haryana) at RPQS, Mumbai           |
| 3.      | Dr. S. Ramani, Principal Scientist, CPRS, Shillong                                                                                                  | Conference on "Agricultural development in NEH Region: Challenges and opportunities"                                  | 18 <sup>th</sup> -19 <sup>th</sup> June, 2008 at ICAR Research Complex for NEH Region, Umiam                                                |
| 4.      | Dr. JP Singh, Principal Scientist, CPRS, Jalandhar                                                                                                  | Annual workshop of the ICAR sponsored Network Project on climate Change                                               | 23 <sup>rd</sup> - 24 <sup>th</sup> June, 2008 at CRIDA, Hyderabad                                                                          |
| 5.      | Dr. JP Singh, Principal Scientist, CPRS, Jalandhar                                                                                                  | UNFCCC Workshop on "Impacts, vulnerability assessment and adaptation to climate change and global warming"            | 11 <sup>th</sup> -12 <sup>th</sup> August, 2008 at India International Centre, New Delhi                                                    |
| 6.      | Sh. AK Srivastava, Scientist, CPRS, Shillong                                                                                                        | Workshop cum orientation programme on seeds and planting materials production"                                        | 31 <sup>st</sup> August-1 <sup>st</sup> September, 2008                                                                                     |
| 7.      | Drs. SS Lal, JP Singh, PM Govindakrishnan, MC, Sood, VK Dua, Manoj Kumar, Parveen Kumar, S Rawat, MK Jatav, NK Pandey & Rajesh K Rana, CPRI, Shimla | Workshop on "Global climate change and Indian horticulture: Current status and future priorities"                     | 6 <sup>th</sup> -7 <sup>th</sup> September, 2008 at CPRI, Shimla                                                                            |
| 8.      | Dr. Anil Kumar, Sr. Scientist, CPRI, Shimla                                                                                                         | International Conference on "Novel approaches for food & health security in high altitudes"                           | 6 <sup>th</sup> -10 <sup>th</sup> September, 2008 at Defence Institute of High Altitude Research (DRDO), Leh-Ladakh                         |
| 9.      | Dr. Shashi Rawat, Scientist (SS), ARIS, CPRI, Shimla                                                                                                | Workshop on "Web design methodologies, protocols and content management strategies" under NAIP funded AGROWEB project | 9 <sup>th</sup> to 10 <sup>th</sup> September, 2008 at NAARM, Hyderabad                                                                     |
| 10.     | Dr. VK Chandla, Principal Scientist, Ms. Anupam Sharma, SRF & Ms. Puja Rani, SRF, PP, CPRI, Shimla                                                  | Symposium on "Emerging trends of research in insect management & environment safety"                                  | 24 <sup>th</sup> to 26 <sup>th</sup> September, 2008 organised by UP Zoological society, Muzaffarnagar at Nishkam Sewa Sadan, Haridwar (UA) |

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| Sl. No. | Name                                                                                                                                                                          | Title of the Conference/ Symposia/Workshop                                                                                       | Dates & Venue                                                                                                                                             |
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| 11.     | Dr. MN Bhat, Sr. Scientist, CPRIC, Modipuram                                                                                                                                  | National Symposium on "Advances in microbial diversity and disease management for sustainable crop production"                   | 13 <sup>th</sup> -15 <sup>th</sup> October, 2008 at GB Pant University, Ranichauri, Tehri Garhwal, UK                                                     |
| 12.     | Dr. NC Upadhyay, Principal Scientist, CPRIC, Modipuram                                                                                                                        | National conference on "Organic farming in horticultural crops with special reference to plantation crops"                       | 15 <sup>th</sup> -18 <sup>th</sup> October, 2008 at CPCRI, Kasaragod                                                                                      |
| 13.     | Dr. NK Pandey, Principal Scientist, CPRI, Shimla                                                                                                                              | MDP Workshop on "Policy & prioritization, monitoring & evaluation support to consortia-based research in agriculture"            | 21 <sup>st</sup> -25 <sup>th</sup> October, 2008                                                                                                          |
| 14.     | Dr. SV Singh, Principal Scientist, Dr. Parveen Kumar, Sr. Scientist, Dr. Dinesh Kumar, Sr. Scientist, CPRIC, Modipuram & Dr. RS Marwaha, Principal Scientist, CPRS, Jalandhar | 3 <sup>rd</sup> Indian Horticulture Congress-2008 on "New R&D Initiatives in Horticulture for Accelerated Growth and Prosperity" | 6 <sup>th</sup> - 9 <sup>th</sup> November, 2008 at Orissa University of Agriculture & Technology, Bhubaneswar                                            |
| 15.     | Dr. R. Ezekiel, Principal Scientist, CPRI, Shimla                                                                                                                             | Golden Jubilee conference on "Challenges and emerging strategies for improving plant productivity"                               | 12 <sup>th</sup> -14 <sup>th</sup> November, 2008 at IARI, New Delhi                                                                                      |
| 16.     | Dr. RM Sharma, Incharge, Lib. & Doc., CPRI, Shimla                                                                                                                            | Two days workshop on "Krishi Prabha- Indian Agricultural Doctoral Dissertation Repository- SAU/DAU/ICAR Librarians"              | 14 <sup>th</sup> -15 <sup>th</sup> November, 2008 at Haryana Agricultural University, Hisar.                                                              |
| 17.     | Dr. MN Bhat, Sr. Scientist, CPRIC, Modipuram                                                                                                                                  | Conference and Symposium on "Advances in Biotechnology for Plant Protection"                                                     | 17 <sup>th</sup> -19 <sup>th</sup> November, 2008 at University of Mysore, Manasagangori, Mysore                                                          |
| 18.     | Dr. VS Kushwah, Principal Scientist, Dr. SP Singh, Sr. Scientist, CPRS, Gwalior & Dr. Dhruv Kumar, Sr. Scientist, CPRIC, Modipuram                                            | National Symposium on " New paradigms in agronomic research"                                                                     | 19 <sup>th</sup> -21 <sup>st</sup> November, 2008 at Navsari Agricultural university, Gujrat                                                              |
| 19.     | Dr. S. Ramani and Sh. AK Srivastava, CPRS, Shillong                                                                                                                           | ICAR training-cum-workshop on "Intellectual property and technology management"                                                  | 20 <sup>th</sup> -22 <sup>nd</sup> November, 2008 at ICAR Research complex for NEH Region, Umiam                                                          |
| 20      | Dr. SK Pandey, Director, CPRI, Shimla & Dr. S. Ramani, Principal Scientist, CPRS, Shillong                                                                                    | Regional Conference on "Food Security and sustainable agriculture development"                                                   | 24 <sup>th</sup> -25 <sup>th</sup> November, 2008 organised by IGNOU, New Delhi in collaboration with IGNOU Regional Centre, Tripura University, Agartala |

