वार्षिक प्रतिवेदन
ANNUAL REPORT
2011-12

केन्द्रीय आलू अनुसंधान संस्थान, शिमला

Central Potato Research Institute, Shimla

(Indian Council of Agricultural Research)

ICAR

CPRI

वार्षिक प्रतिवेदन / ANNUAL REPORT 2011-12

ANNUAL REPORT 2011-12

CPRI Annual Report 2012

Printed : June, 2012 (300 copies)

Acknowledgment

Material for this report was received from Jt. Director CPRI Campus, Modipuram, Heads of Divisions/ Sections at CPRI Hqrs. and Head of Regional Stations - Jalandhar, Patana Gawalior, Ooty, Shiloong Kufri

Published by

Dr. BP Singh
Director
Central Potato Research Institute , Shimla - 171 001 (Himachal Pradesh)
E-mail: dircpri@sancharnet.in,directorcpri@gmail.com
Websits : http://cpri.ernet.in
Phone : 0177-2625073
Fax : 0177-2624460

Designed and Printed by

Azad Offset Printers (P) Ltd., 144, Press Site, Indl. Area-1, Chd.
(0172) 2021253-54, 4611489 www.azadoffsetprinters.com

Preface

The Central Potato Research Institute is a premier institution in the field of potato research and development in India. Since its inception, the institute has been instrumental in increasing production and productivity of potato across the country through its dynamic research achievements viz. development of new varieties and improved potato technologies suitable for specific regions. Due to sustained efforts of the institute, India now has become second largest producer of potato with production surpassing 38 million tons during the year 2010-11. The demand of potato is increasing day by day due to ever increasing population and changing food habits of the consumers. The processing sector is also growing fast due to availability of many potato varieties suitable for making chips and french fries, which has been released by the institute.

CPRI has made notable contribution in the field of potato research and development during the period under report. The institute was a partner in a consortium of 26 international institutes that helped in deciphering the complex genome of potato (*S. phureja)*. Sanger, Illumina and 454 other technologies were adopted for sequencing of 727 Mb constituting 86% of the complete potato genome which was published in high impact journal Nature. In the field of crop improvement, six advance stage hybrids for table purpose namely, J/2-14 (Jalandhar), MS/6-819 and MS/6-1947 (Modipuram), PS/5-73, PS/5-75 and PS/6-88 (Patna) and two for processing, MP/04-578 (French fry) and MP/04-816 (chips) were introduced in AICRP for multi-location testing. Hybrids (LBY-15, LBY-17 and SM/92-338) possessing combined resistance to late blight and potato virus Y, and hybrid OS/01-497 having combined resistance to late blight and cyst nematode were also introduced into AICRP (P) for multilocation trials. The institute has validated molecular markers for late blight, potato virus Y and cyst nematode resistance in 165 genotypes and identified 18 genotypes with PVY resistance (*RYadg*), 84 genotypes with late blight resistance genes (*R1 & R3a*) and 79 genotypes with cyst nematode resistance genes *(HC, H1* & *Gro1-4).* Besides, 16 genotypes were identified possessing multiple resistance genes for late blight, PVY and cyst nematodes. Presently, CPRI is maintaining more than 3900 germplasm accessions which are being conserved in field gene banks, in-vitro repository and also as TPS. Decision support systems' Plausible Potato Growing Seasons Estimator (PPGSE) and Yield Estimator were developed for measuring spatial and temporal diversification in potato cultivation. Potato Temperature Stress Degree Hours Estimation tool was developed to help breeders to characterize environments for effective targeting of genotypes. Potato Potential Yield Estimation tool was also developed to estimate the yield gap and provide information on the expected yield. Under nucleus seed production programme a total of 20,220 tubers of 24 varieties were indexed at five different seed production centers/stations. A total production of 31234.66 quintals nucleus and breeder seed was achieved from an area of 168.14 hectares under conventional and hi-tech seed production system. As part of human resource development several training programmes were organized for farmers as well as for extension functionaries of state development departments and private companies to disseminate new potato technologies to the stakeholders.

I would like to appreciate the whole team of scientists and technical staff who were involved in compilation, editing and printing of this comprehensive annual report. I sincerely thank Joint Director, CPRIC, Modipuram, Project Co-ordinator , AICRP(Potato) and all heads of divisions for their efforts and kind cooperation in timely submission of the reports. My thanks are due to the entire editing team of Drs. VK Dua, S. Sundaresha, Sanjeev Sharma, JS Minhas, RK Arora, Dhruv Kumar and NK Pandey who meticulously edited the report. Finally, I express my gratitude to Director General, ICAR, Deputy Director General (Horticulture) and Research Advisory Committee members for providing valuable guidance, direction and suggestion in developing and implementing various research programmes.B

(BP Singh)
Director

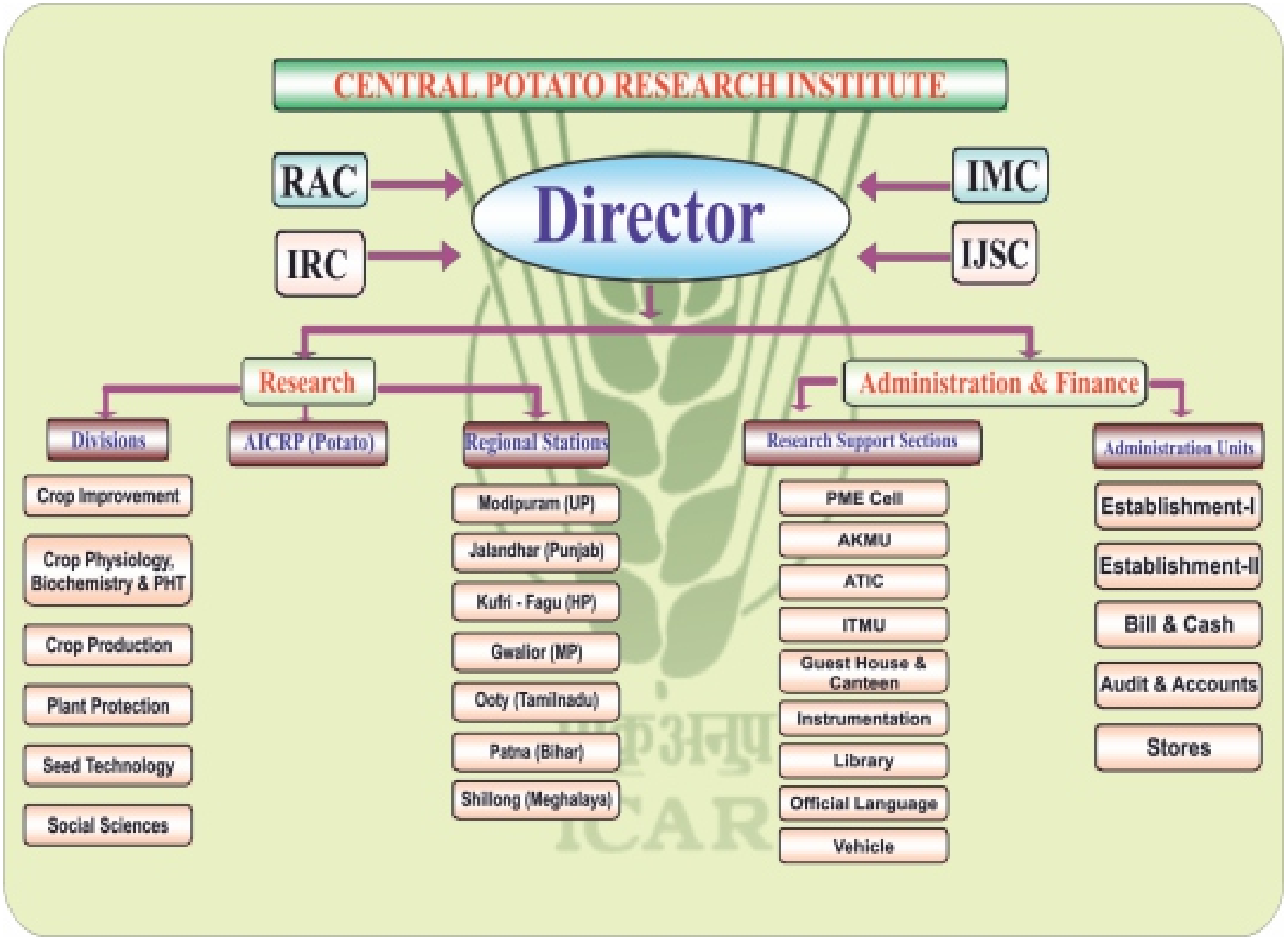
Contents

CPRI- An Introduction

The Central Potato Research Institute was established under the Ministry of Agriculture, Government of India in August 1949 at Patna (Bihar) on the recommendations of the then Agricultural Advisor to the Government of India, Sir Herbert Steward. The institute was shifted to Shimla in the year 1956 in order to facilitate hybridization work in potato and maintain seed potato health. It was transferred to the Indian Council of Agricultural Research (ICAR) in April 1966.

The Research and Development Activities of the institute is carried out under six divisions namely, Division of Crop Improvement, Crop Production, Plant protection, Seed technology, Crop Physiology, Biochemistry and Post Harvest Technology and Social Sciences. In addition to regular research programme, 22 extremely funded research projects sponsored by the ICAR, CIP, ABSP-II (USAID), AP Cess Fund, DBT, NABARD (RIF), & Mini Mission-I are also under operation. Production of Breeders' seed is being done by the Institute under a Revolving Fund Scheme and National Seed Programme. The headquarters of the institute is located in the heart of Shimla city, 4 kilometer from Shimla bus stand near Bemloe. It is located at an altitude of 2000 metres above mean sea level and has wet temperate climate. It has one campus at Modipuram (UP) and six regional stations located across the country viz. Kufri Fagu (HP), Jalandhar (Punjab), Gwalior (MP), Patna (Bihar), Shillong (Meghlaya) and Ooty (Tamil Nadu) to cater the need for location specific research and extension activities.

The institute has established state-of-the-art laboratories for conducting basic and strategic research in different areas of potato. The All India Co-ordinated Research Project on Potato (AICRP-Potato) is also located in the institute and has been functioning since 1971. It has 25 centers located in nearly all agro-climatic zones of the country to test the performance of new hybrids potato varieties and develop region specific technologies in. An Agricultural Technology Information Centre (ATIC) is also functioning in the institute which looks after the transfer of technology activities of the institute. The institute not only develops new varieties and technologies for potato growers of the country but also takes care of dissemination of these technologies to the ultimate clientele through various trainings, demonstrations, farmers fair, exhibitions etc. Currently the institute has a dedicated team of 72 scientists, 172 technical staffs and 105 administrative staffs working on potato crop.


CENTRAL POTATO RESEARCH INSTITUTE
RAC
IRC
Director
IMC
IJSC
Research
Administration & Finance
Divisions
AICRP (Potato)
Regional Stations
Research Support Sections
Administration Units
Crop Improvement
Crop Physiology, Biochemistry & PHT
Crop Production
Plant Protection
Seed Technology
Social Sciences
Modipuram (UP)
Jalandhar (Punjab)
Kufri - Fagu (HP)
Gwalior (MP)
Ooty (Tamilnadu)
Patna (Bihar)
Shillong (Meghalaya)
PME Cell
AKMU
ATIC
ITMU
Guest House & Canteen
Instrumentation
Library
Official Language
Vehicle
Establishment-I
Establishment-II
Bill & Cash
Audit & Accounts
Stores

The Mission

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

Mandate

The Central Potato Research Institute (CPRI) is a non profit 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 agro-ecosystem. 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 coordinate 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 technologies for upgrading scientific manpower in modern technologies for potato production.
- To provide consultancy in potato research and development.

Work of the Institute is being carried out by the six Divisions; Crop Improvement; Plant Protection; Crop Production, Crop Physiology, Biochemistry & Post Harvest Technology; Seed Technology and Social Sciences under 18 well defined research programmes. In addition to regular research programme, 22 extrenally funded research projects sponsored by the ICAR, CIP, ABSP-II (USAID), AP Cess Fund, DBT,

Research Highlights

- In north eastern region at Patna, potato + onion (1:2 ratio) - bottle guard inter cum relay system was most productive and remunerative followed by potato + onion (1:1) - bottle guard system. Growing potato with broadbeans or rosemary in 1:1 ratio was most productive and profitable intercropping for the southern hills at Ooty.

- At Hassan, Karnataka during Kharif potato, variety Kufri Surya performed better followed by Kufri Himalini and Kufri Jyoti. Optimum time of planting was 10th June for all the varieties.

- Decision support systems' Plausible Potato Growing Seasons Estimator (PPGSE) and Yield Estimator were developed for spatial and temporal diversification of potato cultivation. These provide the growing seasons and their durations, climatic features of the seasons and estimated yield potential for important locations in India.

- Potato Temperature Stress Degree Hours Estimation tool was developed to help breeders to characterize environments for effective targeting of genotypes. Potato Potential Yield Estimation tool was also developed to estimate the yield gap and provide information on the expected yield.

- Winter potato acreage and production were estimated through remote sensing, GIS and crop modelling for 2011-12. The acreage forecast under winter potato during 2011-12 in Punjab, Uttar Pradesh, Bihar and West Bengal was 90.6, 516.0, 322.5 and 345.0 thousand hectares, respectively, while the total production was predicted as 2071.1, 11439.7, 5262.4 and 8266.2 thousand tons, respectively.

- The germplasm viz. J-93-98, MS/82-638 and MS/82-398 were identified as more N efficient than Kufri Gaurav based on nitrogen requirement for getting equivalent yield. The chlorophyll content index (CCI) was observed to be a good index to work out supplementary N requirement for potato crop.

- In long term manurial/fertilizer experiment at Modipuram, system productivity was higher in maize–potato–onion (54.5 t/ha) followed by paddy–potato–wheat (48.7 t/ha) and sesamum-potato–green gram system (39.3 t/ha). Paddy–potato–wheat and maize–potato–onion recorded higher C stocks in soil than sesamum–potato–green gram cropping system. The integrated application of organic amendments along with fertilizers worked out to be the best management practice for enhancing C sequestration in soil for sustainable crop productivity.

- The harvesting and collection system of an experimental 2-row tractor operated potato combine harvester was designed and fabricated. The prototype functions to dig out, separate dug tubers from soil mass, conveys, elevates and fills in a trolley. Fabrication work of the frame, grading and power transmission systems of the grader for potato experimental plots and for small farmers was carried out.

- In an extensive survey in Jalandhar and Hoshiarpur districts of Punjab and Kangra

district of Himachal Pradesh, the potato grader and potato combine harvester were identified as the major and immediate needs of medium to large potato farmers. For small farmers in hills, power tiller along with suitable attachments was identified as the major requirement.

- Virus free buffer stock of 25 varieties was maintained after rigorous testing under ELISA followed by PCR against all the viruses.
- A total 20,220 tubers of 24 varieties were indexed for nucleus and breeder seed production at five different seed production centers/stations.
- A total production of 31234.66 quintals nucleus and breeder seed was achieved from an area of 168.14 hectares under conventional and hi-tech seed production system.
- Biopesticides treatment of microplant, microtubers and minitubers improved establishment and vigour
- The new population of *Phytophthora infestans* (mt DNA haplotype Ia) which was introduced in 2002 has almost replaced the old population (Ib haplotype) in all the locations. There is no host specificity among the *P. infestans* isolates of tomato and potato.
- Effect of elevated temperature on efficacy of R genes revealed that the resistance of R1 and its combinations may be eroded if *P. infestans* adapts to higher temperature.
- Hybrids (LBY-15, LBY-17 and SM/92-338) possessing combined resistance to late blight and potato virus Y, and hybrid OS/01-497 having combined resistance to late blight and cyst nematode were introduced into AICRP (P) for multilocation trials.
- Validated molecular markers for late blight, potato virus Y and cyst nematode resistance in 165 genotypes and identified 18 genotypes with PVY resistance (*RYadg*), 84 genotypes with late blight resistance genes (*R1 & R3a*) and 79 genotypes with cyst nematode resistance genes (*HC, H1 & Gro1-4*). Besides, 16 genotypes were identified possessing multiple resistance genes for late blight, PVY and cyst nematodes.
- Standardized protocols for the detection of PALCV (duplex PCR), PVA & PVM (RT-PCR) and PSTVd (realtime PCR). The whole genome of eight PALCV isolates was cloned and sequenced.
- Phylotyping of 90 isolates of *Ralstonia solanacearum* was done through multiplex PCR which could separate the isolates into phylotype I, II & IV.
- Application of pencycuron (0.25%) on potato tubers at planting was most economical and effective against black scurf of potato while that of thiacloprid (0.4%) alone or in combination with summer oil against sucking pests.
- Integration of soil solarisation with neem cake + Trichoderma viride recorded maximum yield of potato and minimum cyst nematode population.
- Antioxidants, anthocyanin and total carotenoids were determined in ten potato varieties. Anthocyanin content was highest in Kufri Satlej (0.833 µg/g) and total carotenoid content was highest in Kufri Surya (230 µg carotene/100g FW).
- The resistant starch content in Kufri Chipsona-1 was 1 mg/100 mg before storage which increased to 1.4 and 1.3, after 90 days of storage at 4 and 12^{0}C, respectively.
- Foliar spray of growth retardants (paclobutrazol and ethrel) 4/6 weeks before harvest recorded mild sprout suppression effect in progeny tubers up to 90 days of storage in heaps.
- A commercial formulation of 1,4-

Dimethylnaphthalene (1,4 DMN) named 1,4 Seed significantly reduced number of sprouts/tuber and length of the longest sprout in seed potatoes of two varieties stored in diffused light storage up to 240 days.