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| Sl. No. | Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Title of the Conference/ Symposia/Workshop                                                                        | Dates & Venue                                                                                                                                          |
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| 21.     | Dr. SP Trehan, Principal Scientist, CPRS, Jalandhar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | National Seminar on "Developments in Soil Sciences-2008"                                                          | 27 <sup>th</sup> -30 <sup>th</sup> November, 2008 at University of Agricultural Sciences, Bangalore                                                    |
| 22.     | Dr. SS Lal, Principal Scientist, CP, CPRI, Shimla                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | National Conference on "Eco-friendly Approaches in Sustainable Agriculture and Horticulture Production"           | 28 <sup>th</sup> -30 <sup>th</sup> November, 2008 organised by Doctor's Krishi Evam Bagwani Vikas Sanstha, Lucknow at Amity University Campus, Lucknow |
| 23.     | Dr. S. Ramani, PS & Act. Head, CPRS, Shillong                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Leslie Coleman Memorial National Symposium on "Plant Protection"                                                  | 4 <sup>th</sup> -6 <sup>th</sup> December, 2008 at GKV, Bangalore                                                                                      |
| 24.     | Dr. SK Pandey, Director, Dr. Jai Gopal, PS, Dr. SK Kaushik, Sr. Scientist, Dr. D. Pattanayak, Sr. Scientist, Dr. Vinay Bhardwaj, Scientist (SS), Dr. PH Singh, PS, Dr. EP Venkatasalam, Scientist (SS), Dr. S.S. Lal, PS & Head, CP, Dr. M.C. Sood, PS, Dr. PM Govindakrishnan, PS, Dr. VK Dua, Sr. Scientist, Dr. Manoj Kumar, Sr. Scientist, Sh. MK Jatav, Scientist, Dr. NK Pandey, Head, SS, Dr. Rajesh Kumar Rana, Sr. Scientist, Dr. Anil Kumar, Sr. Scientist, Dr. SK Chakrabarti, Head, PP, Dr. ID Garg, PS, Dr. VK Chandla, PS, Dr. Jagesh Kumar, Scientist, Dr. R. Ezekiel, PS & Head, PHT, Dr. JS Minhas, PS, Dr. Brajesh Singh, Sr. Scientist, Dr. Shashi Rawat, Scientist (SS), <b>CPRI, Shimla</b> , Dr. Birpal Singh, PS & Joint Director, Dr. OP Singh, PS, Dr. NC Upadhyay, PS, Dr. Satya Vir Singh, PS, Dr. Raj Pal Singh, PS, Sh. Rambir, Sr. Scientist, Dr. (Mrs.) Kamlesh Malik, Sr. Scientist, Dr. SK Luthra, Sr. Scientist, Dr. Name Singh, Sr. Scientist, Dr. Dinesh Kumar, Sr. Scientist, Dr. Vinay Singh, Sr. Scientist, Dr. M Narayan Bhat, Sr. Scientist, Dr. Praveen Kumar, Sr. Scientist, Dr. MA Khan, Sr. Scientist, Er. Sukhwinder Singh, Scientist (SG), Sh. Sanjay Rawal, Scientist (SG), Sh. Dhruv Kumar, Scientist (SG), Dr. Vijai Kishore Gupta, Scientist (SS), Dr. Devendra Kumar, Sr. Scientist, <b>CPRI Campus, Modipuram</b> , Dr. GS Kang, PS, Dr. RK Arora, PS, Dr. JP Singh, PS, Dr. (Mrs.) Ashiv Mehta, PS, Er. Manjit Singh, PS, Dr. RS Marwaha, PS, Dr. SP Trehan, PS, Dr. Raj Kumar, Sr. Scientist, Er. Sunil Gulati, Scientist (SG), <b>CPRS, Jalandhar</b> , Dr. AK Somani, PS, Dr. Anuj Bhatnagar, Sr. Scientist, Dr. Shiv Pratap Singh, Sr. Scientist, Dr. Vinod Kumar, Scientist (SS), <b>CPRS, Gwalior</b> , Dr. RP Rai, PS Head, Dr. Gulab Ram, PS, Dr. Shambhu Kumar, Sr. Scientist, Dr. SK Singh, Sr. Scientist, Dr. Barsati Lal, Scientist (SS), Dr. G. Ravichandran, Sr. Scientist, Dr. R. Muthu Raj, Scientist (SS), Dr. Nethi Somasekhar, Scientist, <b>CPRS, Muthorai, Ooty</b> and Dr. YK Sharma, Sr. Scientist, Sh. Ashwani Kumar Sharma, Scientist (SS), Dr. Vinod Kumar, Sr. Scientist & Officiating Head, <b>CPRS, Kufri</b> attended/participated in " <b>Global Potato Conference 2008</b> " from 9 <sup>th</sup> -12 <sup>th</sup> December, 2008 at NASC Complex, New Delhi |                                                                                                                   |                                                                                                                                                        |
| 25.     | Dr. Barsati Lal, Scientist (SS), CPRS, Patna                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | ISSE-National Seminar 2008 on "Innovative Extension Strategies for Agricultural Development and rural prosperity" | 18 <sup>th</sup> -20 <sup>th</sup> December, 2008 at Rajendra Agricultural university, Pusa, Samastipur, Bihar                                         |