- Four hours of low night temperature was sufficient for tuberization in potato, however, tuber size and weight increased up to 12 hr night duration.
- Growth retardant Paclobutrazole spray 30 days after planting improved tuber yield and harvest index under heat stress conditions.
- Hybrid HT/05-935 was found to be resistant to hopper and mite burn during early planting.
- Root pulling force can be used as screening criterion for drought tolerance.
- In Germplasm enhancement programme, presently CPRI has more than 3900 germplasm accessions which are being conserved in field gene banks, *in-vitro* repository and also as true seeds.
- In Genetic improvement of potato, six advance stage hybrids for table purpose namely J/2-14 (Jalandhar), MS/6-819 and MS/6-1947 (Modipuram), PS/5-73, PS/5-75 and PS/6-88 (Patna) and 2 for processing, MP/04-578 (French fry) and MP/04-816 (chips) are being introduced in AICRP(P) for multi-location testing.
- Five interspecific potato somatic hybrids between *S. tuberosum* and *S. cardiophyllum* were regenerated through protoplast fusion to introgress late blight resistance.
- In Genomics programme, complex genome of potato (*S. phureja*) was deciphered by a consortium of 26 international institutes including CPRI. Sanger, Illumina and 454 technologies were adopted for sequencing of 727 Mb constituting 86% of the complete potato genome which was published in the high impact journal Nature.
- Micro-irrigation systems are very beneficial for improving quality as well as quantity of potato. The cost of potato cultivation under sprinkler and drip irrigation systems, respectively, was 12 and 20% higher than the cultivation under furrow.
- The per hectare yield of potato on drip and sprinkler irrigated farms was 33 and 20% higher in Gujarat and 23.4 and 6.67% higher in MP as compared to the furrow irrigation system.
- Altogether 56 potato technology demonstrations were laid out in HP, Bihar, UP and Meghalaya states of India. Observations from these demonstration revealed that new varieties of CPRI like Kufri Himalini, Kufri Ashoka, Kufri Frysona etc. are having 20-35% yield advantage over local varieties. Moreover, with recommended dose of pesticides there was lesser incidence of pest and diseases.
- The impact of Model training courses revealed that there was 20 to 23% gain in knowledge level of extension functionaries after conduct of training with maximum gain in case of breeding, biotechnology and storage aspects of potato cultivation.

Staff & Finance

The Institute has 622 sanctioned staff strength comprising of 107 scientific, 206 technical, 102 administrative and 207 supporting staff. The staff position as on 31.3.2012 was 484 including 73 Scientific, 165 Technical, 105 Administrative and 141 Supporting staff. The expenditure of the Institute for the year (Plan & Non-Plan & RFS) was Rs 42.69 crores and receipts Rs. 5.16 crores including RFS. The CPRI generated about 12.11 % 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.325.50 lakhs this year and the scheme has been most successful and widely acclaimed. During the year, five scientists were appointed, three were retired, four were transferred from the Institute. In technical category, 49 technicals were promoted, 11 were retired, 5 were transferred. In administrative category, 8 persons promoted, 3 retired, 7 transferred from the Institute. In Skilled Supporting Staff, 6 were promoted and 9 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 AKMU 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.

Executive Summary

Crop Improvement

The division of crop improvement has three research programmes aimed at genetic improvement of potato. The management and the enhancement of potato germplasm is the basic programme of the division aimed at collection, conservation, evaluation and documentation of germplasm and its genetic enhancement through pre-breeding. During the year 71 new accessions were added to the collection and the present collection in the national repository at the CPRI has more than 3900 accessions. These are being conserved in field gene banks, *in-vitro* repository and also as true seeds. The collection was evaluated for a number of important biotic and abiotic stresses and promising accessions were identified. The information generated has been added to electronic databases. Core collection of *Andigena group* comprising 77 genotypes was characterized using set of microsatellite markers of PGI kit. The data depicted reasonable differences among genotypes confirming the distinctness revealed through morph-agronomic traits.

The second programme is on breeding improved cultivars, which aims at developing varieties for table and processing purposes besides standardizing the agronomy of newly developed hybrids/ varieties with emphasis on resistance to important diseases and pests. Besides generating a number of new populations, the clonal material was evaluated in early as well as advanced generations. Based on consistent performance over the years, six advance stage hybrids for table purpose namely J/2-14 (Jalandhar), MS/6-819 and MS/6-1947 (Modipuram), PS/5-73, PS/5-75 and PS/6-88 (Patna) and 2 for processing hybrids, MP/04-578 (French fry) and MP/04-816 (chips) are being introduced in AICRP for multi-location testing.

The third programme is on use of biotechnology for crop improvement. During the year the complex genome of potato (*S. phureja*) was deciphered by a consortium of 26 international institutes including CPRI. Sanger, Illumina and 454 technologies were adopted for sequencing of 727 Mb constituting 86% of the complete potato genome and published in the high impact journal *Nature*. Ninety RNAi transgenic events silencing Invertase (INV) and UDP-Glucose Phosphorylase (UGPase) in Kufri Chipsona-1, Kufri Chipsona-3 and Kufri Surya were produced and multiplied under net-house conditions at CPRS, Jalanadhar. Five interspecific potato somatic hybrids between *S. tuberosum* and *S. cardiophyllum* were regenerated through protoplast fusion to introgress late blight resistance from the *S. cardiophyllum* which is not crossable with cultivated potato. ISSR profiling and characterization of somatic hybrids (*S. tuberosum dihaploid C-13* (+) *S. pinnatisectum*, and C-13 (+) *S. etuberosum*) was also carried out. In Functional genomics, analysis of genes involved in late blight resistance was carried out using microarray technology, which revealed that several candidate genes and pathways are involved in transcriptional control of late blight resistance response.

Crop Production

At Patna, the highest potato equivalent yield (PEY) was recorded in potato+onion (1:2) -bottle guard inter cum relay system (65.5 t/ha) followed by potato+onion (1:1)-bottle guard system (64.6 t/ha). In NEH region at Shillong, PEY (44.3 t/ha) was higher under potato-cabbage followed by potato-radish (36.5 t/ha) crop sequence. Potato+radish intercropping (1:1) recorded highest land equivalent ratio (1.23) and potato equivalent yield (24.5 t/ha). Application of 50% recommended dose of fertilizers (RDF) to potato

and 50% N through FYM and 100% RDF to subsequent crop brought out significant improvement in PEY (43.0 t/ha) and it was found advantageous in comparison with that of sole potato crop.

Growing potato with broad beans or rosemary in 1:1 ratio recorded the highest PEY at Ooty. The recommended practice of growing potato with French beans intercropping (3:2) in summer season followed by cabbage crop in autumn season had shown more stable yield levels in comparison with all other combinations of cropping.

At Shimla the highest yield of garlic (5.0 t/ha) was obtained in garlic–late potato sequence, whereas the potato yield was highest in garlic–potato relay sequence. PEY (32.8 t/ha) was higher in garlic–late potato sequence and was 13.2% higher over second best treatment i.e garlic–potato relay system (28.4 t/ha). In another study at Shimla a positive correlation (0.969*) was observed between accumulated day-degrees and final tuber yield.

Tillage significantly influenced emergence and potato tuber yield at Patna. Minimum tuber yield of 17.9 t/ha was recorded in no tillage treatment, while highest tuber yield (28.6 t/ha) was recorded in treatment having one mould board ploughing + one harrow + one tiller + one planking.

The potential yield of different locations for *kharif* potato was estimated by running the potential yield through INFOCROP-Potato model. Among the locations, Balehonnur and Hassan in Karnataka and Pune in Maharashtra, are expected to have highest yield potential. In most of the locations the potential yield ranged between 20 to 40 t/ha. In a field experiment at Hassan, Karnataka during *Kharif* potato variety Kufri Surya performed better followed by Kufri Himalini and Kufri Jyoti. Among the different planting dates, June 10th proved to be more suitable for all the varieties and at this time of planting Kufri Himalini performed better than Kufri Surya and Kufri Jyoti.

Post emergence application of propaquizafop herbicide at 0.781 kg/ha effectively controlled the weeds in potato and gave yield at par with weed free check at Modipuram and Gwalior. At Shillong metribuzin herbicide at 1 kg/ha as pre emergence was effective for controlling weeds in potato.

Decision support systems' Plausible Potato Growing Seasons Estimator (PPGSE) and Yield Estimator were developed for spatial and temporal diversification of potato cultivation. These give the growing seasons and their durations, climatic features of the seasons and estimated yield potential for important locations in India totalling about 1,500. Potato Temperature Stress Degree Hours Estimation tool, to help breeders to characterize environments for effective targeting of genotypes, was developed. This tool is useful in evaluation of genotypes tolerant to heat stress and also for identifying their target sites for deployment and in manipulating date of planting with minimum stress. Potato Potential Yield Estimation tool was developed to estimate the yield gap and provide information on the expected yield.

Winter potato acreage and production were estimated through remote sensing, GIS and crop modelling for 2011-12 in collaboration with Space Applications Centre (ISRO), Ahmedabad. The acreage forecast under winter potato during 2011-12 in Punjab, Uttar Pradesh, Bihar and West Bengal was 90.6, 516.0, 322.5 and 345.0 thousand hectares, respectively, while the total production was predicted as 2071.1, 11439.7, 5262.4 and 8266.2 thousand tons, respectively.

Out of 752 F_1C_2 clones planted at Jalandhar, 331 were selected for testing for high N efficiency. The yield range of the selected clones was 490 to 1000 g/plant as compared to 460 g/plant of control Kufri Gaurav. The germplasm, J-93-98, MS/82-638 and MS/82-398 appear to be more N efficient than previously identified most N efficient cultivar, Kufri Gaurav based on nitrogen requirement for getting equivalent yield. The chlorophyll content index (CCI) is a good index and can be used to work out supplementary N requirement of potato.

Among six cultivars evaluated at Patna, root volume was highest in Kufri Gaurav (6.53

cm^3/plant). In a sand culture pot experiment at Patna, efficient cultivars like Kufri Gaurav and Kufri Pushkar had significantly higher root/shoot ratio as compared to inefficient cultivar Kufri Jyoti. At Shillong, based on the control yield (No P applied) and dose of P required to produce fixed tuber yield in the same field, Kufri Girdhari was most P efficient followed by cvs. Kufri Giriraj and Kufri Jyoti.

The 35 of the advanced numbers out of 66, tested under plot wise trial at Modipuram produced equal/higher yield than popular varieties Kufri Bahar and Kufri Pukhraj at all irrigation levels *i.e*. 20, 25 and 30 mm cumulative pan evaporation. Water use efficiency of cv. Kufri Pukhraj was 166, 132 and 94 kg tubers/ha-mm water with drip, sprinkler and furrow irrigation method, respectively. Nitrogen fertilizer given in two splits 50% at planting+50% at earthing-up /or stolon formation stage gave higher yield under drip and sprinkler irrigation methods. The extent of increase in tuber yield was in the order of 132.3%, 97.7 % and 41.71% under transparent poly mulch, black poly mulch and silver poly mulch, respectively in comparison to no mulch condition at Shimla.

In long term manurial/fertilizer experiment at Modipuram, system productivity was higher in maize–potato–onion (54.5 t/ha) followed by paddy–potato–wheat (48.7 t/ha) and sesamum-potato–green gram system (39.3 t/ha). The system productivity, tuber size and number in inorganic treatments were higher than organic treatments. The application of micro and secondary nutrients increased the productivity of all systems.

The carbon (C) sequestration study revealed that among the three cropping systems, paddy–potato–wheat and maize–potato–onion recorded higher C stocks in soil than sesamum–potato–green gram cropping system. The incorporation of organic amendments (viz. vermicompost/crop residue) resulted in higher stock of C as well as C sequestration rate in all the cropping systems. The integrated application of organic amendments along with fertilizers worked out to be the best management practice for enhancing C sequestration in soil for sustainable crop productivity.

WOFOST (WOrld FOod STudies) crop growth model was calibrated and validated for long duration potato cultivar Kufri Badshah and medium duration cultivars, Kufri Jyoti and Kufri Bahar using time course data on potato crop growth parameters generated at Jalandhar and a close match was found between simulated and observed values. Under controlled conditions, incubation period of *Phytopthora infestans* was more at lower temperature and less at higher temperature (20 ºC). A positive correlation was observed between incubation period and lesion area development. JHULSACAST model was also validated at Modipuram during 2011-12.

The harvesting and collection system of an experimental 2-row tractor operated potato combine harvester was designed and fabricated. The prototype functions to dig out, separate dug tubers from soil mass, conveys, elevates and fills in a trolley. It requires two tractors to work with the machine, one to operate the machine and second one to carry the trolley to receive the dug tubers. On evaluation, the prototype machine was found to work satisfactorily under the optimum soil and field conditions. The machine requires further improvements to achieve satisfactory performance under clod forming soils and weed infested fields.

Design and fabrication work of the required number of dies for preparing MS/GI wire square openings for their subsequent use in making square wire meshes for an improved square wire mesh type of potato grader for pre-cold storage of potatoes was carried out. Fabrication work of the frame, grading and power transmission systems of the grader for potato experimental plots and for small farmers, was carried out.

A survey was conducted in Jalandhar and Hoshiarpur districts of Punjab and Kangra district of Himachal Pradesh to assess the mechanization needs of the potato farmers. The farmers were found to face severe shortage of farm labour. The

potato grader and potato combine harvester were identified as the major and immediate needs of medium to large potato farmers. For small farmers in hills, power tiller along with suitable attachments was identified as the major requirement.

Two aeroponic systems developed from locally available materials, first made of 50 mm thick thermocol and second made of polythene sheet were compared for potato minituber production. An experiment was conducted under net house conditions for raising potato variety Kufri Chipsona-3 in both the systems. In polythene box 30.9% more number of tubers were obtained as compared to thermo box.

New pallet was designed, fabricated and evaluated for loose handling of potato. On testing in actual working conditions improvement was observed in terms of uniform opening but still there was certain portion of tubers which didn't flow down and got stuck in between two floor parts. Also tuber bruising was observed while washing and treatment. Pallet needs further improvement.

Plant Protection

Late blight incidence in the sub-tropical plains was again insignificant this year. No change in race spectrum, mating types and metalaxyl tolerance was observed in *Phytophthora infestans*. Analysis of mitochondrial haplotypes revealed that new population (Ia haplotype) which was introduced in 2002 has almost replaced the old haplotype Ib in all the locations. The pathogen population was also characterized by SSR markers which revealed that genetic diversity level of *P. infestans* was very high as no correlation was established between year of collection or place of origin. Results of aggressiveness and host specificity of *P. infestans* isolates of tomato and potato revealed that there is no host specificity among the isolates and tomato isolates were more aggressive that potato isolates. PCR based protocol was validated to detect oospores of *P. infestans* in artificial infested soil which could detect up to 20 oospores per gram soil. JHULSACAST model successfully forecasted late blight appearance in North West Indo-Gangetic plains including Punjab. A Decision Support System validated for need based application of fungicides proved better over blanket fungicidal recommendation. The equation developed earlier for prediction of yield loss was also validated which showed deviation from 0 to 9.69% between observed and predicted values. Results of effect of elevated temperature on efficacy of R genes revealed that the resistance of R1 and its combinations may be eroded if pathogen adapts to higher temperature. Two isolates of *Pseudomonas aureoginosa* and two plant species found promising against *P. infestans.* Treatment combination- *Bacillus subtilis* (B5) +*Trichoderma viride* (before disease appearance) - Cymoxanil based (at disease appearance) and subsequently *Bacillus subtilis* (B5) +*Trichoderma viride* spray was found highly effective for the management of late blight. Transformed two Indian potato cultivars Kufri Khyati and Kufri Pukhraj with siRNA and amiRNA gene constructs for late blight resistance.

For development of late blight resistant cultivars, 16800 seedlings were screened out of which 2066 resistant seedlings were retained for further studies. 619 early generation (F_1C_1-F1C_5) hybrids were evaluated and 124 hybrids were retained for further evaluation. In advanced generation, 10 hybrids were evaluated and all were retained for further evaluation.The hybrids LBY-15, LBY-17 and SM/92-338 possessing combined resistance to late blight and PVY were introduced into AICRP (Potato) for multilocation trials. The DNA fingerprinting of advanced hybrids completed with ten SSR markers. Molecular markers for late blight, potato virus Y and cyst nematodes resistance were validated in 165 genotypes and identified 18 genotypes with PVY resistance (*RYadg*) , 84 genotypes with late blight resistance genes (*R1 & R3a*) and 79 genotypes with cyst nematode resistance genes (*HC, H1 & Gro1-4*). Besides, 16 genotypes were identified possessing multiple resistance genes for late blight, PVY and cyst nematodes.