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| Sl. No. | Name                                                                                                                   | Title of the Conference/ Symposia/Workshop                                                                | Dates & Venue                                                                                                                                                                                |
|---------|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 26.     | Dr. Devender Kumar,<br>Dr. MN Bhat, Dr. Parveen Kumar Gupta, Er. Sukhwinder Singh & Dr. Dinesh Kumar, CPRIC, Modipuram | Seminar on "Good Agricultural Practices"                                                                  | 23 <sup>rd</sup> December, 2008 organised by Bureau of Indian Standards jointly with ICAR, New Delhi at NASC Complex, New Delhi                                                              |
| 27.     | Er. Manjit Singh, Principal Scientist (FM&P), CPRS, Jalandhar                                                          | 22 <sup>nd</sup> National Convention of "Agricultural Engineers (NCAE-09)"                                | 20 <sup>th</sup> -21 <sup>st</sup> January, 2009 at CSKHPKVV, Palampur (HP)                                                                                                                  |
| 28.     | Dr. S. Ramani, Principal Scientist, CPRS, Shillong                                                                     | National Symposium on "IPM strategies to combat emerging pests in the current scenario of climate change" | 28 <sup>th</sup> -30 <sup>th</sup> January, 2009 organised by the entomological society of India, New Delhi in collaboration with NAAS N-E chapter and CAU, Imphal at CHF, CAU, Pasighat, AP |
| 29.     | Dr. Rajesh K. Rana, Sr. Scientist, CPRI, Shimla                                                                        | 22 <sup>nd</sup> National conference on "Agricultural Economics" ,                                        | 25 <sup>th</sup> -27 <sup>th</sup> February, 2009 at PAU, Ludhiana                                                                                                                           |

# Expenditure and Receipts 2008-09

CENTRAL POTATO RESEARCH INSTITUTE: SHIMLA - 171 001 (HP)  
CLASSIFIED ABSTRACT OF EXPENDITURE IN RESPECT OF : "NON-PLAN"  
FOR THE MONTH 3/2009

| HEAD OF ACCOUNT                                                      | PROGRESSIVE      |
|----------------------------------------------------------------------|------------------|
| <b>I. ESTABLISHMENT CHARGES</b>                                      |                  |
| 1 Pay of Officers                                                    | 51566786         |
| 2 Pay of Establishment                                               | 54178409         |
| 3 D.P.                                                               | 17519087         |
| 4 Dearness Allowance                                                 | 30617126         |
| 5 H.R.A.                                                             | 8304265          |
| 6 C.C.A                                                              | 2855844          |
| 7 Other Allowances                                                   | 7794756          |
| 8 Ad-hoc Bonus                                                       | 1777558          |
| 9 Transport Allowance                                                | 2670653          |
| 10 O.T.A.                                                            | 3773             |
| 11 Temporary Status                                                  | 3665791          |
| <b>TOTAL ESTABLISHMENT CHARGES</b>                                   | <b>180954048</b> |
| <b>II. Travelling Allowance</b>                                      | <b>999964</b>    |
| <b>III. ANNUAL MAINTENANCE AND REPAIRS</b>                           |                  |
| a) Office Building                                                   | 3537586          |
| b) Residential Building                                              | 1225076          |
| c) Minor Work                                                        | 1737338          |
| <b>TOTAL MAINTENANCE AND REPAIRS</b>                                 | <b>6500000</b>   |
| <b>IV. NON RECURRING EXPENDITURE</b>                                 |                  |
| a) Land                                                              | 0                |
| b) Tools, Plants & Equipments etc.                                   | 927552           |
| c) Building & Other original Works                                   | 0                |
| d) Typewriter Accounting Machine                                     | 0                |
| e) Furniture, fixture & fitting work                                 | 33205            |
| f) Vehicle including cycles                                          | 2644827          |
| g) Livestock purchases                                               | 8280             |
| h) Library books & Journals                                          | 1278548          |
| <b>TOTAL ASSETS ACQUIRED</b>                                         | <b>4892412</b>   |
| <b>V. OTHER RECURRING EXPENDITURE</b>                                |                  |
| a) i) Chemical apparatus & other consumable stores for research work | 328918           |
| ii) Seed                                                             | 24171            |
| b) Fertilizer                                                        | 223106           |
| c) Feeding & upkeep of animals                                       | 2480             |
| d) Telephone : Office/Residence                                      | 321361           |

Contd...



Contd...

| HEAD OF ACCOUNT                                           | PROGRESSIVE      |
|-----------------------------------------------------------|------------------|
| e) Office contingencies                                   | 3393059          |
| f) Other contingencies/Operational Expenses               | 1232775          |
| g) Consumable stores                                      | 422342           |
| h) Sports & Tournaments                                   | 144254           |
| i) Lubricants/POL                                         | 736195           |
| j) Electricity charges                                    | 4207396          |
| k) Water charges                                          | 52465            |
| l) Rent/Lease                                             | 0                |
| m) MC/Road taxes                                          | 11440            |
| n) Animals required for research work                     | 0                |
| o) Printing & Binding                                     | 53200            |
| p) Postage                                                | 215643           |
| q) TA to members of selection committee                   | 0                |
| r) TA to candidate (in the Institute)                     | 0                |
| s) TA/DA to non-officials                                 | 112637           |
| t) Research schemes, fellowships, scholarships and awards | 0                |
| u) Seminars & conferences                                 | 590230           |
| v) Stationary                                             | 271881           |
| w) Refreshment                                            | 15565            |
| x) Watch & Ward                                           | 1148494          |
| <b>TOTAL RS.</b>                                          | <b>206854036</b> |

\*This includes an amount of Rs. 76.38 lakhs for CPRS, Shillong in NEH Region.