Fifty nine germplasm accessions were tested for PVY and PVX resistance through mechanical

inoculation and ELISA. Under NCS-TCP, one thousand eight hundred and eighty four samples were tested for PVX, PVS, PVY, PVA, PVM, PLRV, CMV, PMTV, TMV, TNV, TRSV, TSV, TSWV, PYDV through DAS- ELISA and PSTVd by RT-PCR. All the samples were found negative. Eighty three samples were planted in the quarantine glass house and tested for the presence of PVT, PYDV, AVB, APMoV, APLV, TRV, TRSV, PSTVd and *Clavibacter*. Out of which, seven *in-vitro* and five TPS samples were found positive to PSTVd. Duplex PCR protocol for the detection of PALCV and RT-PCR protocols for PVA and PVM detection were standardized. Realtime PCR protocol for the detection of PSTVd was also standardized. The coat protein of PVX was cloned in expression vector and its expression was confirmed in *E.coli*. The purified coat protein of PALCV and PVY was injected in rabbits and polyclonal antisera was purified and tested through DAS-ELISA. The selected PALCV transgenic lines were planted and inoculated with PALCV through grafting, the symptom expression was observed and virus load was quantified through realtime PCR. Transgenic plants showed varied resistance against PALCV as compared to untransformed control plants. One line of GTLC2 (GTLC2-127) and three of the KPLC2 (KPLC2-37, KPLC2-44, KPLC2-53) transgenic lines showed complete resistance. Only in selected resistant lines, the copy number was quantified in terms of cycle threshold Ct with respect to a house control gene Elongation factor 1-alpha. Copy number varied from 8 (GTLC2 127) to 3(GTLC2 90) per tetraploid genome of potato. The whole genome of eight PALCV isolates was cloned and sequenced using ABI3500 genetic analyzer. The coat protein genes of PVY, PVA and PVM were cloned and sequenced.

Collected, purified and maintained 39 isolates of *Ralstonia solanacearum*, 13 of *Rhizoctonia solani*, and 40 of *Streptomyces* species. Bivar determination of 48 isolates of *R. solanacearum* revealed that 87.5% belonged to biovar 2 (i.e. race 3), 6.25% to biovar 3 (race1) and 6.25% to biovar 4 (race1) of the pathogen. Biovar 2 was dominant in Madhya Pradesh, West Bengal, Meghalaya and Odisha whereas biovar 4 and biovar 3 were encountered only in Himachal Pradesh. Phylotype of 90 isolates of *R. solanacearum* determed through multiplex PCR (Pmx-PCR),showed that 65.6% isolates belonged to phylotype II, 30% to phylotype I and 4.4% to phylotype IV. Amplification of *egl* and *hrpB* region of thirty five isolates of *R. solanacearum* DNA using EndoF/ EndoR and hrpBf/ hrpBr primers, generated a single band of the predicted size, i.e. 850bp for *egl* and 1434bp for *hrpB* genes, respectively. The phylogenetic position of the strains was entirely consistent with their phylotype on the basis of Pmx-PCR, and distinguished strains clustered in phylotype I, II and IV. Taqman real time PCR protocol could detect the isolates belonging to phylotype I and II but could not detect phylotype IV. Amplification of the nuclear rDNA region of ITS including 5.8S rDNA of forty *R. solani* isolates showed 80.0 to 87.3 % similarity to the isolate ST 11-6 from potato (EF532825) and 74.9 to 82.4 % similarity to tobacco isolate (AB000004) both of which belong to anastomosis group, AG-3. Variation was observed within the isolates and they formed six different subgroups. PCR run with universal primer of 16s RNA of *Stretpomyces* revealed that majority of the isolates possessed *Txt AB+,* followed by nec1+ and tom A+. Maximum isolates belonged to *S. stelliscabiei* followed by *S. scabies* and none belonged to *S. acidiscabies*, *S. turgidiscabies*, and *S. aureofaciens*. A combined treatment with *Bacillus subtilis* (@ 8g/kg seed) +*Trichoderma viride* (@4.5g/kgseed) + PSB (@12.5g/kg seed + Hoagland solution in vermiwash + 1.5% Boric acid +0.04% imidacloprid as seed priming material revealed that it was effective for control of black scurf but significant declined crop emergence and yield at harvest. Among other alternatives a combination of 0.06% oxystrobulin + 0.006% thiomethoxam resulted in maximum control of black scurf and a significant increase in yield. This was followed by 1.15% pencycuron + 1.0% imidacloprid. These chemicals can be used in development of a seed priming formulation. A spray of 0.25% pencycuron (22.9%) on potato tubers at planting was the most economical and effective method for management of black scurf disease of potato

At Modipuram, *Myzus persicae* crossed the critical level in the first week of December. The population of whitefly and leafhopper continued to decline in December-January while that of Aphis gossypii increased till mid December and then declined till third week of January. *M. persicae* continued to increase in December through January. Application of emamectin benzoate @144 g/ha or higher dose provided cent percent protection against mites while abamectin benzoate (0.75 0r 1.25 ml/l) was also effective. Application of thiacloprid (4ml/10L) alone or in combination with summer oil provided protection against sucking pests.

For breeding cyst nematode and late blight resistant varieties, 50,500 hybrid TPS were produced from 20 bi-parental crosses involving selected late blight and cyst nematode resistant parents. Nine thousand five hundred seedlings belonging to 7 cross combinations were screened for late blight and 545 selections were made. One thousand three hundred and forty hybrids were evaluated in single hill/observational rows and 591 hybrids were selected in early generations. Forty one advance generation hybrids were assessed along with standard checks, of which 32 hybrids were selected on the basis of agronomic traits, and resistance to late blight and cyst nematodes. Hybrid OS/01-497 possessing combined resistance to late blight and cyst nematode was introduced into AICRP for multiplication trials in Nilgiris. Integration of soil solarisation with neem cake + *Trichoderma viride* recorded the maximum yield and minimum PCN multiplication and it was at par with solarisation treatments combined with carbofuran. Biofumigation with incorporation of radish leaves @1kg/m2 with polythene covering, recorded maximum yield and minimum PCN multiplication. Application of Cartap hydrochloride was found as effective as Carbofuran against cyst nematodes. Evaluation of soil management practices on PCN dynamics revealed that intercropping with broad bean (1:1) recorded lowest Rf value for PCN. Growing of rosemary as intercrop in susceptible potato K. Giriraj (1:1) recorded better potato equivalent yield and lowest Rf value. In resistant potato hybrid (OS/93-D-204) growing of sole potato was more advantageous both in terms of potato equivalent yield and nematode population. As trap crops for PCN, the susceptible K. Jyoti attracted more juveniles than the resistant K. Swarna and recorded 53% reduction in nematode population. Results of survey reports revealed that the population of cyst nematodes was very high in areas where potato-potato-potato cropping sequence is followed while it was least in the areas where after fallow potato-beet root/cabbage/bean sequence is followed.

Crop Physiology, Biochemistry & Post Harvest Technology

Forty four potato varieties were analyzed again this year for nutrients content. Highest ascorbic acid content (25 mg/100g FW) was observed in three varieties viz. Kufri Chipsona-2, Kufri Sindhuri and Kufri Surya. Highest protein content was observed in Kufri Frysona (293 mg/100g FW). Antioxidants, anthocyanin and total carotenoids were determined in ten potato varieties. Anthocyanin content was highest in Kufri Satlej (0.833 µg/g) and total carotenoid content was highest in Kufri Surya (230 µg carotene/100g FW). Peels and flesh of tubers of twelve potato varieties were analyzed and the concentration of phenols and ascorbic acid was found to be higher in peels, while the concentration of reducing sugars and free amino acids were higher in flesh. Glyco-alkaloids α-solanine and α-chaconine were determined in peels of freshly harvested tubers of eight potato varieties. Highest concentration of α-solanine (130 mg/100g FW) and α-chaconine (183 mg/100g FW) were observed in Kufri Lauvkar. Acrylamide content was determined in chips prepared from forty three potato varieties and a minimum concentration of acrylamide was observed in Kufri Frysona (91 µg/kg) and a maximum concentration was observed in Kufri Himalini (2241 µg/kg). There was a significant positive correlation (r = 0.46) between acrylamide and reducing sugars. In tubers of Kufri Jyoti, after 90 days of storage, starch content (78%) was higher and reducing sugar content (276 mg/100g FW) was lower at 12^0C as compared to 4^0C (74% and 647 mg/100g FW, respectively). The resistant

starch content in Kufri Chipsona-1 was 1 mg/100 mg before storage and it increased to 1.4 and 1.3, after 90 days of storage at 4 and 12^{0}C, respectively. Flours of potato (cv Kufri Pukhraj), banana (cv Nendran) and tapioca (cv Jaya) were blended in different proportions (1:3, 1:1 and 3:1). Lower starch and higher amylose contents were observed in potato flour, whereas, higher starch and lower amylose contents were observed in tapioca flour, while banana flour showing intermediate values. Blending of potato flour with banana and tapioca flours resulted in increased starch, resistant starch, amylose, reducing sugar and sucrose contents. French fry cuts were osmotically dehydrated (OD) using NaCl and sucrose, frozen for 24h and then fried for 1.5 min. at 180^{0}C. The oil content of fried OD product was significantly lower (4.7%) as compared to frozen French fries (10.4%). Microwave cooking (2.30 minutes cooking in microwave) resulted in lower oil content (3.7 – 5.4%) compared to fried frozen French fries (9.6 – 15.4%). Fractionation of potato leaves and stems showed that stem residue had higher starch, reducing sugar and sucrose contents but lower phenols content as compared to leaf residue.

CIPC spray in freshly harvested potatoes reduced sprouting and post harvest losses in 5 cultivars up to 60 days after treatment, while the treatment remained effective in only two cultivars (Kufri Chipsona-1 and Kufri Surya) previously stored at 2-4°C for 5 months. In studies on the effect of tuber maturity and curing of skin on storability and processing quality of potatoes, haulm cutting 15 days before harvest reduced losses under heap storage and at 4 and 12°C. Reducing sugar concentration in stored potatoes remained low in Kufri Chipsona-1 up to 105 days of storage in heaps and chip colour was acceptable even in immature and uncured tubers. At harvest dry matter content was lower in tubers harvested immaturely. Starch content varied from 82.5 to 84% and it decreased with increase in storage duration at 4 and 12°C. The decrease in starch content was more in tubers stored at 4^{0}C than at 12^{0}C which was accompanied by higher accumulation of reducing sugars at 4^{0}C. Foliar spray of growth retardants (paclobutrazol and ethrel) 4/6 weeks before harvest recorded mild sprout suppression effect in progeny tubers up to 90 days of storage in heaps. A commercial formulation of 1,4-Dimethylnaphthalene (1,4 DMN) named 1,4 Seed significantly reduced number of sprouts/tuber and length of the longest sprout in seed potatoes of two varieties stored in diffused light storage up to 240 days. Method for the analysis of 1,4- DMN from potato tubers was standardized by HPLC procedure. A decrease in DMN residues was recorded with the age when the dormancy is terminated. Extract of one plant species in three solvents recorded good sprout suppression activity up to two weeks of storage at 18°C and 85% RH. Catalase activity increased during storage at 4 and 12°C in three varieties and higher activity (0.413 to 0.646 µmoles/min/g fresh weight) was recorded on prolonged storage at 180 days. In studies on changes in ascorbic acid contents during storage at 4 and 12°C, contents decreased during storage at both the temperatures with a lesser decrease recorded at 4°C.

Out of 1074 successful crosses for heat tolerance, 2, 41,199 seeds were extracted. 1609 selections were made from the seedlings raised from these seeds in F_1C_1in the glass house and field. In the field selection at Modipuram, 242 clones were selected from F_1C_2-F_1C_5 stage for further evaluation. Heat tolerance in advanced hybrids was quantified by leaf bud tuberization test under controlled conditions. Four hours of low night temp was sufficient for tuberization in potato, however, tuber size and weight increased up to 12 hr night duration. Growth retardant, Paclobutrazole, 5 and 10 ppm spray 30 days after planting improved tuber yield and harvest index under heat stress conditions. Hybrid HT/05-935 was found to be resistant to hopper and mite burn during early planting. At Jalandhar, Kufri Surya out-yielded Kufri Pukhraj during early planting. For drought tolerance 879 hybrids were selected at F_1C_1 stage from 20530 seeds from seven crosses. 5 hybrids were selected from 2005 series, 32 selected from 2006 and 2007 series, 70 from 2009 and 74 from 2010 series. Root pulling force can be used as

screening criterion for drought.

Seed Technology

During the year a total of 20,220 tubers of different potato cultivars were indexed at Modipuram, Jalandhar, Gwalior, Patna and Kufri. Over all health status of Modipuram, Jalandhar, Gwalior, Patna and Kufri recorded during tuber indexing was 96.5, 98.2, 97.0, 90.0 and 100.0 %, while in stage-I, it was 97.13, 95.80, 96.60, 97.83 and 98.90%, respectively. A total production of 31234.66 quintals nucleus and breeder seed was achieved in an area of 168.14 hectares under conventional and hi-tech seed production system. Under nucleus and breeder seed, total 118.54 hectares area was planted under conventional seed production system and a production of 19869.77 quintals was achieved in different stages whereas under hi-tech seed production system an area of 49.60 hectares was planted and 11364.89 quintals production was achieved in different generations. Therefore, during the year 29.50% area and 36.39% production was achieved under hi-tech seed production system and the rest from the conventional system. A total of 23892.42 quintals breeder seed was produced through conventional (14173.81 quintals) and hi-tech (9718.61 quintals) seed production systems. In generation-0, 655282 in numbers and 94.95 quintals minitubers/tubers were produced from microplants, microtubers, through aeroponic and recycling of <3 g minitubers at different stations. A total of Rs.4,10,52,585 was generated under revolving fund scheme through sale of breeder seed of potato. At CPRS, Ooty and Shillong, an area of 14.30 hectares was planted and 1758.07 quintals quality seed was produced. In addition to this an area of about 92.69 hectares was planted under rotational crops viz., wheat, gram, mustard, bajra, lentil, moong, dhaincha, bean and tea and revenue of Rs.33.46 lakhs was generated through rotational crops.

At Kufri crop raised with tissue culture and conventional seed tubers did not had any significant effect on different yield attributing characters. However, at Jalandhar more number of stems was recorded while, at Gwalior more number of seed was recorded in G-1 and G-2. In virus profiling, infection of PVX (48.5%) and PVS (40.4%) in Fagu, and PVX (85.7%) in Una was observed. Survey in Punjab revealed presence of mild mosaic and severe mosaic in 95.7% and 57.4% samples, respectively. In Gwalior a new disease with symptoms of bright yellowing from the lower corners of leaflets and veinal necrosis symptoms were observed. Potato-green manure-wheat crop-Potato rotation together with the use of seed treated with 3% boric acid resulted in a sharp decrease in incidence of russet scab and black scurf at Jalandhar. At Shimla, boric acid (3%), monceron (0.3%), captan (0.3%), mancozeb (0.4%) and carbendazim (0.3%) were equally best for the management of black scurf. Biopesticide treatment of minitubers promoted vegetative growth and resulted better post harvest storage in terms of sprout vigour and minimum weight loss. In aeroponic system maximum number of tubers and yield per plant as well as mean tuber weight was obtained in 20x20 cm spacing. After five cycles of sub-culturing the medium prepared without growth regulator had significant effect on microplant height, number of leaves, number of nodes and root length. In general, upper portion of microplantlets treated with IBA 125 ppm resulted better establishment, number of roots as well as root length and at par with rootex. *T. viride* (2%) resulted highest survival (93.3%) of microplants as compared to control (60%). *P. fluorescence* (2%) significantly increased number and weight of minituber in comparison to control. In microtubers about 50% less weight loss than control was recorded in Chitosan 1.0% and resulted better performance in terms of stand establishment, tuber number and yield. Higher doses of biopesticide priming in microtubers at ambient temperature resulted no adverse effect on sprouts growth, shoot and root development and significantly enhanced the re-sprouting behavior compared to control.

Social Sciences

During the year 2011-12, a survey was conducted in Gujarat and Madhya Pradesh states of India

regarding effectiveness of micro-irrigation systems like drip and sprinkler system. It was found that the cost of potato cultivation under sprinkler and drip irrigation systems was 12 and 20% higher than the cultivation under furrow irrigation in Gujarat state. The benefit cost ratio of potato cultivation in Gujarat under furrow, sprinkler and drip irrigation systems was 1.37, 1.52 and 1.97, respectively. The per hectare yield of potato on drip and sprinkler irrigated farms was 33 and 20 per cent higher compared to the furrow irrigation system in the state of Gujarat. The gap in yield and profitability was lower in MP compared to Gujarat. Availability of canal water (6% non adopter respondents), costly micro-irrigation installation (30% non adopter respondents) and adjustment leading to convenience in the old set-up (64% non adopter respondents) were the principal constraints in the way of adoption of micro irrigation technology.

Moreover, 56 potato technology demonstrations were laid out in HP, Bihar, UP and Meghalaya states of India. Observations from these demonstrations were recorded and analysis of data revealed that new varieties of CPRI like K. Himalini, K. Ashoka, K. Frysona etc. are having 20-35% higher yield advantage over local varieties. Also, with recommended dose of pesticides there was lesser incidence of pest and diseases on these varieties as compared to local check. During this period, the social sciences division also conducted two 8-days Model Training courses for extension officers of different state department of agriculture. The impact of these Model training courses revealed that there was 20 to 23% gain in knowledge level of extension functionaries after conduct of training with maximum gain in case of breeding, biotechnology and storage aspects of potato cultivation. Besides, 8 more trainings were conducted in CPRI, Shimla and many at its regional stations to train farmers in improved methods of potato cultivation. The experts from institute also took part in 12 Live Phone in programmes and chat show on AIR and Shimla Doordarshan.