Central Potato Research Institute:  
Shimla - 171 001 (HP)

Classified Abstract of Expenditure in Respect of :  
"Plan" for the month 3/2009

| HEAD OF ACCOUNT                      |                                                                | PROGRESSIVE UPTO 3/2009 |
|--------------------------------------|----------------------------------------------------------------|-------------------------|
| <b>I. ESTABLISHMENT CHARGES</b>      |                                                                |                         |
| 1                                    | Pay of Officers                                                | 0                       |
| 2                                    | Pay of Establishment                                           | 0                       |
| 3                                    | D.P.                                                           | 0                       |
| 4                                    | Dearness Allowance                                             | 0                       |
| 5                                    | H.R.A.                                                         | 0                       |
| 6                                    | C.C.A                                                          | 0                       |
| 7                                    | Other Allowances                                               | 0                       |
| 8                                    | Ad-hoc Bonus                                                   | 0                       |
| 9                                    | Transport Allowance                                            | 0                       |
| <b>TOTAL ESTABLISHMENT CHARGES</b>   |                                                                | 0                       |
| <b>II.</b>                           | <b>HRD</b>                                                     | <b>36900</b>            |
|                                      | Travelling Allowance                                           | 1500000                 |
| <b>III. NON RECURRING (ASSETS)</b>   |                                                                |                         |
| a)                                   | Land                                                           | 0                       |
| b)                                   | Tools, Plants & Equipments                                     | 31924234                |
| c)                                   | Building & Other Original Works                                | 10420024                |
| d)                                   | Typewriter Accounting Machine                                  | 0                       |
| e)                                   | Furniture, fixture & fitting work                              | 207056                  |
| f)                                   | Vehicles including cycles                                      | 0                       |
| g)                                   | Livestock purchases                                            | 0                       |
| h)                                   | Library books & Journals                                       | 1321493                 |
| <b>Total Assets Acquired</b>         |                                                                | <b>43872807</b>         |
| <b>IV OTHER RCURRING EXPENDITURE</b> |                                                                |                         |
| a)                                   | Chemical apparatus & other consumable stores for research work | 3514967                 |
|                                      | Seed                                                           | 82480                   |
| b)                                   | Fertilizer                                                     | 485376                  |
| c)                                   | Feeding & upkeep of animals                                    | 0                       |
| d)                                   | Telephone : Office/Residence                                   | 160451                  |
| e)                                   | Office contingencies                                           | 2504220                 |
| f)                                   | Other contingencies/Operational Expenses                       | 725257                  |
| g)                                   | Consumable stores                                              | 1824023                 |
| h)                                   | Lubricants/POL                                                 | 542174                  |

Contd...

Contd...

| HEAD OF ACCOUNT                                           | PROGRESSIVE UPTO 3/2009 |
|-----------------------------------------------------------|-------------------------|
| i) Electricity charges                                    | 1045264                 |
| j) Water charges                                          | 0                       |
| k) Rent                                                   | 0                       |
| l) MC/TC Road taxes                                       | 15712                   |
| m) Animals required for research work                     | 0                       |
| n) Postage Stamp                                          | 50000                   |
| o) Stationary                                             | 79282                   |
| p) TA to members of selection committee                   | 0                       |
| q) TA to candidate                                        | 0                       |
| r) TA/DA to non-officials                                 | 0                       |
| s) Research schemes, fellowships, scholarships and awards | 0                       |
| t) Seminars & conferences                                 | 316319                  |
| u) Printing & Binding                                     | 1766986                 |
| v) Watch & Ward                                           | 0                       |
| vi) Farm Operation Work                                   | 3777407                 |
| <b>TOTAL RS.</b>                                          | <b>62299625</b>         |

\*This includes an expenditure of Rs. 33.63 lakhs for CPRS, Shillong in NEH Region.

| HEAD OF ACCOUNT                                       | Amount (Rs.) |
|-------------------------------------------------------|--------------|
| Pension & other retirements benefits                  | 47998238     |
| Plan Scheme funded from Plan budget                   | 36335705     |
| Loan & Advances                                       | 1248400      |
| R-Deposit                                             | 41633521     |
| RFS                                                   | 49063820     |
| AP Cess Scheme                                        | 1122631      |
| Transaction under IRGS                                | 485588       |
| <b>RECEIPTS</b>                                       |              |
| <b>A-I OTHER RECEIPTS</b>                             |              |
| 1 Sale Proceeds of Farm Products                      | 11489385     |
| 2 Sale Proceeds of Fruits and Vegetables              | 0            |
| 3 Land                                                | 0            |
| 4 Buildings & Other original Work                     | 0            |
| 5 Machines & Vehicles etc.                            | 0            |
| 6 Sale Proceeds of Livestock                          | 0            |
| 7 Rent/License Fee                                    | 598958       |
| 8 Application fee from Candidates                     | 0            |
| 9 Other application fee, diploma charges etc.         | 0            |
| 10 Receipts from Services rendered by Institute       | 2802180      |
| 11 Receipts from schemes, analytical testing fee etc. | 0            |

Contd...



Contd...

| HEAD OF ACCOUNT |                                                | Amount (Rs.)    |
|-----------------|------------------------------------------------|-----------------|
| <b>II</b>       | <b>PUBLICATIONS</b>                            |                 |
| 1               | Sale of Publications                           | 39269           |
| 2               | Advertisement                                  | 0               |
| <b>III</b>      | <b>MISCELLANEOUS RECEIPT</b>                   | 875600          |
| <b>IV</b>       | <b>LEAVE SALARY &amp; PENSION CONTRIBUTION</b> | 0               |
| <b>V</b>        | <b>INTEREST ON SHORT TERM DEPOSITS (LC)</b>    | 95952           |
| <b>VI</b>       | <b>INTEREST ON LOAN &amp; ADVANCES</b>         | <b>647475</b>   |
| <b>VII</b>      | <b>INCOME GENERATED FROM IRGS:</b>             |                 |
| a)              | Training                                       | 127762          |
| b)              | Consultancy-contract services                  | 1034791         |
| c)              | Consultancy-Contract Research Projects         | 292228          |
| d)              | Sale of Technology                             | 0               |
|                 | <b>TOTAL IRGS</b>                              | <b>1454781</b>  |
| <b>VIII</b>     | <b>Prior Period Income</b>                     | 0               |
| i)              | <b>TOTAL OTHER RECEIPTS</b>                    | 16548819        |
| ii)             | Interest on STD                                | 1568219         |
| iii)            | Interest NAIP                                  | 709210          |
|                 | <b>Grand Total</b>                             | <b>20281029</b> |
| <b>B</b>        | <b>RFS i) Receipt</b>                          | 35346335        |
|                 | ii) Interest                                   | 1721149         |

## Promotions/Retirements/Transfers/Deaths

Promotions / Retirements / Transfers / Deaths from 01.04.2008 to 31.3.2009 in Respect of Scientific Category

### Transfers

1. Dr. Manoj Kumar, Sr. Scientist transferred from CPRS, Patna to CPRI, Shimla w.e.f 19.05.2008.
2. Dr. N. Somasekhar, Sr. Scientist transferred from CPRS, Ooty to DRR, Hyderabad w.e.f 17.05.2008.
3. Dr. VK Gupta, Sr. Scientist, CPRS, Shillong transferred to CPRIC, Modipuram.

### Resignations

1. Dr. KC Thakur, Sr. Scientist, CPRI, Shimla w.e.f 28.05.2008.
2. Sh. Shyamlat Jyoti, Scientist, CPRI, Shimla w.e.f 23.05.2005.

### Appointments/Joining

1. Dr. Jagesh Kumar, Scientist, CPRI, Shimla w.e.f 19.05.2008.
2. Dr. (Mrs.) Uma Maheshwari, Scientist, CPRS, Ooty w.e.f 16.05.2008.
3. Sh. AK Srivastava, Scientist, CPRS, Shillong w.e.f 16.05.2008.
4. Dr. Eradasappa. E, Scientist, CPRS, Patna w.e.f 10.07.2008.
5. Dr. Murlidhar J. Sadawarti, Scientist, CPRS, Gwalior w.e.f. 3.11.2008.

### Promotions

1. Dr. RR Burman, Scientist( SS) CPRS, Shillong promoted to the grade of Sr. Scientist by ASRB at IARI, New Delhi.
2. Dr. LC De, Sr. Scientist, CPRS, Shillong promoted to the grade of Principal Scientist by ASRB at NRC for Orchids.
3. Dr. D. Sarkar, Sr. Scientist, promoted to the next grade of Principal Scientist by ASRB at CRIJAF, Barrackpore.
4. Dr. SK Chakrabarti, PS, CPRI, Shimla has been selected to the post of Head, Divn. of Plant Protection, CPRI, Shimla.
5. Dr. NK Pandey, PS, CPRI, Shimla has been selected to the post of Head, Divn. of Social Sciences, CPRI, Shimla.
6. Dr. Arun Pandit, Scientist (SS) promoted to the grade of Sr. Scientist by ASRB at CRRI, Cuttack.

### Retirements

1. Dr. KC Sud PS, CPRI, Shimla w.e.f 31.05.2008.
2. Dr. DB Singh, PS, CPRIC, Modipuram w.e.f 31.05.2008.
3. Dr. PC Pande, PS, CPRIC, Modipuram w.e.f 30.06.2008.

4. Dr. Shiv Kumar, PS, CPRIC, Modipuram w.e.f 30.06.2008.
5. Dr. Sarjeet Singh, Head, Seed Technology w.e.f 31.07.2008.
6. Dr. CK Sharma Sr. Scientist, CPRIC, Modipuram got compulsory retirement w.e.f 11.08.2008.
7. Dr. ( Mrs.) V. Sunaina, PS, CPRIC, Modipuram w.e.f 31.01.2009.
8. Dr. GS Kang, Head, CPRS, Jalandhar w.e.f 31.03.2009.

## Technical

### Promotion :

1. Sh. Ram Das Rai, T-1, CPRS Shillong promoted to T-2
2. Sh. Nihal Singh, T-1, CPRS Gwalior promoted to T-2
3. Sh. Ashok Kumar, T-1, CPRI Shimla promoted to T-2
4. Sh. T Selvaraj, T-1, CPRS Muthurai promoted to T-2
5. Sh. Harbans Lal, T-2, CPRS Jalandhar promoted to T-3
6. Sh. Naresh Kumar Sharma, T-2, CPRI Shimla promoted to T-3
7. Sh. Ajay Vir, T-2, CPRIC Modipuram promoted to T-3
8. Sh. Agre Nand Singh, T-2, CPRS Patna promoted to T-3
9. Sh. Kuldeep Singh, T-2, CPRI Shimla promoted to T-3
10. Sh. Nirmal Singh, T-2, CPRS Jalandhar promoted to T-3
11. Sh. Mahesh Pal Singh, T-2, CPRIC Modipuram promoted to T-3
12. Sh. Narayan Singh, T-2, CPRIC Modipuram promoted to T-3
13. Sh. Radha Krishan T-2, CPRS Gwalior promoted to T-3
14. Sh. Sampati Singh Tomer, T-2, CPRS Gwalior promoted to T-3
15. Sh. Kundan Singh, T-3, CPRIC Modipuram promoted to T-4
16. Sh. Udaivir Singh, T-3, CPRIC Modipuram promoted to T-4
17. Sh. Munna Lal Bharti, T-3, CPRIC Modipuram promoted to T-4
18. Sh. Hesting Jyrwa, T-3, CPRS Shillong promoted to T-4
19. Sh. Jaspal Singh, T-3, CPRS Jalandhar promoted to T-4
20. Sh. Rajneesh Rajput , T-4 , CPRI Shimla promoted to T-5.
21. Smt. Kusum Singh, T-4, CPRIC Modipuram promoted to T-5.
22. Sh. RS Kappor, T-4 , CPRI, Shimla promoted to T-5.
23. Sh. Kashi Prasad, T-4, CPRS Gwalior promoted to T-5.
24. Smt. Shruti Gupta, T-4, CPRI, Shimla promoted to T-5
25. Sh. Rabindra Sharma, T-4, CPRS Patna promoted to T-5
26. Sh. Vijay Kumar Yadav, T-4, CPRIC Modipuram promoted to T-5
27. Sh. Murari Lal, T-4, CPRIC Modipuram promoted to T-5



28. Sh. B.Chandran, T-4, CPRS Muthorai promoted to T-5
29. Sh. Santosh Kumar, T-4, CPRIC Modipuram promoted to T-5
30. Sh. Omvir Singh, T-4, CPRIC Modipuram promoted to T-5
31. Sh. Shyam Kumar Gupta, T-4, CPRS Gwalior promoted to T-5
32. Sh. Munna Lal, T-5, CPRS Jalandhar promoted to T-6
33. Sh. Harvir Singh, T-5, CPRIC Modipuram promoted to T-6
34. Sh. Ramesh Chand, T-5, CPRIC Modipuram promoted to T-6
35. Sh. Krishan Pal Singh, T-5, CPRIC Modipuram promoted to T-6
36. Sh. Ashok Kumar, T-5, CPRIC Modipuram promoted to T-6
37. Sh. Islam Ahmed, T(7-8), CPRIC Modipuram promoted to T-9

### Transfers

1. Sh. Bhag Singh, T-2, Transferred from CPRI Shimla and joined at CPRS Jalandhar.
2. Sh. Yogesh, T-5, Transferred from CPRI, Shimla and joined at CPRS Patna.