Research Programmes

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

Research Programmes and Institute Code No.	Programme Leader and Associates
Molecular characterization, detection and management of potato pathogens P1-2010/9-IPR-H20/0210	Dr. SK Chakrabarti **Associates:** Drs. Sanjeev Sharma, Vinay Sagar, A Jeevalatha, Baswaraj, VU Patil and EP Venkatasalam
Characterization, detection and management of major soil and tuber borne pathogens of potato P1-2010/10-IPR-H20/0210	Dr. RK Arora **Associates:** Drs. Vinay Sagar, KK Pandey, AK Somani, Sanjeev Sharma, A Jeevaatha, MS Gurjar and Rahul Bakade
Population dynamics and management of potato pests P1-2010/11-IPR-H20/0210	Dr. (Mrs.) Kamlesh Malik **Associate:** Dr. Anuj Bhatnagar
Management of potato nematodes P1-2010/12-IPR-H10/0210	Dr. TA Joseph **Associates:** Drs. R Uma Maheswari, K Manorama, Sh. I Abdul Rasheed and Sh. B Chandran
Physiological and genetic approaches in managing heat and water stress under sub-tropical environment in potato P1-2010/13-IPR-F60/0210	Dr. JS Minhas **Associates:** Drs. Devendra Kumar, VK Gupta, Sanjay Rawal, Kamlesh Malik, Brajesh Singh, Shashi Rawat, Name Singh and Mrs. Shailly Chopra
Potato storage: Efficient and eco-friendly methods for improved quality P1-2010/14-IPR-F60/0210	Dr. (Mrs.) Ashiv Mehta **Associates:** Drs. R Ezekiel, Brajesh Singh, Bandana, Pinky, MA Khan, Sh. Yogesh Gupta and Mrs. Vineet Sharma
Nutritional value of potato and potato products P1-2010/15-IPR-Q10/0210	Dr. R Ezekiel **Associates:** Drs. Ashiv Mehta, Brajesh Singh, Mrs.Pinky, Ms Bandana and Mrs. Vineet Sharma
Production of breeder seed of potato through conventional and hi-tech system P1-2010/16-IPR-F00/0210 Impact of potato technologies developed by the Institute P1-2010/17-IPR-C00/0210	Dr. KK Pandey **Associates:** Drs. BP Singh, SK Chakrabarti, EP Venkatasalam, Vinod Kumar, Ashwani Kumar Sharma, SK Kaushik, Rajpal Singh, Dhruv Kumar, Vinay Singh, JS Minhas, RK Arora, AK Somani, Anuj Bhatnagar, SP Singh, MJ Sadawarty, Manoj Kumar, SK Singh, RK Singh, Rahul Bakade, Er. Sukhwinder Singh, R Muthuraj, G Ravichandran, TK Bag, S Eradasppa, Ratna Preeti Kaur and Sh. YP Singh, Sh. RK Samadiya, Sh. Parvesh Jassal, Mrs. Sumita Sharma, Sh. RK Verma, Sh. Balak Ram Singh, Sh. KP Singh, Sh. NK Sood, Sh. Jasvir Singh, Sh. Santosh Kumar, Sh. Pushpender Kumar, Sh. Satinder Kumar, Sh. Kapil Kumar Sharma, Sh. Akhilesh Kumar, Sh. Arun Kumar Singh, Sh. V Rajendran and Sh. Sanjay Sharma
Climate change impact and adaptation strategies for potato crop P1-2011/18-IPR-F27/0210	Dr. NK Pandey **Associates:** Drs. Rajesh K Rana, Dhiraj Kumar Singh, SK Yadav, Sh. Rambir, Sh. TK Sinha and Sh. Ashok Kumar Chauhan Dr. VK Dua **Associates:** Drs. JS Minhas, Mehi Lal, Kamlesh Malik, BP Singh, Sanjeev Sharma, Vinay Sagar, Sanjay Rawal, SK Singh, SP Singh, Sushil Kumar and Sh. Yogesh

Results Framework Document (2011-12)

Inter se priorities among key objectives, success indicators and targets

Objectives	Weight	Action	Success Indicators	Unit	Weight	Progress
1. Enhancing productivity and quality of potato through varietal improvement	20	Development and introduction of improved hybrids in AICRP	Number of hybrids introduced in AICRP for multi-location trial	Number	15	9
		Collection and conservation of genetic resources for sustainable use	Number of germplasm accessions added to gene bank	Number	5	71
2. Production of quality Planting material of potato	19	Production of potato nucleus and breeder seed through conventional system	Quantity of seed produced	Quintals	8	19869.77
		Production of potato nucleus and breeder seed through tissue culture	Quantity of seed produced	Quintals	8	11364.89
		Production of minitubers through aeroponics	Number of minituber produced	Number	3	62700
3. Resource based planning and crop management	15	Field trials for evaluation of nutrient and water use efficiency	Number of varieties/hybrids evaluated	Number	6	More than 7 varieties/hybrids have been evaluated for nutrient and water use efficiency. The detailed annual report already submitted.

Contd.....

Objectives	Weight	Action	Success Indicators	Unit	Weight	Progress
		Characterization of potato growing environments in *kharif* season.	Areas for growing *kharif* potato with potential growing period and yield.	Date	6	Areas for growing *Kharif* potato with potential growing period and yield have been identified before the target date *i.e.* 31.12.2011. The detailed annual report already submitted.
		Field trials for identifying promising crop sequences/inter-cropping systems for north-eastern plains	Crop sequences/inter-cropping systems with high yield potential and/or nutrient use efficiency	Date	3	Crop sequences/inter-cropping systems with high yield potential and/or nutrient use efficiency have been identified for north-eastern plains before the target date i.e. 31.3.12. The detailed annual report already submitted.
4. Effective and eco-friendly crop protection.	15	Collection of *Phytophthora infestans* isolates from different agro-ecological zones and their phenotyping	Isolates of *P. infestans* collected, characterized and conserved	Number	7	One hundred and forty isolates of *Phytophthora infestans* were collected, characterized for mating types, race spectrum and metalaxyl sensitivity and conserved in liquid nitrogen. As per the success indicators, more number of isolates were phenotyped before the target/criteria value (*i.e.* 31st March 2012).
		Study genome variability of potato apical leaf curl virus isolates of sub-tropical areas	Clustering of PALCV isolates on the basis of genome variability	Date	4	Eight isolates from Jalandhar (1), Modipuram (2), Haryana (1), Hisar (1), Gwalior (1), Deesa (1) and Faizabad (1) were selected for whole genome sequencing based on the variation in coat protein gene region. RCA was performed with templiphi kit to amplify the DNA A and DNA B components and the products were digested with Xba I enzyme and cloned in pUC 18 vector. The recombinant colonies were selected by blue white selection by X-gal-IPTG and further confirmed by colony PCR and restriction digestion. The clones were sequenced through primer walking in ABI 3500 genetic analyzer. Phylogenetic analysis was performed using clustal X software.

Contd.....

Objectives	Weight	Action	Success Indicators	Unit	Weight	Progress
		Development of diagnostic kits for potato pathogens	PCR based diagnostic protocol for *Phytophthora infestans*	Date	4	PCR based diagnostic protocol for detection of *Phytophthora infestans* in host tissues has been developed by validating the specific primer sets. The ptotocol could detect infection up to 20 mm away from diseased tissue with sensitivity up to 10 fg of genomic DNA. As per the success indicators, the protocol was developed before the target/ criteria value (*i.e.* 31 December 2011).
5. Improving storage methods and nutritional quality of potato based foods	10	Screening of environmental friendly sprout inhibitors	Number of compounds screened	Number	5	1. Salicylaldehyde, methanol and diphenyl amine were tested for their sprout suppression effect and was found effective in suppressing sprout growth of potatoes stored at 24± 2°C. 2. One compound namely 1.4 dimethyl naphtha-lene has been tested for its sprout suppression effect and was found effective in suppressing sprout growth of potatoes.
		Define pre-harvest biomarkers for improved storability	Determining the effect of tuber maturity and curing of varieties/hybrids	Number	3	1. Potatoes of three varieties harvested at two maturity levels, with and without curing were stored at 4 to 12°C, in the end of the March and the experiment is in progress 2. The dry matter content was higher in Kufri Chipsona-I and lower in Kufri Pukhraj. Mature tubers showed higher dry matter content as compared to immature tubers. After 90 days of storage, higher weight loss was observed in tubers stored at 12°C as compared to 4°C in all the three varieties. Starch content showed little difference while phenol content was higher in tubers stored at 12°C. 3. Potatoes of three varieties harvested at two maturity levels, with and without curing have been stored at 4 and 12°C at 90% RH.

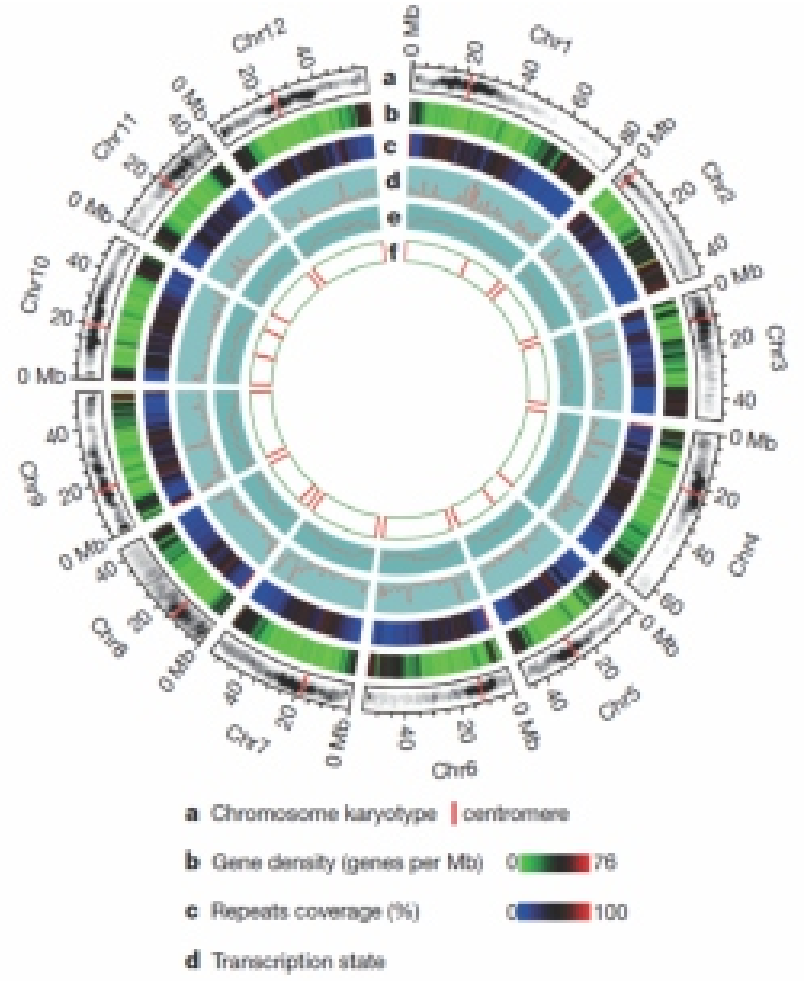
Contd.....

Objectives	Weight	Action	Success Indicators	Unit	Weight	Progress
		Value added products with improved nutritional quality	Recipes with improved nutritional quality	Number	2	One
6. Seed chain analysis, human resource development and technology transfer	10	Analyse seed potato distribution chain	Respondent covered	Number	3	The survey of 270 farmers, 30 traders and 6 district level officers was conducted in six district of Punjab and UP. Thus, a total of **306** respondents were interviewed regarding seed potato cultivation.
		Capacity building and training to farmers/ KVK officials and other extension functionaries	Beneficiaries provided training	Number	2	Altogether 341 farmers were provided training at CPRI, Shimla. In addition to this, 91 extension functionaries from different part of India were also given training. So, a total of **432** beneficiaries were provided training.
		Technology dissemination through mass media and on-farm demonstration	Technology dissemination activities	Number	2	55 on farm demonstrations in Shimla, Patna, Modipuram and Shillong were conducted. phone in programmes on AIR, Shimla and Doordarshan. So a total of **72** technology dissemination activities were carried out during 2011-12.
		Analysis of adoption pattern of potato growers	Farmers to be covered	Numbers	3	The survey of **95** potato growers of Shimla, Mandi and Kangra districts of Himachal Pradesh was conducted regarding adoption of potato technologies.
7. Efficient functioning of the RFD system	11	Timely submission of RFD for 2011-12	On-time submission	Date	2	Timely submitted
		Timely submission of results for 2011-12	On-time submission	Date	1	Timely submitted
		Finalize a strategic plan	Finalize the strategic Plan for next 5 years	Date	2	Timely submitted

Contd.....

Objectives	Weight	Action	Success Indicators	Unit	Weight	Progress
		Identify potential areas of corruption related to organisation activities and develop an action plan to mitigate them	Finalize an action plan to mitigate potential areas of corruption	%	2	Identified
		Implementation of Sevottam	Create a Sevottam complaiant system to implement, monitor and review Citizen's Charter	Date	2	Created
			Create a Sevottam Compliant system to redress and monitor public grievances	Date	2	Created

Division of Crop Improvement



Management and enhancement of potato germplasm

Genetic resources of a crop are the basic raw material required for its genetic improvement. CPRI thus maintains a potato germplasm collection and has been designated as the National Active Germplasm site for potato. The main activities of the programme are to import, conserve and evaluate the germplasm collection for important biotic and abiotic stresses and lastly to document the information in easily retrievable form for use by the researchers. The wild species are evaluated for traits like low cold induced sweetening and late blight resistance which are not available in the cultivated collection. Besides, the cultivated groups of germplasm i.e. Tuberosum and Andigena are pre-bred to improve their agronomic performance and disease-pest resistance.

Potato germplasm collection, conservation & documentation

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.

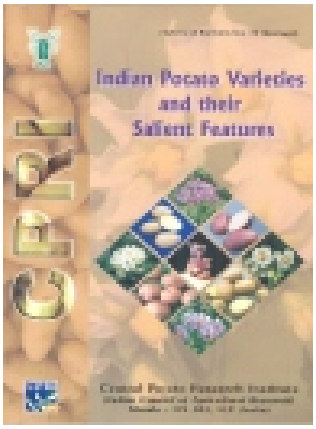


Fig. 3. Indian Potato Varieties and their Salient Features

Fig. 1. In-vitro germplasm repository at CPRI Shimla

Collection

During the year under report, 71 accessions including 27 from CIP Lima Peru, 8 accessions from USA, 10 from the Netherlands, 8 from China, 7 from Australia, 10 from New Zealand and 1 from Egypt were added to cultivated germplasm collection. The present germplasm collection at CPRI consists of more than 3,900 accessions of cultivated and wild species from 30 countries.

Conservation

One thousand three hundred ninety-nine Tuberosum accessions, 768 Andigena accessions and 69 indigenous samples were maintained in fields at Jalandhar. Nearly 1275 Tuberosum accessions and 90 indigenous samples were maintained in fields at Kufri. Ten dihaploids of Indian commercial varieties were maintained in glasshouse at Shimla. Three hundred and fourteen accessions (both in tuber and TPS forms) of 103 species were conserved at CPRI, Shimla.

With a view to evaluate different wild species, 78 clones were obtained from 13 accessions

belonging to 5 species by raising seedlings from TPS. A total of 5813 true seeds of 5 accessions pertaining to 3 wild species were produced through sib-mating/selfing at Shimla. With the objective of conservation of wild species in DNA form, DNA was extracted from 20 clones of 15 accessions pertaining to 12 species.

Nearly 1750 Tuberosum and 44 accessions of Andigena core-collection were maintained in in-vitro form. Minitubers of 140 accessions from in-vitro repository were produced and added to the germplasm collection maintained under field conditions at Jalandhar and Kufri. Out of 15 virus infected accessions, 7 were freed of PVA by meristem tip culture.

Evaluation for Adaptability

Temperate long days (Kufri)

Twenty-eight accessions found to be good yielder or resistant to late blight or both during previous years were evaluated in a replicated trial. None out yielded the best control variety Kufri Himalini (238g/plant, CD 58 at 5%). In another single row trial set, 183 accessions were evaluated along with Kufri Jyoti, Kufri Giriraj, Kufri Himalini and Kufri Girdhari as controls. None of the accession out-yielded the best control variety Kufri Himalini (317g/plant). The top high yielding five accessions were CP 1623 (285 g), CP 1358 (281 g), CP 1544 (260 g), CP 3612 (255 g) and CP 1658 (253 g). All these accessions were resistant to late blight also.

Sub-tropic short days

Jalandhar

One hundred (100) Tuberosum accessions were evaluated under spring planting conditions. The yield of germplasm accessions ranged from 28 to 679 g/plant. Best control variety was Kufri Jyoti (450 g/plant). The highest yielding (g/plant) five germplasm accessions were: CP 3771 (679), CP 3784 (614), CP 3677 (550), CP 3776 (543) and CP 3762 (529).

Modipuram

Under early planting, 73 Tuberosum genotypes including five control varieties viz., K. Bahar, K. Pukhraj, K. Khyati, K Surya and K. Sadabahar were evaluated under heat stress conditions in replicated trial at 75 DAP. The highest tuber yield (g/plant) was recorded in K. Surya (164) followed by CP 3358 (151), CP 3427 (136), CP 3447 (135), CP 3275 (129), CP 3355 (126), CP 3428 (125), CP 3382, CP 3208 and CP 3413 (109).