### Retirements :

1. Sh. Jaspal Singh, T-2, CPRS Jalandhar retired on 30.4.2008
2. Sh. Gurnam Dass, T-5 , CPRS Jalandhar retired on 30.6.2008
3. Sh. Hans Raj, T-4, CPRS Patna retired on 31.7.2008
4. Sh. DC Chandel, T(7-8), CPRI, Shimla retired on 31.8.2008
5. Sh. Prithi Singh, T-1, CPRS Jalandhar retired on 31.12.2008
6. Sh. Gulzar Singh, T-5 CPRI, Shimla retired on 31.1.2009

## Administrative

### Promotions:-

1. Sh. Suresh Kumar, Steno Grade-III, CPRI, Shimla granted 1<sup>st</sup> Financial Upgradation in the pay scale of Rs.5500-175-9000 w.e.f. 10.4.2008.
2. Smt. Shashi Bala Thakur, Steno Grade-III, CPRI, Shimla granted 1<sup>st</sup> Financial Upgradation in the pay scale of Rs.5500-175-9000 w.e.f. 18.4.2008.
3. Sh. Santosh Kumar, LDC, CPRIC, Modipuram granted 1<sup>st</sup> Financial Upgradation in the pay scale of Rs. 4000-100-6000 w.e.f. 13.5.2008.
4. Sh. Mahender Singh, Sr. Clerk, CPRIC, Modipuram granted 2<sup>nd</sup> Financial Upgradation in the pay scale of Rs. 5500-175-9000 w.e.f. 28.6.2008.
5. Sh. Ram Chand, Steno Grade-III, CPRI, Shimla Appointed to the post of PA through LDCE in the pay scale of Rs. 5500-175-9000 w.e.f. 7.7.2008 .
6. Smt. Poonam Sood, Sr. Clerk, CPRI, Shimla Appointed to the post of Assistant through LDCE in the Pay Band of Rs. 9300-34800 + Grade Pay Rs. 4200/- W.e.f. 01.10.2008.
7. Sh. Sandeep Verma, LDC, CPRI, Shimla promoted to the post of UDC in the Pay Band of Rs. 5200-20200+ Grade Pay Rs. 2400/- w.e.f. 14.10.2008.

### Retirements:-

1. Sh. PC Verma, Sr. Stenographer, CPRI, Shimla Retired on 28.2.2009

### Transfers:-

1. Sh. RR Das, Assistant, joined at CPRS, Gwalior on 19.5.2008 on transfer basis from CPRS, Patna to CPRS, Gwalior.
2. Sh. Tej Singh, LDC, CPRS, Gwalior, transfer from CPRS, Gwalior to CPRI, Shimla and joined on 4.8.2008(FN).
3. Sh. Raghubir Singh, LDC, CPRIC, Modipuram transferred from CPRIC, Modipuram to CPRI, Shimla and joined on 8.8.2008(FN).

### Deaths:-

1. Sh. Uttam Singh, Assistant expired on 19.1.2009.

## Supporting Staff

### Promotions:-

1. Sh. Kashi Chaudhary, SS Gr.III to IV, CPRS, Patna w.e.f. 11.04.2008
2. Sh. Sheo Balak Paswan, SS Gr.III to IV, CPRS Patna w.e.f. 21.05.2008
3. Sh. Nain Singh, SSGr.III to IV, CPRIC, Modipuram w.e.f. 22.05.2008
4. Sh. Bijender Singh, SS Gr.II to III, CPRS, Gwalior w.e.f. 21.05.2008
5. Smt. Birmo Devi, SS Gr.II to III, CPRIC, Modipuram w.e.f. 21.07.2008
6. Sh. Mangtey, SS Gr.II to III, CPRIC, Modipuram w.e.f. 15.01.09
7. Sh. Dharambir, SS Gr.II to III, CPRIC, Modipuram w.e.f. 15.01.09
8. Sh. Suraj Singh, SS Gr.II to III, CPRIC, Modipuram w.e.f. 28.02.09
9. Sh. Virendra Singh, SS Gr.I to II, CPRS Gwalior w.e.f. 21.05.08
10. Sh. Kedar Singh, Ss Gr.I to II, CPRS. Gwalior, w.e.f. 02.07.08
11. Sh. Kallu, SS Gr.I to II, CPRS, Gwalior w.e.f. 15.07.08
12. Sh. Ranbir Singh, SS G.I to II, CPRS, Gwalior w.e.f. 15.07.08

### Retirements:-

1. Sh. Lachman Dass, SS Gr.III, CPRS, Jalandhar w.e.f. 31.05.2008
2. Sh. Pargan Singh, SS Gr.II, CPRS, Jalandhar w.e.f. 31.07.08
3. Sh. Rajbir Singh SS Gr.III, CPRIC, Modipuram w.e.f. 31.08.2008
4. Sh. Nain Singh, SS Gr.III, CPRIC, Modipuram w.e.f. 30.11.08
5. Sh. Rayappan, SS Gr.I, CPRS, Muthorai w.e.f. 31.12.2008
6. Sh. Munna, SS Gr.III, CPRIC, Modipuram w.e.f. 31.01.09

## Personnel

### Scientific

1. Dr. SK Pandey, Director

### AICRP (Potato) Unit

1. Dr. PS Naik, PS & Project Coordinator

### Divn. of Crop Improvement

1. Dr. Jai Gopal, PS & Head
2. Dr. SK Kaushik, Sr. Scientist
3. Dr. D. Pattanayak, Sr. Scientist
4. Dr. Vinay Bhardwaj, Sr. Scientist
5. Sh. A.Chanemougasoundharam, Scientist