Under normal planting condition, 77 Tuberosum genotypes including five control varieties viz., K. Bahar, K. Pukhraj, K. Khyati, K. Sadabahar and K Surya were evaluated in replicated trial at 90 DAP. The highest tuber yield (g/plant) was recorded in CP 3676 (747) followed by K. Khyati (723), CP 3654 (674), CP 3558 (657), CP 3687 (637), CP 3605 (632), CP 3685 (617), CP 3627 (614), CP 3785 (613), CP3773 (612), CP 3672 (608) CP 3689 (605) and K. Pukhraj (677)

Evaluation for diseases and insect-pests

Late blight: Twenty-eight accessions were evaluated at Kufri in replicated trial with Kufri Jyoti, Kufri Giriraj, Kufri Himalini and Kufri Girdhari as controls. The AUDPC values indicated that 6 accessions namely CP Nos. 1012, 1085, 1187, 2001, 2003 and 2030 were highly resistant (AUDPC<30), 4 accessions namely CP Nos.1319, 1812, 2320 and 2390 were resistant (AUDPC 31-100). Accessions namely CP Nos. 1012, 1187, 1319, 1812, 2001, 2003 and 2330 were promising during last year also. Remaining 18 accessions namely CP Nos. 1160, 1181, 1207, 1230, 1315, 1351, 1415, 1817, 1822, 1826, 1890, 1978, 1879, 1983, 2330 2290, 2584 and 3184 were susceptible (AUDPC>300) to late blight.

In another set, 180 accessions were evaluated in single row trial for foliage resistance to late blight. On the basis of AUDPC value, 18 accessions were found to be highly resistant, 17 accessions were resistant and 55 moderately resistant. Remaining 90 accessions were susceptible to late blight.

Seventy seven accessions found promising at Kufri during previous years were evaluated at Shillong and Ooty. Ten accessions namely CP Nos. 1750, 2018, 2132, 2187, 2279, 2298, 2379, 2411, 3776 and 3841 showed resistance at par with the best control variety Kufri Girdhari at both the location.

By detached leaf method, 127 germplasm accessions were tested for foliage resistance to late blight. Only four accessions (CP 2093, CP 2187, CP 3094 and CP 3413) were highly resistant, 21 accessions were resistant and 67 were moderately resistant. Out of 73 accessions tested for tuber resistance by tuber slice method, only one accession (CP 3184) was found to be highly resistant, two accessions (CP 3135 & CP 4101) were resistant and 29 accessions were moderately resistant.

Stem necrosis: A total of 64 germplasm accessions were screened in field at Gwalior for the 4th successive year. Of them 7 accessions viz., CP No's: 1349, 1471, 1586, 1829, 1991, 2003 and 2072 were found to be highly resistant, 9 were resistant and 17 were moderately resistant. A total of 43 germplasm accessions were screened for the 3rd successive year. Among these 16 accessions were highly resistant, 4 accessions were resistant and 4 were moderately resistant. Thirty-six germplasm accessions were screened for the second time. 20 accessions were highly resistant and 4 were moderately resistant.

Viruses: Fifty-nine germplasm accessions were screened for resistance against PVX and PVY viruses by mechanical inoculation and through DAS-ELISA. Out of these, 12 accessions namely CP Nos. 1623, 2023, 2212, 2397, 3170, 3376, 4113, 4172, 4176, 4178, 4187 and 4192 were possessing combined resistance to PVX and PVY, while 9 and 17 accessions possessed only resistance to PVX and PVY, respectively.

Leaf hopper and mites: Seventy three accessions were evaluated under early planting conditions for hopper burn and mite damage. Eight accessions namely CP Nos. 3275, 3277, 3355, 3358, 3362, 3372, 3379 and 3427 were promising (<10% burn) to hopper burn whereas 15 accessions namely CP Nos. 3259, 3262, 3279, 3353, 3361, 3363, 3365, 3391, 3396, 3397, 3428, 3431, 3432, 3442 and 3447 had less than 10% mite damage. In other experiment, out of 98 genotypes, 10 accessions viz., CP 2181, CP 2182, CP 2187, CP 2287, CP 2242, CP 2294, CP 2300, CP 2310, CP 2346 and CP 2364 were promising to both hoper burn and mite damage.

Cyst nematodes: A total of 79 Tuberosum accessions were screened against both the species of cyst nematodes viz. Globodera pallida and G. rostochiensis at Ootacamund, by planting 5 tubers of each accession in earthen pots (one tuber/pot) containing soil with about 10,000 propagules of both the species. The plants were maintained at 21±2 ^{0}C in a glasshouse. At 65 and 75 days after planting the plants were depotted and entire root ball was observed for PCN development. Data on developing females were recorded and accessions were grouped as resistant (< 5 females), moderately resistant (6-10 females) and susceptible (> 10 females). The data indicated that only 4 accessions (CP 3080, CP 4080, CP 4089 and CP 4137) were resistant to both the species and 3 accessions namely CP 1197, CP 3081 and CP 4187 were resistant to *G. rostochiensis* whereas, CP 1623 and CP 1832 were resistant to *G. pallida.*

Evaluation for Biochemical, Physiological and other traits

Keeping quality: Seventy-five Tuberosum accessions with two controls namely Kufri Dewa and Kufri Badshah were evaluated for keeping quality at room temperature (18-37oC, 46-83% RH) for 105 days from March onward at Jalandhar. Monthly observations on weight loss, sprouting, tuber rottage were recorded during the period of storage. Twenty-one accessions viz., CP Nos. 2351, 2360, 2364, 2365, 2369, 2370, 2374, 2378, 2384, 2379, 2389, 2397, 2406, 2414, 2419, 2422, 2427, 2639, 2994, 3035 and 3036 having total weight losses (7.76 to 12.87%) at par with the best control cv. Kufri Dewa (12.37%) and were rated as the best keepers. Out of these, 15 accessions had either long or medium dormancy period. Twenty-three accessions were rated as good keepers, where total losses ranged between 13.97-17.56% (at par with Kufri Badshah, 15.19%) and 17 as average keepers where total losses ranged between 18-25%. The remaining were poor keepers (total loss > 25%).

Chipping and physico-chemical constituents: At Jalandhar, 75 Tuberosum accessions were evaluated for chip colour, dry matter, reducing sugars, sucrose, total phenols and free amino

acids after harvest. Dry matter ranged between 15.4% (CP 2385) to 25.6% (CP 2348), reducing sugars between 48.42 (CP 2380) to 643.24 mg/100 g fr. wt. (CP 2385), while sucrose content between 261.99 mg/100 g fr. wt. (CP 2379) to 927.2 mg/100 g fr. wt. (CP 2399), total phenols between 79.11 mg/100 g fr. wt. (CP 2524) to 271.47 mg/100 g fr.wt. (CP 2411) and free amino acids from 663.93 mg N/100 g fr. wt. (CP 2403) to 1392.3 mg N/100 g fr. wt. (CP 2416). Based on chip colour (acceptable score up to 3 on 1-10 scale of increasing dark colour) 7 accessions namely CP Nos. 2348, 2350, 2353, 2359, 2380, 2393 and 2409 were found to be suitable for chipping. Seventy five accessions were also evaluated for vitamin C content which varied widely between 14.28 (CP 1518) to 28.27 mg/100 g fr.wt. (CP 1536). Five top most accessions for vitamin C content (mg/100g fr.wt.) were: CP 1492 (27.07), CP 1466 (26.77), CP 1586 (26.52), CP 1539 (25.33) and CP 1581 (25.23).

Water use efficiency: Twenty two accessions found to be promising during last year along with K. Bahar and K. Pukhraj were evaluated at 3 irrigation level i.e. 20, 25 and 30 mm cumulative pan evaporation (CPE) for higher yield and water use efficiency. The result showed that 12 accessions viz. CP Nos. 1175, 1214, 1218, 1235, 1302, 1304, 1308, 1316, 1330, 1333, 1343 and 1352 were promising for higher yield and water use efficiency. However, the accessions CP 1057, CP 1151, CP 1181, CP 1197, CP 1310 and CP 1314 produced higher yield at 20 mm CPE water level, but the productivity was less at lower irrigation level (30 mm CPE) in comparison to K. Bahar and K. Pukhraj. In another experiment, 20 accessions were evaluated but only one accession (CP 1710) was found promising for higher water use efficiency.

Nitrogen efficiency of germplasm: Twenty germplasm received from breeding section were tested under nitrogen deficient and sufficient conditions in a single row, 2.4 m long without replication in first year. The tuber yields of different germplasm varied between 29 and 174 q/ha under N stress (without nitrogen application) whereas, mean tuber yields over different rates of N varied between 64 and 318 q/ha. The 12 germplasm having either control yield more than 97 q/ha or mean yield more than 172 q/ha were selected for testing their N efficiency under plot wise trial next year.

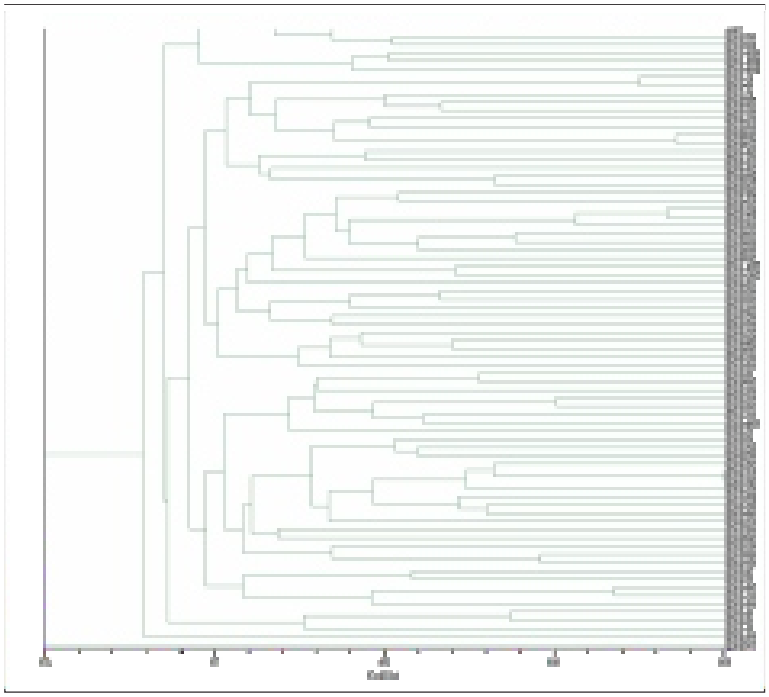


Fig. 2. Dendrogram based on the Dice similarity coefficient of the Andigena potato core collection

Microsatellite characterization of the Indian Andigena potato core collection

Twenty-four informative microsatellite (SSR) markers of new PGI kit were used to analyze the genetic diversity of the recently developed Indian Andigena potato core collection. This new core collection is comprised of genetically distinct 77 *Solanum tuberosum* subsp. *andigena* accessions that represent exotic collection of 740 accessions. The core collection was constructed previously at CPRI based on morphological, agronomic, disease and pests descriptors. To validate the core collection, in SSR analysis, polymorphic information content (PIC), allelic richness per locus of microsatellite loci and cluster analysis showed the high diversity of core collection. In total, 214 SSR alleles were detected in core collection, whereas PIC values ranged from 0.61 to 0.90. SSR-based dendrogram of 77 accessions revealed eight clusters including 26 single accessions at Dice similarity coefficient value of 0.37, which were distantly separated to each other. None of the accession showed full similarity with any other accession, except maximum similarity (0.83) was observed between the accessions JEX/A-316 and JEX/A-317. These SSR results support and validate the genetic differences of the Andigena core collection constructed based on various agronomic traits. The genetic diversity of the core collection based on the microsatellite data appears to have quite distinct genotypes that were formed by the morph-agronomic traits. These findings not only demonstrate the diverse core collection but also useful for selecting genetically distinct potato materials to widen the genetic background of the potato gene pool. This core collection may be a useful source for detecting genes/QTLs underlying quantitative traits in potato marker-trait association analysis. The pictorial representations of the Andigena core collection are shown in the Fig. 2.

Genetic enhancement of Tuberosum and Andigena

Crosses were attempted at Kufri for genetic enhancement of tuberosum lines for foliage maturity. A total of 16,911 seeds were obtained from 31 crosses. Seedlings were raised at Jalandhar, and at 90 days harvest, single tuber of each of 94 promising clones belonging to 8 families were selected on the basis of desirable tuber characters for further evaluation.

For andigena improvement, crosses among unrelated improved andigena hybrids were attempted at Kufri for further improvement of andigena population. Out of the large number of crosses attempted 6405 seeds were obtained from 16 crosses. Crosses were also attempted among andigena cross populations and in total 4731 seeds from 9 crosses were obtained. Seedlings were raised at Jalandhar, and at harvest depending upon the availability, 15-60 tubers representing different genotypes were randomly retained from different cross combinations for further use in hybridization and evaluation.

Maintenance of cross populations

In F_1C_1 generation, 30-60 genotypes/cross of 19 crosses from andigena x andigena hybrids were retained for evaluation and use in hybridization. In second clonal generation, 15 genotypes per cross of 3 cross population from andigena x andigena hybrids were retained for evaluation and use in hybridization.

Evaluation of clonal generation material

In third clonal generation, clones from andigena x andigena hybrids and back-crosses of andigena hybrids, were evaluated in observational rows. Out of 51 clones planted 9 clones were selected for further evaluation. The yield range of selected clones was 540-590 g/plant as compared to control Kufri Pushkar (530g/plant). Five hybrids from andigena x andigena crosses and backcrosses of andigena hybrids were evaluated in replicated trial at 90 days for yield but none could outperform the commercial cultivar Kufri Pushkar.

Evaluation of wild species

Screening for late blight resistance under field conditions

To broaden the resistance source against late

blight, 260 clones from 88 accessions of 31 species were screened for late blight resistance under natural epiphytotic conditions at Kufri. One hundred ten clones were highly resistant or resistant. The identified resistant sources shall be further confirmed for their resistance in the next crop season.

Screening for late blight resistance under lab conditions

One hundred seventy one accessions of 27 wild species were screened for late blight resistance by detached leaf method using complex races of *Phytopthora infestans*. Results revealed that 17

Fig. 4. Late blight screening by detach leaf method

accessions were highly resistant, 28

wereresistant, 83 were moderately resistant and remaining 43 were susceptible. The identified sources shall be further tested for their resistance under field conditions.

Chip characters of wild species clones Eighty four wild species clones along with five controls were processed into chips after harvest. Wild species clones namely SS 1732, SS 2064, SS 2593-06, SS 1652-09, SS 1848-20, SS 2595-01, SS 1846, SS 1780-03, SS 2593-04, SS 2677-04, SS 1548-17 and Atlantic possessed acceptable chip colour (up to 3) and were found suitable for processing. K Chipsona-3

Germplasm registration

Two somatic hybrids were registered with NBPGR.

I) **E 1-3 (INGR 11050):** Interspecific potato somatic hybrid produced by protoplast fusion between dihaploid *Solanum tuberosum* L. (C-13) and wild spp. S. *etuberosum*. The somatic hybrid is tetraploid, male fertile and possesses resistance to potato virus Y introgressed from S. *etuberosum*.

Fig. 5. C-13 S. etuberosum Somatic hybrid (E-1-3)

ii) **P 7 (INGR 11051):** Interspecific potato somatic hybrid produced by protoplast fusion between dihaploid *Solanum tuberosum* L. (C-13) and wild spp. S. *pinnatisectum*. The somatic hybrid is tetraploid, male fertile and possesses rresistance to potato late blight introgressed from S. *pinnatisectum*.

Fig. 6.C-13 S. pinnatisectum Somatic hybrid (P 7)

Breeding for improved varieties

The programme develops improved cultivars both for table and processing purposes besides standardizing the agronomy of newly developed hybrids/ varieties. The major objectives of this programme are to replace the existing popular varieties with suitable early bulking short/medium duration varieties with field resistance to late blight and good keeping quality, develop more processing varieties specially for short duration and French fries and improvement of parental lines, to develop high yielding white/red skinned TPS populations with early bulking and better seedling survival.

Breeding improved varieties for plains

Hybridization and seedling raising: A total of 3,29,141 true potato seeds were obtained from the 183 successful crosses at Jalandhar, Modipuram and Patna and 82, 855 seedlings were raised. At harvest, 8, 924 promising clones were selected.

Initial clonal generation: In initial clonal generation (F_1C_1, F_1C_2 and F_1C_3), 16,348 clones were evaluated at 60/75/90 DAP and 2,450 promising clones were selected.

Replicated yield trials: Seventy three advance stage hybrids were evaluated in 13 yield trials at 60/75/90 DAP at Jalandhar, Modipuram and Patna and 22 promising hybrids were selected. In preliminary yield trials, 12 promising hybrids namely J/7-516, J/6-182 (Jalandhar), MS/8-88, MS/8-214, MS/8-215, MS/8-228, MS/8-861, MS/8-1148, MS/8-1463, MS/8-1565 (Modipuram), PS/07-7 and PS/07-12 (Patna) were selected from 47 hybrids evaluated. In confirmatory yield trials, five promising hybrids namely J/5-252 (Jalandhar), MS/7-645, MS/7-2051, MS/7-2191 (Modipuram), PS/06-88 (Patna) were selected from 15 hybrids evaluated. In confirmatory yield trials, five promising hybrids i.e. J/2-14 (Jalandhar), MS/6-819 and MS/6-1947 (Modipuram), PS/5-73 and PS/5-75 (Patna) were selected from 11 hybrids evaluated.

Introduction of advance stage hybrids in AICRP

Based on consistence performance over the years, six advance stage hybrids namely J/2-14 (Jalandhar), MS/6-819 and MS/6-1947 (Modipuram), PS/5-73, PS/5-75 and PS/6-88 (Patna) were introduced in AICRP for multi-location trials (Table 1,2,3).

J/2-14: The hybrid produced 9%, 11% and 9% higher yield over control Kufri Khyati at 60, 65 and 75 days harvests, respectively. The hybrid produces creamy long oval tubers with shallow eyes and yellow-cream flesh with 15.4% dry matter.

MS/6-819 (CP3379 x MS/92-1090): The hybrid produced 42%, 7% and 15% higher tuber yield than K. Bahar, K. Pukhraj and K Sadabahar, respectively at 90 days. The hybrid produces yellow oval tubers with shallow eyes and light yellow flesh with 18.8% dry matter and good keeping quality.

MS/6-1947 (MS/82-638 x JX576): The hybrid produced 49%, 13% and 21% higher tuber yield than K. Bahar, K. Pukhraj and K Sadabahar, respectively at 90 days. The hybrid produces yellow oval tubers with shallow eyes and light yellow flesh with 15.1% dry matter and good keeping quality. The hybrid possesses field resistance to late blight under Modipuram conditions.

PS/5-73 (K. Lauvkar x K. Pukhraj): The hybrid produced 8% higher tuber yield than K. Pukhraj at 75 days. The hybrid produces white oval tubers with fleet eyes and creamy flesh with 16.8% dry matter, medium dormancy with good keeping quality. The hybrid is moderately resistance to late blight at Patna conditions.

PS/5-75 (CP2376 x K. Kanchan): The hybrid produced 12% higher tuber yield than K. Arun at 75 days. The hybrid produces red flattened oval tuber with fleet eyes and creamy flesh wth 17.5% dry matter, medium dormancy with good keeping quality and moderately resistance to late blight at Patna conditions.

PS/6-88 (K. Arun x CP3192): The hybrid produced 13% higher tuber yield than K. Arun at 75 days. The hybrid produces dark red round tubers with medium deep eyes and yellow flesh with 17.8% dry matter, medium dormancy with good

Fig. 7. Tubers of advance potato hybrids introduced in AICRP

Release of MS/99-1871 (Kufri Garima): A promising advance hybrid MS/99-1871 (PH/F-1045 x MS/82-638) was recommended for release for Indo-Gangetic plains and Plateau region in the 29th AICRP group meeting held at Raipur, Chhattisgarh during September 10-12, 2011. Its tubers are light yellow, ovoid with shallow eyes and light yellow flesh. Hybrid possesses good keeping quality, medium tuber dry matter (18%) and field resistance to late blight. It yields 30-35 t/ha under optimum agronomical practices.

Optimization of fertilizer requirement

Kufri Sadabahar at Modipuram: The N level of 140 kg ha-1 gave significantly better total and marketable tuber yields (37.3 tha-1 and 36.1 tha-1, respectively) over control (26.7 & 27.7 tha-1, respectively), which was also statistically at par with all higher N doses. Marketable and total tuber yield improved by 35.2% and 34.6%, respectively at 140 kg N ha-1 in comparison to control. The P2O5 dose of 40 kg ha-1 was responsive and statistically higher total tuber yield (39.2 tha-1) over control (36.2 tha-1) was recorded, which was also significantly better overall than higher P2O5 levels. Marketable and total tuber yield improved by 6.5 and 8.3%, respectively at 40 kg P2O5 ha-1 over the control. Application of potassium was better for improving the tuber productivity in cv. K. Sadabahar and K level of 150 kg ha-1 recorded

maximum and significantly better marketable (35.3 t ha-1) and total tuber yield (36.4 t ha-1) over lower doses and control. Around 10 and 10.6% more yield of marketable and total tubers could be harnessed with 150 kg K_2O ha-1 over the control.

MS/99-1871 (Kufri Garima) at Modipuram: MS/99-1871 responded linearly up to 210 kg ha-1 N level and significantly better marketable (47.9 tha-1) and total tuber yield (50.5 tha-1) were observed at this dose over lower N levels and the control (31.3 & 33.4 tha-1, respectively). An improvement of 53 and 51.2% was recorded in marketable and total tuber yield with this level in comparison to control. No significant difference was observed for marketable and total tuber yields with any of the graded P levels. Hybrid MS/99-1871 exhibited linear response with graded K doses, where maximum marketable (46.6 tha-1) and total tuber yield (49.5 tha-1) was recorded with 225 kg K_2O ha-1, which was significantly better over the control (37.0 & 39.7 tha-1, respectively). However, it remained at par with 150 Kg K_2O dose (44.1 & 46.4 tha-1, respectively). Marketable and total tuber productivity improved by 26 and 24.7%, respectively, at 225 kg K_2O ha-1 in comparison to control.

Nitrogen requirement of advance hybrids at Patna: The experiment aimed at standardization of N fertilizer dose of red skin hybrids, 2000-P-55, 2001-P-55 and varieties K. Arun, K. Lalima with four graded levels of N (0,80,160 and 240 Kg ha-1) at constant dose of phosphorous (60 Kg P_2O_5 ha-1) and potassium (100 Kg K2O ha-1). Application of N @160 Kg /ha in the soils having available nitrogen in the medium range was found suitable for the new red skin hybrids namely 2001-P-55 and 2000-P-55.

Evaluation of advance stage hybrids for late blight resistance

Jalandhar: Late blight screening of 27 advance stage hybrids based on tuber slice method revealed that hybrids viz., J/5-114, J/5-141, J/6-193, J/5-249 and J/6-197 were moderately resistant, while all other hybrids were either susceptible or highly susceptible to late blight.

Modipuram: Among 32 advance stage hybrids evaluated for late blight under field conditions, all hybrids showed less AUDPC compared to control K. Bahar. Advance hybrids MS/8-219 (58-AUDPC), MS/8-198 (81), MS/7-2051 (104), MS/2-3964 (110), MS/7-645 (123), MS/8-215 (147), MS/8-257 (153) and MS/8-228 (171) revealed very less AUDPC and rAUDPC. Based on detached leaf method, two hybrids viz MS/8-214 and MS/8-264 were highly resistant (HR) against late blight. Based on tuber slice method for resistance to late blight, MS/8-1565 was highly resistant (HR) and MS/8-264 was resistant (R). Seven advance stage hybrids i.e. MS/99-1871, MS/1-4906, MS/4-2261, MS/7-121, MS/7-2191, MS/7-1148, MS/8-198, were moderately resistant (MR) to late blight.

Patna: Seventeen advance stage hybrids along with controls were evaluated for late blight resistance under field conditions at Patna. Hybrids, PS/1-67, PS/1-26, PS/2-14 and PS/2-26 were the most promising for late blight resistance. Kufri Bahar was the most susceptible control followed by J/97-168 and Kufri Surya.

Table 1. Performance of J/2-14 being initiated in AICRP from Jalandhar

Genotype	Yield (t/ha)										
	2007-08		2008-09	2009-09	2010-11		2011-12		Average		
	60 days	75 days	65 days	65 days	60 days	75 days	60 days	75 days	60 days	65 days	75 days
J/2-14	30.3	43.8	35.4	36.7	33.7	44.5	25.1	44.2	29.7	36.1	44.2
Kufri Pukhraj	26.1	35.9	30.9	33.6	29.5	41.1	24.8	37.7	26.8	32.2	38.2
Kufri Khyati	-	-	31.1	34.0	29.4	43.1	25.0	37.7	27.2	32.5	40.4
CD (0.05)	3.11	4.47	1.85	1.57	3.61	3.58	2.91	3.7			

Table 2. Performance of MS/6-819 and MS/6-1947 being initiated in AICRP from Modipuram

Genotype	Total tuber yield t/ha					Average	
	2009-2010	2010-2011		2011-12			
	80 DAP	75 DAP	90 DAP	75 DAP	90 DAP	75 DAP	90 DAP
MS/6-819	39.22	38.11	50.03	34.22	47.86	36.17	48.95
MS/6-1947	41.16	42.20	54.77	35.83	48.22	39.02	51.50
K Bahar	31.19	29.51	37.15	29.43	32.04	29.47	34.60
K Pukhraj	35.93	36.86	46.03	33.23	45.11	35.05	45.57
K S Bahar	33.22	34.09	42.48	31.80	42.96	32.95	42.72
C.D. (0.05)	3.29	2.39	2.47	1.93	2.24		

Table 3. Performance of PS/5-73, PS/5-75 & PS/6-88 being initiated in AICRP from Patna

Genotype	Total tuber yield t/ha at 75 days				
	2008-09	2009-10	2010-11	2011-12	Average
PS/5-73	31.80	26.28	30.26	24.68	28.25
PS/5-75	24.69	22.33	29.06	24.92	25.25
PS/6-88	-	25.09	21.94	29.46	25.50
K Arun	21.32	19.25	26.36	23.15	22.52
K Lalima	-	-	-	22.12	22.12
K Pukhraj	-	24.31	28.18	26.15	26.21
K. Khyati	23.76	21.71	29.75	26.58	25.45
CD (0.05)	2.90	1.38	2.00	1.48	-

Breeding for processing and export quality

Hybridization: A total of 1,01,776 hybrid TPS of 63 crosses were produced and 798 clones were selected from the transplanted seedlings.

Initial clonal generations: A total of 952 clones in F1C1 and 98 clones in F1C2 stage were evaluated and 64 and 39 clones, respectively were selected based on tuber characters and chip colour. In F1C3 44 clones were evaluated in replicated trial and on the basis of chip colour, dry matter and yield 18 promising clones were selected. In F1C4 generation 3 genotypes namely MP/07-214, MP/07-215, and MP/07-595 were selected out of eight hybrids tested.

Advanced clonal generations: Ten hybrids along with 6 control varieties were evaluated at 75 and 90 DAP and on the basis of total tuber yield, processing grade yield, chip colour & dry matter, seven genotypes namely MP/02-204 (French fry), MP/04-578 (French fry), MP/04-816 (chips), MP/05-1009 (chips), MP/06-26 (chips), MP/06-39

Fig. 8, MP/04-578

Fig. 9, MP/04-816

Introduction of advance stage hybrids in AICRP

Based on consistence performance over two years during (2010-2012), 2 advance stage hybrids namely MP/04-578 and MP/04-816 are being proposed for introduction in AICRP for multi-location testing (Table 4 & 5). Both hybrids possess acceptable chip/FF colour, 20% tuber dry matter, 16.3- 32.5 glucose (mg/100 g f wt) and good keeping quality.

MP/04-578 (Kufri Chipsona-1 x MP/92-35): The hybrid produced 20%, 14% and 16% higher tuber yield over controls, Kufri Chipsona-1, Kufri Frysona and Kufri Surya, respectively at 90 days harvest. Tubers are white cream, oblong, shallow and suitable for French fries.

MP/04-816 (MP/97-847 x MP/92-35): The hybrid produced 16%, 14% and 24% higher tuber yield than K. Chipsona-1, K. Chipsona-4 and Atlantic, respectively at 90 days and it remained at par with K. Chipsona-3. Tubers are light-yellow, oval, shallow, yellow and suitable for chips.

Tuber yield and processing quality of advanced hybrids at Jalandhar: Twelve varieties/advanced hybrids were evaluated (Table 6.) for yield and processing quality at 100 DAP and MP/01-816 gave maximum total tuber yield (49.4 t/ha) followed by MP/02-204 (38.3 t/ha) and MP/04-578 (37.5 t/ha). All the hybrids could make acceptable colour French fries at haulm cutting and it improved further during the curing period of 20 days. At 100 DAP, chip colour was acceptable only in MP/04-32 and after curing period in MP/04-32 and MP/04-816. Dry matter content at harvest was more than ≥ 20% in all the hybrids/varieties except MP/04-32 and K. Surya.

Processing quality during storage at 10-12°C with CIPC treatment: Dry matter content in 12 processing hybrids and the control varieties was higher than 20%. Among the hybrids, MP/03-626, MP/04-816 and MP/04-32 recorded more than 23% mean dry matter content. Hybrid MP/04-816 could make acceptable colour chips throughout storage up to 180 days recording minimum mean colour code values (2.9) followed by K. Surya (3.20) and K. Chipsona-1 (3.5). All the varieties/hybrids made acceptable colour fries throughout storage with mild deterioration in colour at some sampling dates. Among the hybrids, MP/04-816 made the best colour fries up to 180 days of storage (mean colour code values 2.0) followed by MP/03-626 (2.7) and MP/04-32 (2.9). Hybrid MP/04-816 maintained the lowest mean reducing sugar contents (RS) (78 mg/100 g fr. wt) followed by MP/04-32 (131 mg/100 g fr. wt) which were at par with the control cultivars K. Surya, K. Chipsona-1, K. Chipsona-3 and K. Himsona. Among the hybrids, MP/03-626, MP/04-578 and MP/04-816 recorded minimum mean sucrose levels during storage. Mean free amino acid contents were highest in K. Surya (1070) and ranged between 644 to 880 mg/100 g fresh weight

in rest of varieties. K. Surya recorded the maximum mean phenol contents (103 mg/100 g fr. wt) during storage. Among the hybrids, MP/03-626 recorded maximum mean phenol contents during storage (78 mg/100 g fr. wt).

Processing quality during storage in heaps with CIPC treatment: Reducing sugar contents in potatoes decreased during storage in heaps while sucrose and phenol contents increased during storage. Reducing sugars contents in heap stored potatoes of all the processing varieties/hybrids were low (18-113 mg/100 g fresh weight). In general, the chip colour and the fry colour of potatoes improved after 90 days of storage in heaps. All processing hybrids/varieties stored in heap made acceptable colour chips and fries. Results showed that heap stored potatoes of all the varieties/hybrids can meet the short term needs of processing industries.

The optimization of N, P and K requirements of cv. K. Frysona under drip and sprinkler irrigation at Modipuram

Nitrogen: Kufri Frysona was evaluated for tuber yield and quality parameters under drip and sprinkler irrigation systems at different nitrogen levels (0, 170, 220, 270 & 320 kg N ha^{-1}). Yields (graded and total tuber yield) and quality parameters (specific gravity and fry colour) of cv. K. Frysona had a tendency to improve with drip irrigation; however the differences were statistically at par but tuber dry matter content improved significantly in drip system (24.5%) over sprinkler irrigation (23.6%). N level of 270 kg ha^{-1} recorded the highest 27.3, 43.2 and 47.3 t ha^{-1} of French fry, process grade and total tuber yields which was significantly better over lower N doses (0, 170 and 220 kg ha^{-1}) and control, and also comparable to higher N dose of 320 kg ha^{-1}. Specific gravity (1.087) and fry colour (2.3) was statistically similar to lower or higher N application, but tuber dry matter content declined with 270 kg N ha^{-1}.

Phosphorus: Kufri Frysona was evaluated for tuber yield and quality parameters under drip and sprinkler irrigation systems at different phosphorus levels (0, 25, 50, 75 & 100 kg P_2O_5 ha^{-1}). French fry, process grade and total tuber yield improved markedly in drip irrigation by 29.9, 22.7 and 30%, respectively over sprinkler irrigation. But quality traits more or less remained unaffected with different sources of irrigation. Graded tuber yield had a linear tendency up to a level of 50 kg P_2O_5 ha^{-1}, but differences were not significant over control. Highest French fry grade yield (25.2 t ha^{-1}) was recorded with this level, while higher P doses (75 and 100 kg P_2O_5 ha^{-1}) tended to decline the tuber productivity. Specific gravity and fry colour remained comparable at different P doses, whereas tuber dry matter content improved markedly with graded P application.

Potash: Kufri Frysona was also evaluated for tuber yield and quality parameters under drip and sprinkler irrigation systems at different potash levels (0, 50, 100, 150 & 200 kg K_2O ha^{-1}). French fry, process grade and total tuber yield improved significantly in drip irrigation by 54.9, 40.6 and 38.2%, respectively over sprinkler irrigation. Specific gravity and fry colour remained more or less same, but tuber dry matter content was significantly higher in sprinkler irrigation (25.9%) as compared to drip irrigation system (24.2%). Application of K did not affect tuber productivity up to a level of 150 kg K_2O ha^{-1}, but highest K level (200 kg K_2O ha^{-1}) recorded highest and significantly better French fry (26.1 tha^{-1}), process (41.2 tha^{-1}) and total tuber yield (43.6 tha^{-1}) over control (22.9, 33.9 & 36.5 tha^{-1}). Quality parameters were not significantly affected by potash fertilizers.