### Division of Seed Technology

1. Dr. PH Singh, PS and Acting 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
6. Sh. MK Jatav, Scientist (SS)

### Division of Social Sciences

1. Dr. NK Pandey, PS and Head
2. Dr. Rajesh Kumar Rana, Sr. Scientist
3. Dr. Anil Kumar, Sr. Scientist

### Division of Plant Protection

1. Dr. SK Chakrabarti, PS and Head
2. Dr. ID Garg, PS
3. Dr. VK Chandla, PS
4. Dr. Jagesh Kumar, Scientist

### Division of Crop Phy. & PHT

1. Dr. R. Ezekiel, PS & Head
2. Dr. JS Minhas, PS
3. Dr. Brajesh Singh, Sr. Scientist

### ARIS Cell

1. Dr. Shashi Rawat, Sr. Scientist

### CPRI Campus, Modipuram

1. Dr. Birpal Singh, PS & Joint Director
2. Dr. OP Singh, PS
3. Dr. NC Upadhyay, PS
4. Dr. Satya Vir Singh, PS
5. Dr. Raj Pal Singh, PS
6. Sh. Rambir, Sr. Scientist
7. Dr. (Mrs.) Kamlesh Malik, Sr. Scientist
8. Dr. SK Luthra, Sr. Scientist
9. Dr. Name Singh, Sr. Scientist
10. Dr. Dinesh Kumar, Sr. Scientist
11. Dr. Vinay Singh, Sr. Scientist
12. Dr. M Narayan Bhat, Sr. Scientist
13. Dr. RK Verma, Sr. Scientist (Presently working with CITH, RS, Mukteshwar)
14. Dr. Praveen Kumar, Sr. Scientist
15. Dr. MA Khan, Sr. Scientist
16. Er. Sukhwinder Singh, Scientist (SG)
17. Sh. Sanjay Rawal, Scientist (SG)
18. Sh. Dhruv Kumar, Scientist (SG)
19. Dr. Vijai Kishore Gupta, Sr. Scientist
20. Dr. Devendra Kumar, PS

### CPRS, Jalandhar

1. Er. Manjit Singh, PS & Officiating Head
2. Dr. RK Arora, PS



3. Dr. JP Singh, PS
4. Dr. (Mrs.) Ashiv Mehta, PS
5. Dr. RS Marwaha, PS
6. Dr. SP Trehan, PS
7. Dr. Raj Kumar, Sr. Scientist
8. Er. Sunil Gulati, Scientist (SG)

#### CPRS, Gwalior

1. Dr. VS Kushwah, PS & Head
2. Dr. AK Somani, PS
3. Dr. Anuj Bhatnagar, Sr. Scientist
4. Dr. Shiv Pratap Singh, Sr. Scientist
5. Dr. Murlidhar J. Sadawarti, Scientist

#### CPRS, Shillong

1. Dr. S Ramani, Head
2. Dr. KM Nagaraj, Scientist
3. Dr. AK Srivastava, 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

#### CPRS, Kufri

1. Dr. KR Dhiman, PS & Head ( on deputation to Dr. YS Parmar University of Hort. & Forestry, Nauni, Solan(HP).
2. Dr. YK Sharma, Sr. Scientist
3. Sh. Ashwani Kumar Sharma, Scientist (SG)
4. Dr. Vinod Kumar, Sr. Scientist & Officiating Head

#### CPRS, Patna

1. Dr. RP Rai, PS Head
2. Dr. Gulab Ram, PS
3. Dr. Shambhu Kumar, Sr. Scientist
4. Dr. SK Singh, Sr. Scientist
5. Dr. Barsati Lal, Sr. Scientist
6. Sh. Eradassapa. E, Scientist

# Staff Position at CPRI & its Regional Stations as on 31.3.2009

## Scientific Category

| Scientific Category          | Shimla    | Modi.     | Jal.      | Patna     | Shill.    | Gwlr.     | Ooty      | Kufri     | Total     |
|------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Director                     | 01        | -         | -         | -         | -         | -         | -         | -         | 01        |
| PC                           | 01        |           |           |           |           |           |           |           | 01        |
| Prin. Sci.                   | 12        | 06        | 06        | 02        | 01        | 02        | 01        | 01        | 31        |
| Sr. Scientist/Scientist (SG) | 09        | 13        | 02        | 03        |           | 02        | 03        | 03        | 35        |
| Scientist(SS)                | 03        | 00        |           |           |           |           |           |           | 03        |
| Scientist                    | 02        | 00        |           | 01        | 02        | 01        | 01        |           | 07        |
| <b>Total</b>                 | <b>27</b> | <b>19</b> | <b>08</b> | <b>06</b> | <b>03</b> | <b>05</b> | <b>05</b> | <b>04</b> | <b>77</b> |

## Administrative Category

| Name of the post  | Shimla    | Mod.      | Jal.      | Patna    | Shillong | Gwalior  | Ooty     | Kufri    | Total      |
|-------------------|-----------|-----------|-----------|----------|----------|----------|----------|----------|------------|
| Sr. Admn. Officer | 1         | -         | -         | -        | -        | -        | -        | -        | 01         |
| F&AO              | 1         | -         | -         | -        | -        | -        | -        | -        | 01         |
| AO                | -         | -         | -         | -        | -        | -        | -        | -        | -          |
| AAO               | 5         | -         | 1         | 1        | -        | 1        | -        | 1        | 09         |
| AFACO             | 1         | -         | -         | -        | -        | -        | -        | -        | 01         |
| AD(OL)            | 1         | -         | -         | -        | -        | -        | -        | -        | 01         |
| Asstt.            | 15        | 2         | 2         | 1        | 1        | 1        | 1        | 1        | 24         |
| Sr. Clerk         | 17        | 3         | 5         | -        | 2        | -        | 1        | 1        | 29         |
| LDC               | 15        | 4         | 2         | 3        | -        | 4        | -        | 1        | 29         |
| Private Secy.     | 1         | -         | 1         | -        | -        | -        | -        | -        | 02         |
| Sr. Steno.        | 1         | -         | -         | -        | -        | -        | -        | -        | 01         |
| PA                | 6         | 1         | -         | 1        | -        | -        | 1        | -        | 09         |
| Steno. Grade-III  | 3         | 1         | -         | -        | -        | -        | -        | -        | 04         |
| <b>Total</b>      | <b>67</b> | <b>11</b> | <b>11</b> | <b>6</b> | <b>3</b> | <b>6</b> | <b>3</b> | <b>4</b> | <b>111</b> |