Table 4. Yield performance of advance processing hybrids viz., MP/04-578 and MP/04-816 at (75 days harvest) at Modipuram during 2010-11 and 2011-12

Variety/ hybrids	Yield (t/ha)								
	PGY			FFGY			TTY		
	2011-12	2010-11	Av	2011-12	2010-11	Av	2011-12	2010-11	Av
MP/04-578	**21.9**	**25.6**	**23.7**	**5.4**	**11.6**	**8.5**	**24.5**	**29.2**	**26.9**
MP/04-816	**21.9**	**25.2**	**23.5**	**0.0**	**0.0**	**0.0**	**24.1**	**28.4**	**26.2**
K. Chipsona-1	20.7	24.2	22.5	3.7	6.7	5.2	23.2	28.7	26.0
K. Chipsona-3	22.6	23.2	22.9	0.0	0.0	0.0	25.4	29.1	27.3
K. Chipsona-4	19.1	24.3	21.7	0.0	0.0	0.0	20.9	28.2	24.5
K. Frysona	19.4	24.1	21.7	5.6	9.1	7.3	22.8	27.3	25.1
K. Surya	22.1	24.1	23.1	5.1	9.8	7.4	24.0	28.2	26.1
Atlantic	22.3	23.7	23.0	0.0	0.0	0.0	23.7	25.9	24.8
CD (0.05)	2.2	1.9		1.5	1.7		2.3	1.8	

Table 5. Quality performance of advance processing hybrids viz., MP/04-578 and P/04-816 at (75 days harvest) at Modipuram during 2010-11 and 2011-12

Variety/ hybrids	Yield (t/ha)								
	Chip/FF colour (Visual)			DM (%)			Glucose (mg/100 g f wt)		
	2011-12	2010-11	Av	2011-12	2010-11	Av	2011-12	2010-11	Av
MP/04-578	**4.5**	**4.1**	**4.3**	**18.2**	**18.9**	**18.6**	**131.3**	**101.9**	**116.6**
MP/04-816	**4.0**	**3.0**	**3.5**	**19.0**	**19.1**	**19.0**	**25.7**	**30.4**	**28.0**
K. Chipsona-1	4.1	2.5	3.3	20.8	19.4	20.1	12.6	7.7	10.2
K. Chipsona-3	4.6	3.5	4.1	20.1	18.7	19.4	23.6	24.1	23.9
K. Chipsona-4	7.0	4.8	5.9	19.7	20.0	19.8	100.4	29.5	64.9
K. Frysona	4.5	2.3	3.4	18.0	20.0	19.0	25.8	71.5	48.6
K. Surya	4.5	2.7	3.6	18.6	19.1	18.8	65.9	26.0	45.9
Atlantic	5.5	3.9	4.7	20.4	21.7	21.1	37.6	13.8	25.7

Table 6. Tuber yield and processing attributes of processing varieties/hybrids at different sampling dates at Jalandhar

Variety	Tuber yield t/ha			100 days (haulm cutting)			100 + 20 days of curing		
	Fry grade	Chip grade	Total	Chip colour	Fry colour	Dry matter (%)	Chip colour	Fry colour	Dry matter (%)
MP/04-578	25.50	8.34	37.47	5.50	3.00	21.10	5.75	2.63	19.94
MP/04-816	28.63	15.67	49.44	6.50	3.88	19.56	3.13	3.25	19.48
Atlantic	9.00	16.05	33.69	3.38	1.88	20.45	4.50	1.63	22.13
K. Chipsona-1	14.48	10.08	29.26	2.75	3.63	19.16	3.63	2.75	20.15
K. Chipsona-3	11.08	10.23	26.29	2.63	2.50	20.08	4.25	2.50	21.26
K. Chipsona-4	22.48	9.56	35.24	2.75	2.75	21.14	4.38	2.50	20.50
K. Himsona	0.95	8.43	32.41	3.63	2.00	19.45	5.00	1.75	20.52
K. Frysona	19.99	9.01	32.97	4.63	3.13	20.96	5.00	2.13	19.92
K. Surya	25.20	10.73	39.41	3.75	2.88	19.52	5.25	1.88	19.41
Mean	-	-	-	3.94	2.76	19.96	4.63	2.32	20.18
C.D(0.05)	5.42	3.45	6.85	-	-	-	-	-	-

Fry grade (>75 mm long), Chip grade (45-75 mm Long), Chip colour and Fry colour *On a scale of 1-10, colour up to 4.0 was acceptable

Development of TPS population

Production of TPS: Produced 1.83 kg TPS of 40 crosses and 100 gm TPS of 15 crosses for population development and parental line development, respectively. Produced 2.5 kg TPS of hybrid population 92-PT-27 for distribution and sale purposes.

Evaluation of TPS populations as transplanted crop

Yield Trial at CPRS Patna: Thirty seven TPS populations including 18 white x white crosses and 19 red x red crosses along with control 92PT-27 were evaluated at 90DAP. Among red x red 19 crosses, six promising populations namely PS6/76-4 x PS8/97-1, PS6/78-10 x PS8/97-1, K. Arun x PRT-19, PT/11-11, PT/11-9, PS6/82-2 x PS9/97-1 were selected based on significantly higher total tuber yield than the control 92PT-27 (21.9 t/ha). Among 18 white x white crosses, six promising populations namely MST-43 x D-150, KP15C5 x D-150, PS6/76-6 x D-150, PS6/47-1 x D-150, PS6/75-6 x D-150 and PS 5/1-2 x D-150 were selected based on significantly higher total tuber yield than the control 92PT-27 (18.8 t/ha).

Yield trial at CPRS Shillong: Among thirty one TPS populations evaluated, PS8/97-2 x PS8/97-1, PRT-16 x PS8/97-1, PRT-17A x PS8/97-1, PS6/89-1 x PS8/96-1, PS6/39-8 x PS8/97-1 and PRW902 yielded significantly higher than the control 92PT-27 (3.3 t/ha) under rain fed conditions.

Yield trial with seedling tubers (F1C1) at Patna

Trial 1: Fourteen white skinned populations were evaluated at Patna and five populations viz. PT/10-25, PT/10-31, PT/10-35, PWW 907 and PWW 935 yielded significantly higher than the control 92PT-27 at 90 DAP, while only two of them viz. PWW907 and PWW935 yielded significantly superior than the control 92PT-27 at 75 DAP.

Trial 2: Among fifteen red skinned populations four populations namely PT/10-2, PT/10-16, PT/10-47 and PT/10-50 yielded significantly higher than the control K. Kanchan (18.3 t/ha) at

90 DAP.

Development of dihaploids: TPS parents namely 83P47 and D-150 were used in anther culture. In total, 2000 anthers of both parents were cultured in the MS medium + 2 mgl^{-1} D-calcium pantothenate + 60 gl^{-1} sucrose + 0.5 mM cycteine + 1 mM ascorbic acid + 60 gl^{-1} starch + 17.74 uM BA + 0.5% activated charcoal + 2 gl^{-1} gelrite under 16-h photoperiod at 28ºC. However, no androgenesis regeneration was observed in the anthers cultured. This may be due to very poor regeneration potential of the TPS parents for androgenesis.(Fig. 10)

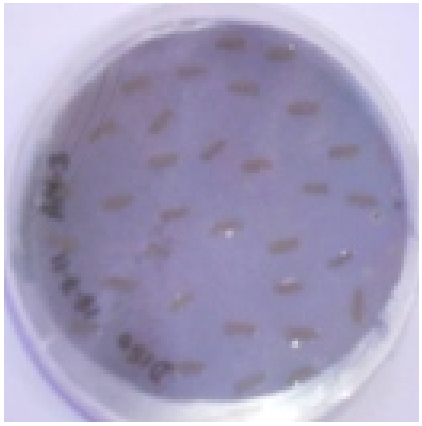


Fig. 10, Andher Culture of TPS Parents

(Introduction of TPS populations in AICRP: Based on promising performance during 2010-12, four TPS populations viz. PS6/82-2 x PS8/97-1, PS6/55-1 x PS8/97-1, PRT-17B x PRT-19, PRT-17A x PS8/97-1 are being proposed for introduction in AICRP for multi-location trials (Table 7).

Table 7. Performance of Red x Red TPS populations as transplanted crop being proposed for introduction in AICRP

Populations	Survival	Plant	Red	Yield (t/ha)-2010-12	Dry	
	%	Vigou	Tuber %	Marketable	Total	
PS6/82-2 x PS8/97-1	86.77	3.84	73.13	15.34	22.53	17.96
PS6/55-1 x PS8/97-1	82.59	3.34	73.95	15.16	21.49	15.79
PRT-17B x PRT-19	81.11	3.17	77.40	16.22	21.26	17.26
PRT-17A x PS8/97-1	75.86	2.84	76.24	14.91	19.73	16.12
83P47 x D-150 **(92PT-27)**	81.59	3.50	--	14.79	18.79	16.11

Biotechnology in potato improvement

The main objectives of this programme are to conduct strategic and applied research on structural and functional genomics of potato and pathogens, gene silencing for development of potato transgenics for reduced cold-induced sweetening; gene expression for potato tuberization and late blight resistance; and production of interspecific potato somatic hybrids using wild Solanum species.

Structural and functional genomics of potato

CPRI as a part of global initiative-Potato Genome Sequencing Consortium (PGSC) has successfully completed the whole genome sequencing of potato (*Solanum tuberosum* Group Phureja) covering almost 86 % of its 844 Mb haploid genome. A total of 96.6 Gb sequence data was produced by 26 institutes belonging to 13 countries across the globe using Illumina Genome Analyser, Roche Pyrosequencing as well as sanger sequencing technologies. Genome was assembled using SOAP de novo resulting in final assembly of 727Mb of which 93.9% was non gaped sequence. Repetitive sequences account for at least 62.2% of the assembled genome (452.5 Mb) with long terminal repeat retrotransposons comprising the majority of the transposable element classes representing 29.4% of the genome. Using newly constructed genetic map based on 2,603 polymorphic markers in conjunction with other available genetic and physical maps developed across the world (Fig. 11), we generated 623 Mb (86%) of the assembled genome and constructed pseudomolecules for

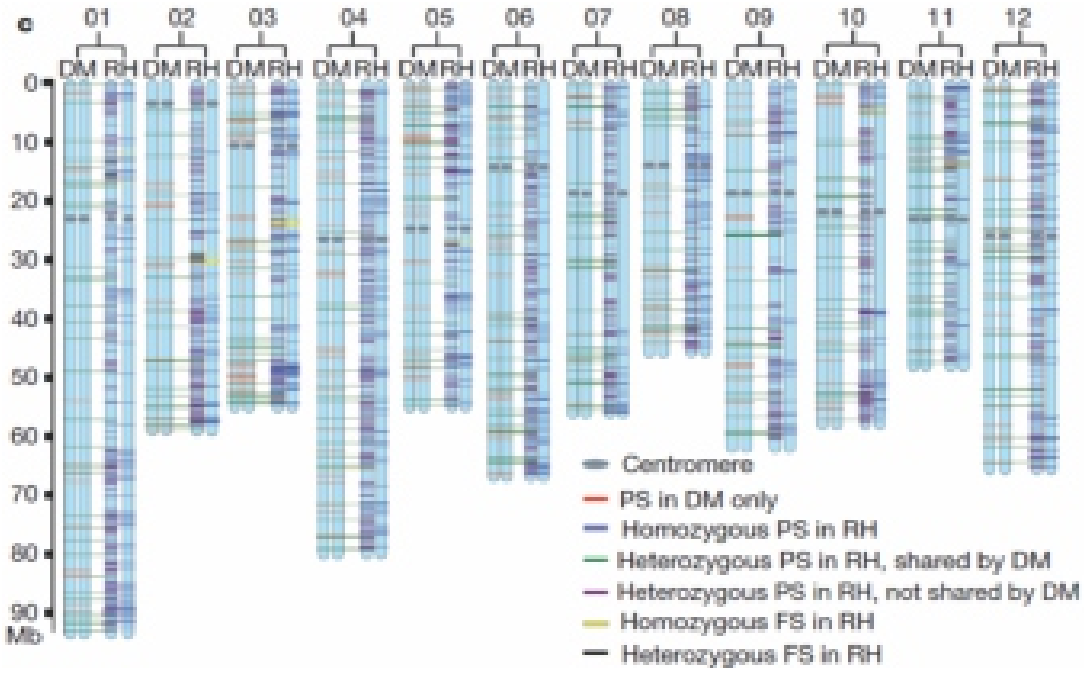


Fig. 11. High density physical map used in assembling the potato genome sequence

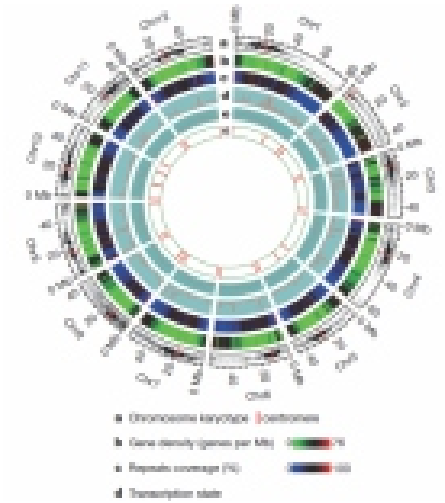


Fig. 12. Assembled potato genome

each of the 12 chromosomes which harbor 90.3% of the predicted genes (Fig. 12).

A total of 15,235 genes are predicted to be involved in tuberization, with 1,217 transcripts exhibiting > 5 folds expression and 333 transcripts involved in transition from stolon to tuber with most highly upregulted transcripts encoding storage proteins. The assembled sequence contains 408 NBS-LLR genes, 57 Toll/interleukin-1 and 402 resistance (R) genes responsible for broad spectrum resistance against ,biotic and abiotic stresses. Apart from these highly regulated potato late blight resistance genes *R1, R2, RB, R3a, Rpi-blb2* and *Rpi-vnt1.1* were present in the assembly.

Shot-Gun whole genome sequencing of *Phytophthora infestans* (A2 mating type) was carried out using GS FLX Titanium next generation sequencer. A total of 3 runs were carried out which yielded a raw sequence data of 1500 Mbp (500 Mb per run) covering around 7x the size of *P. infestans* (appx. 240Mb). The data was processed with various set of softwares like GS Analyser and GS Assembler, and the sequence reads were finally assembled in contigs. Assembly of 44,22,833 reads by GS *De Novo* Assembler yielded total of 18,81,163 contigs of which 83,532 were large contigs with an average contig size 892bp representing 76.8% of total aligned reads.

Development of potato transgenics for improvement of cold-chipping attributes

Seventy two transgenic lines (18 for UGPase amiRNA, 20 for *INV* amiRNA and 16 for both *UGPase* and *INV* combined amiRNAs, 18 *UGPase*-TGS) of three Indian potato cultivars, Kufri Chipsona-1, Kufri Chipsona-3 and Kufri Surya, were multiplied in net-house at Central Potato Research Station, Jalandhar. Harvesting of these lines have been completed and the same will be planted in glass-house at Central Potato Research Institute, Shimla in the month of May and evaluated for processing attributes subsequently after cold. Twenty five marker free transgenic lines (11 KC3MFS and 14 KC3 MFIRINV) of Kufri Chipsona 3 were multiplied in net-house at Central Potato Research Station, Jalandhar. Harvesting of these lines have been completed and the same will be planted in glass-house at Central Potato Research Institute, Shimla in the month of May and evaluated for processing attributes subsequently after cold.

Development of transgenic potato over expressing SP6A gene for photoperiod insensitivity

The SP6A construct DNA (Fig. 13) was procured from Salome Prat, Institute of Molecular Biology, Madrid, Spain in binary vector pBIN19 (pBIN-SP6A) and put into αDH5. The clones were initially selected on appropriate antibiotic medium (Kanamycin). The survived colonies were further tested for their recombinant nature by colony PCR using appropriate primers (Fig. 14). Further confirmation of the positive colonies was done by restriction analysis using EcoR I and Hind III enzymes, which releases the 522 bp *SP6A* gene (Fig. 15). The recombinant plasmid DNA was transformed into *Agrobacterium* strain EHA105.

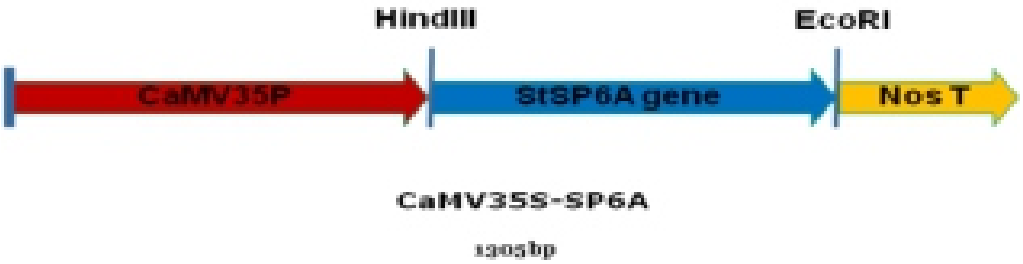


Fig. 13. pBIN-SP6A construct containing StSP6A gene driven by CaMV35S

SP6A gene construct driven by constitutive CaMV 35S promoter was introduced into short day potato cultivar Kufri Sindhuri by*Agrobacterium*–mediated genetic transformation of inter-nodal stem cuttings. About 50 adventitious shoot buds were obtained so far resistant to Kanamycin, which are being regenerated for differentiation into shoots.

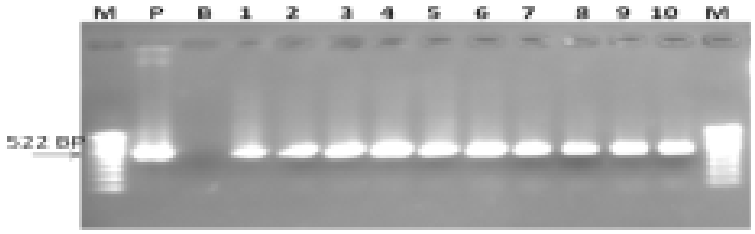


Fig 14. Colony PCR confirming the SP6A gene in pBIN-SP6A binary vector

Fig 6. Restriction analysis of recombinant plasmid with EcoR1 and EcoR1-HindIII

Functional analysis of genes involved in late blight resistance in potato using microarray technology

To quantify the molecular events of potato resistant cultivar Kufri Girdhari to *Phytophthora infestans*, we performed a comprehensive transcriptional analysis using cDNA microarrays, containing 70,083 ESTs (Expressed sequence tag libraries). Leaves of a highly resistant potato cultivar Kufri Girdhari were inoculated with *P. infestans* and sampled before and after inoculation. A total of 1, 35,000 spots representing 2344 *P. infestans* responsive genes in several functional categories by gene ontology were detected as up-regulated genes (log2 ratio >2) by statistical confidence (Fig.16). These genes were more greatly expressed in response to the challenge of *P. infestans*. The selected genes identified by microarray analysis were validated by real-time PCR. These functional genes are mostly related to the whole process of plant defence response to pathogens. Based on general expression pattern of these genes, we discriminated potato defence against *P. infestans* and revealed genes participating during infection process. To further understand the dynamics of *P. infestans* induced gene expression, hierarchical clustering was used to illustrate their various expression profiles during interaction process, including before and after infection of the pathogen. Interestingly, in our study molecular chaperones were found to be mainly up regulated in maintaining the resistance mechanism of Kufri Girdhari and act as downstream signalling pathway for expression of various defense related

(stress/hormone/signalling genes/transporter/ metabolism) genes (Fig. 17). These results reveal several candidate genes and pathways likely involved in transcriptional control of late blight resistance response. In particular, chaperone signalling pathway may represent candidate genes contributing to defense networking in late blight resistant potato cultivar Kufri Girdhari.