## Technical Category.

| Grade              | Shimla    | Mod.      | Jal       | Patna     | Gwlr.     | Shillong | Ooty     | Kufri     | Total      |
|--------------------|-----------|-----------|-----------|-----------|-----------|----------|----------|-----------|------------|
| T-9                | 1         | 1         | -         | -         | -         | -        | -        | -         | 2          |
| TO T(7-8)          | 1         | 1         | 1         | 1         | -         | -        | -        | -         | 5          |
| TO (T-6)           | 1         | 7         | 3         | 2         | -         | -        | -        | -         | 13         |
| TO (T-5)           | 16        | 13        | 11        | 3         | 3         | -        | 1        | 2         | 49         |
| Techn. T-4         | 5         | 13        | 4         | 4         | 4         | 2        | 2        | 3         | 37         |
| Techn. (T-3)/T-I-3 | 9         | 4         | 2         | 5         | 2         | 1        | -        | 1         | 24         |
| Techn. T-2         | 22        | 3         | 4         | 7         | 3         | 4        | 2        | 3         | 48         |
| Techn. T-1         | 5         | 2         | 1         | -         | -         | 1        | -        | 1         | 10         |
| <b>Total</b>       | <b>60</b> | <b>44</b> | <b>26</b> | <b>22</b> | <b>13</b> | <b>8</b> | <b>5</b> | <b>10</b> | <b>188</b> |

## Supporting Staff

| Grade         | Sanctioned | Filled | Vacant |
|---------------|------------|--------|--------|
| SS Grade-I    | 86         | 55     | 31     |
| SS Grade-II   | 65         | 60     | 05     |
| SS Grade-III  | 39         | 39     | -      |
| SS Grade-IV   | 18         | 16     | 01     |
| Sub Total     | 208        | 170    | 37     |
| Canteen Staff |            |        |        |
| Cook          | 1          | 1      | 0      |
| Tea Maker     | 1          | 1      | 0      |
| Wash Boy      | 1          | 1      | 0      |
| Grand Total   | 211        | 173    | 37     |

## Station-wise/Grade-wise list of the Supporting Staff

| Station      | Grade-IV  | Grade-III | Grade-II  | Grade-I   | Total                  |
|--------------|-----------|-----------|-----------|-----------|------------------------|
| Shimla       | 04        | 13        | 06        | 13        | 36+3*<br>canteen staff |
| Kufri        | 02        | 05        | 03        | 05        | 15                     |
| Patna        | 03        | 02        | 09        | 06        | 20                     |
| Jalandhar    | 01        | 02        | 15        | 08        | 26                     |
| Modipuram    | 01        | 07        | 07        | 04        | 19                     |
| Shillong     | 04        | 06        | -         | -         | 10                     |
| Muthorai     | -         | 02        | -         | 05        | 07                     |
| Gwalior      | 01        | 02        | 20        | 14        | 37                     |
| <b>Total</b> | <b>16</b> | <b>39</b> | <b>60</b> | <b>55</b> | <b>170+3=173</b>       |

\*3 Posts of Canteen Staff

Staff position as on 01.4.2009 of CPRI showing number of SCs, STs, OBCs & Women

| Category       | Sanctioned | Total Filled | SC         | ST        | OBC       | Women     |
|----------------|------------|--------------|------------|-----------|-----------|-----------|
| Scientific     | 109*       | 77*          | 11         | 02        | 05        | 06        |
| Administrative | 121        | 111          | 25         | 08        | 06        | 28        |
| Technical      | 207        | 188          | 43         | 08        | 12        | 11        |
| Supporting     | 211        | 170+*3       | 52         | 09        | 12        | 23        |
| <b>Total</b>   | <b>648</b> | <b>548</b>   | <b>131</b> | <b>27</b> | <b>35</b> | <b>68</b> |

\*Excluding 1 RMP

\*3 post of Canteen staff





## **CENTRAL POTATO RESEARCH INSTITUTE**

*(Indian Council of Agricultural Research)*

SHIMLA - 171 001, HP (India)

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Sr. Administrative Officer : (0177) 2627269, Website : <http://crpi.ernet.in>

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Gram : POTATOSEARCH, SHIMLA - 171 001

EPABX : 2624830, 2625182, 2625074, 2621480, 2625181, 2624575, 2625692, 2624501, 2624923

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### **Important Extension Numbers**

|                                     |     |                                                   |                |
|-------------------------------------|-----|---------------------------------------------------|----------------|
| Director                            | 101 | Head, Crop Physiology and Post Harvest Technology | 451            |
| Project Coordinator, AICRP (Potato) | 201 | Head, Plant Protection                            | 401            |
| Sr. Administrative Officer          | 301 | Head, Crop Improvement                            | 501            |
| Finance & Accounts Officer          | 302 | Head, Social Sciences                             | 561            |
| PA to Director                      | 102 | Head, Crop Production                             | 251            |
| Library                             | 110 | Head, Seed Technology                             | 431            |
| Security Post, Main gate            | 579 | Entomology Sec., Lower Lab.                       | Phone: 2674326 |

### **CPRI Campus & Stations**

|                                                                 |                       |
|-----------------------------------------------------------------|-----------------------|
| Joint Director, CPRI Campus, Modipuram - 250 110, Uttar Pradesh | 0121-2956297, 2575497 |
| Head, CPRS, Jalandhar - 144 003, Punjab                         | 0181-2791474          |
| Head, CPRS, Patna - 801 506, Bihar                              | 0612-2224218          |
| Head CPRS, Gwalior - 474 006, Madhya Pradesh                    | 0751-2470302          |
| Head, CPRS, Muthurai - 643 003, Tamil Nadu                      | 0423-2550669          |
| Head, CPRS, Shillong - 793 009, Meghalaya                       | 0364-2560885          |
| Head, CPRS, Kufri - 171 012, Himachal Pradesh                   | 0177-2648234          |