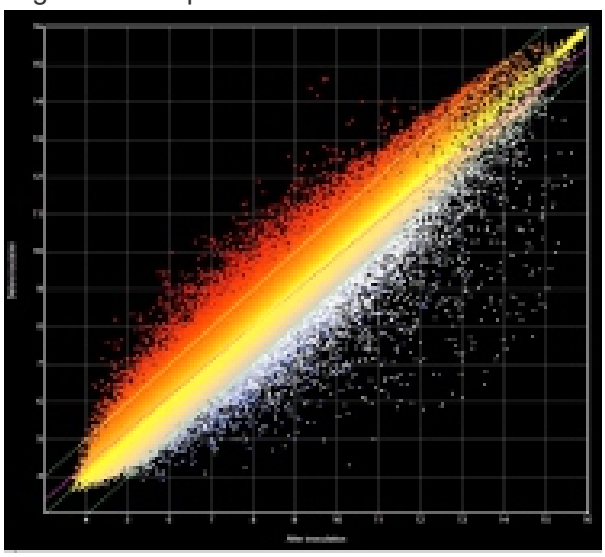


Fig. 16. Scatter plots of expression profiles of Kufri Girdhari before and after inoculated with Phytophthora infestans. Spot represents 2344 unigene transcript up regulated by 2 fold at 99% T test confidence

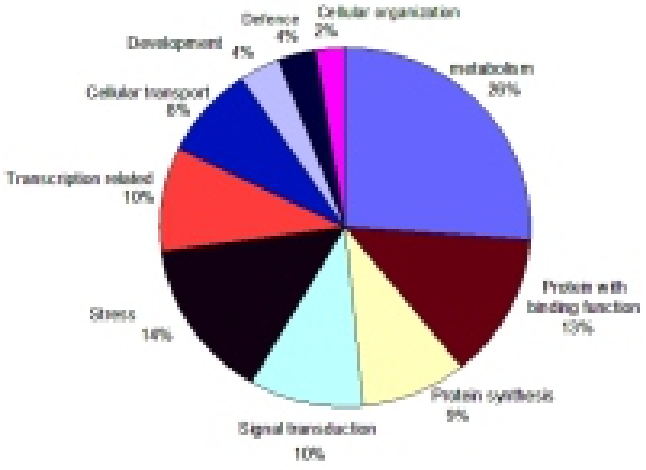


Fig. 17. Pie chart shows the proportion of P. infestans-induced genes in each of the functional categories described in Gene Ontology and uniprot website

Gene expression analysis for potato tuberization using realtime PCR

In potato, tuberization and flowering are mainly affected by fluctuations in day length as well as in temperature. Work in *Arabidopsis*, tomato, potato and rice identified the mobile Flowering Locus T (FT) protein as a main component of the long-range 'florigen', or flowering hormone and 'tuberigen', as tuberization signal. Evidences show that in potato the floral and tuberization transitions are controlled by two different *FT*-like paralogues (St*SP3D* and St*SP6A*) that respond to independent environments and show the expression modulation of the tuberization-control St*SP6A* gene.

Experiment was conducted at Shimla to know the temperature effect on relative expression of St*SP6A* gene in Kufri Chandramukhi (heat sensitive cultivar) and Kufri Surya (heat tolerant cultivar) in relation to growth period at 24^{0}C and 18^{0}C temperature. At 18^{0}C, cultivar Kufri Chandramukhi formed 57% sessile tubers as against 100% in Kufri Surya, whereas, at 24^{0}C the sessile tubers were formed only in Kufri Surya (23%) with no sessile tuber formation in Kufri Chandramukhi (Fig. 18).

The expression of StSP6A in Kufri Chandramukhi up-regulated on 7th day of treatment (Relative quantification (RQ) value-2.96) while transcript accumulation decreased from 8th to 20th day of treatment at 24^{0}C (RQ value-2.96 to 0.4736). However, in Kufri Surya there was abundant transcript accumulation on 18th day of treatment (RQ Value-14.41) and after 18th day, transcript accumulation suddenly decreased to 0.673 on 21st day. At 18^{0}C, Kufri Chandramukhi showed abundant expression of StSP6A on 16th day of treatment, while Kufri Surya showed lesser expression throughout the treatment period (Figs. 19 & 20). Besides, the abundant expression of StSP6A gene was also associated with the tuber-lets production in the leaf bud cuttings on 18th day and 16th day of treatment in Kufri Surya and Kufri Chandramukhi, respectively.

Study indicates that StSP6A acts as a signal for induction of tuberisation with respect to temperature and growth stage in Kufri Surya (heat

tolerant) and Kufri Chandramukhi (early maturing and heat sensitive cultivar). In India developing heat tolerant potato cultivar can expand the potato cultivation in non-traditional plateau areas.

Fig. 18. Tuberization in two potato varieties in response to temperature

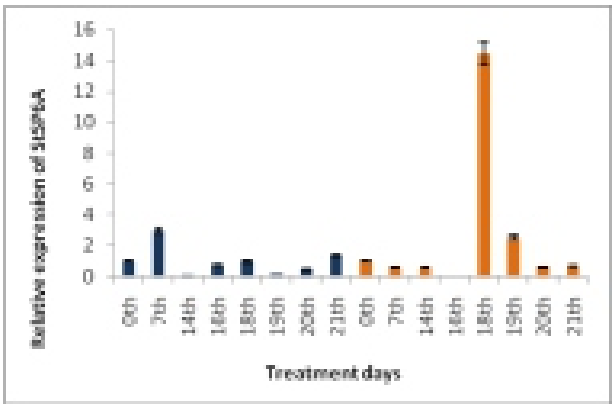


Fig. 19. Relative Expression of StSP6A at 240C in Kufri Chandramukhi and Kufri Surya in Relation to growth period

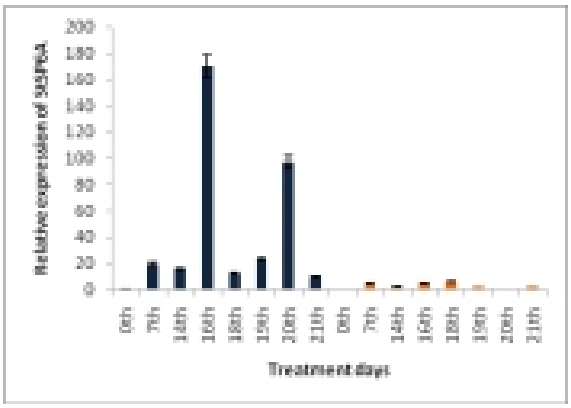


Fig.20. Relative Expression of StSP6A at 180C in Kufri Chandramukhi and Kufri Surya in Relation to growth period

Somatic hybridization in potato improvement

Protoplast isolation, electrofusion and development of putative somatic regenerants

Interspecific symmetric somatic hybridization was attempted between the androgenic dihaploid (C-13) of common potato *S. tuberosum* (2*n*=4*x*=48; 4 EBN) and the wild *S. cardiophyllum* (2*n*=2*x*=24; 2 EBN). These wild and cultivated species are not crossable through conventional means due to the difference in the ploidy and endosperm balance number (EBN). So to overcome the sexual barriers, somatic fusion was done to introgress late blight resistance from the *S. cardiophyllum* into the cultivated potato *S. tuberosum*. Protocol for the plant regeneration from fused protoplasts of

S. tuberosum and *S. cardiophyllum* was developed. In vitro plants were used for protoplast isolation in the solution containing 1% cellulose and 0.5% macerozyme followed by electrofusion in a 3.0 mm microslide using the BTX Elecrto Cell Manipulator. Electrofused protoplasts were cultured in VKM liquid medium supplemented with glucose at 20ºC in the dark. Following the cell wall development, regenerating cells were cultured on MS13K solid medium at 20ºC under a 16-h photoperiod for the calli development. Out of total 90 fusions, based on culture of first shoot per callus, 5 microshoots were regenerated from calli and multiplied on MS medium for further characterization (Fig. 21).

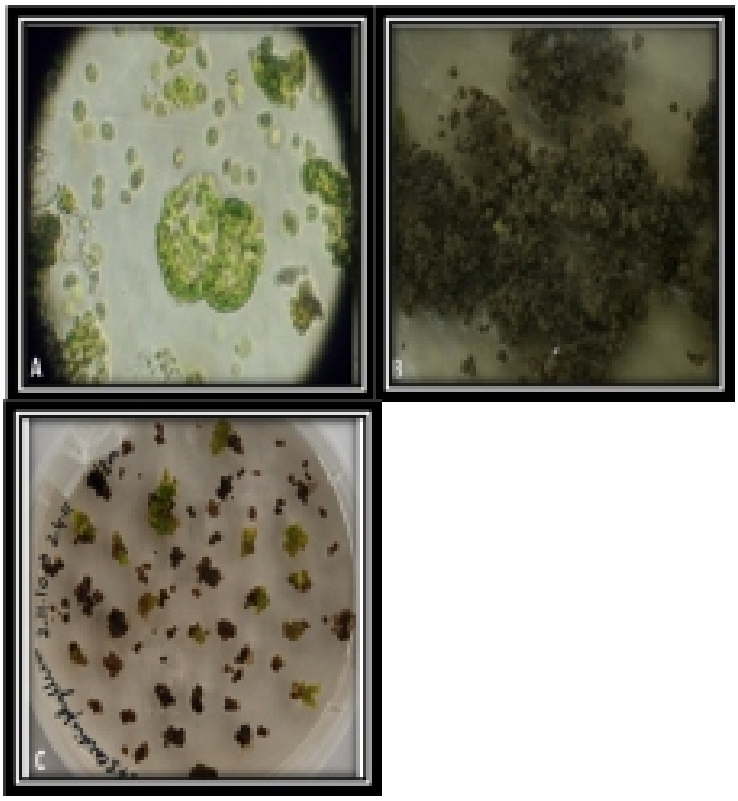
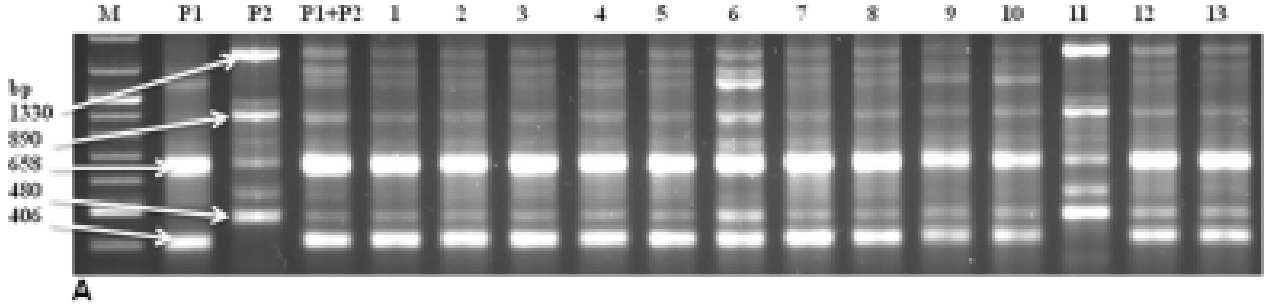


Fig. 21. Protoplast fusion (A), calli regeneration (B) and development of putative somatic regenerants of S. tuberosum dihaploid C-13 (+) S. cardiophyllum (C)

ISSR profilling of somatic hybrids

Sixteen inter simple sequence repeat (ISSR) markers were used for the molecular profiling and characterization of somatic hybrids *S. tuberosum* dihaploid C-13 (+) *S. pinnatisectum*, and C-13 (+) *S. etuberosum*. All the primers detected somatic hybrids possessing species-specific diagnostic bands of their corresponding parents. Somatic hybrids were identified based on the combination of the presence of DNA fragments of both the parents. To illustrate the molecular characterization, primers ISSR 2, ISSR 5, ISSR 2103 and ISSR 2105 for the somatic hybrid C-13 (+) *S. pinnatisectum*, and primers ISSR 1, ISSR 2 and ISSR 5 for the somatic hybrid C-13 (+) *S. etuberosum* are shown by the pictorial representation. Primers viz., ISSR 2 amplified fragments of 406 and 658 bp in C-13, and 480, 890 and 1330 bp in *S. pinnatisectum*; ISSR 5 amplified 420 and 485 bp in C-13, and 679 and 1389 bp in *S. pinnatisectum*; ISSR 2103 amplified, 233 and 1145 bp in C-13, and 690, 922, 1440 and 1867 bp in *S. pinnatisectum*; ISSR 2105 amplified 208 and 376 bp C-13, and 980 and 1436 bp in *S. pinnatisectum*. Primers viz., ISSR 1 amplified fragments of 360, 460 and 735 bp in C-13, and 945, 1340, 1750 bp in *S. etuberosum*; and ISSR 2 amplified fragments of 664 bp in C-13, and 574 bp in *S. etuberosum* (Figs. 22 & 23).



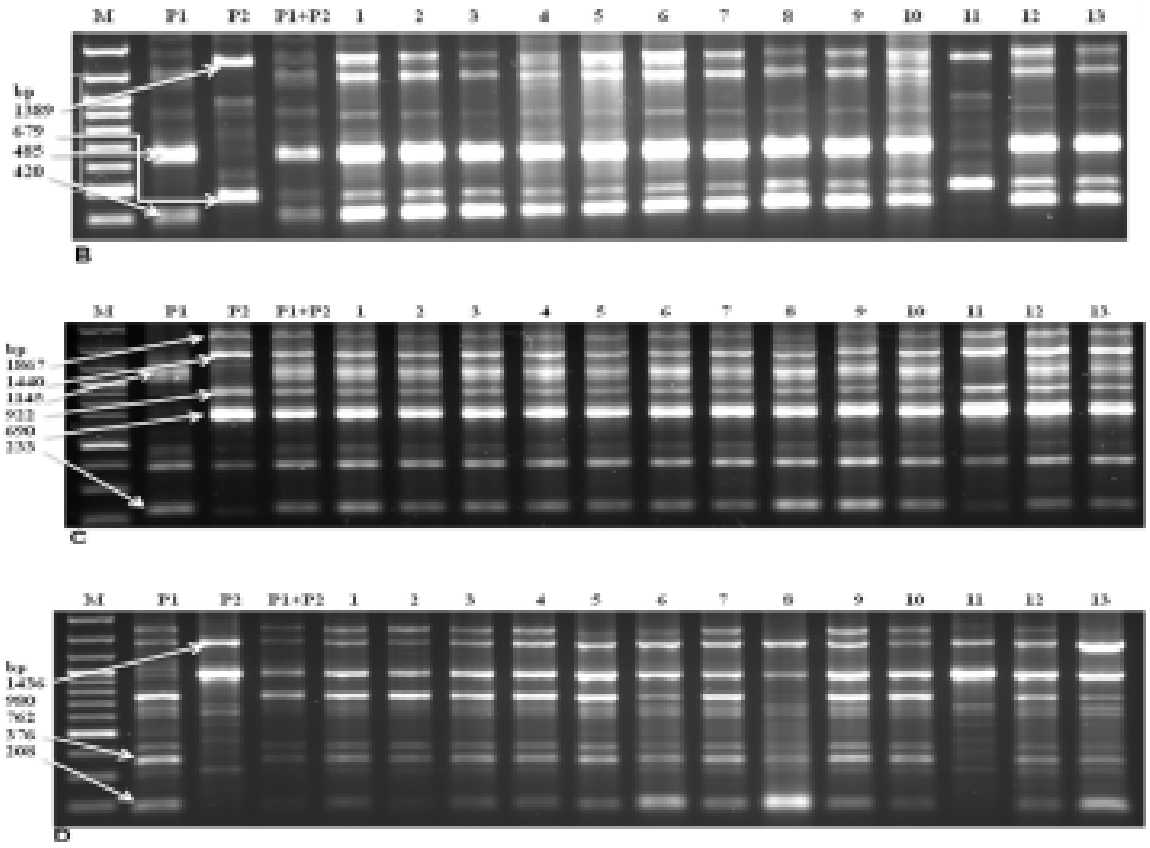


Fig. 22. Molecular profiles of potato somatic hybrids of C-13 (+) S. pinnatisectum generated by ISSR markers. Primer ISSR2 (A), ISSR5 (B), ISSR 2103 (C), and ISSR 2105 (D). M=100 bp ladder, P_1=C-13, P_2=S. pinnatisectum, P_1+P_2=Pooled parental DNA, Conformed somatic hybrids (Nos. 1 to 10, 12 and 13).

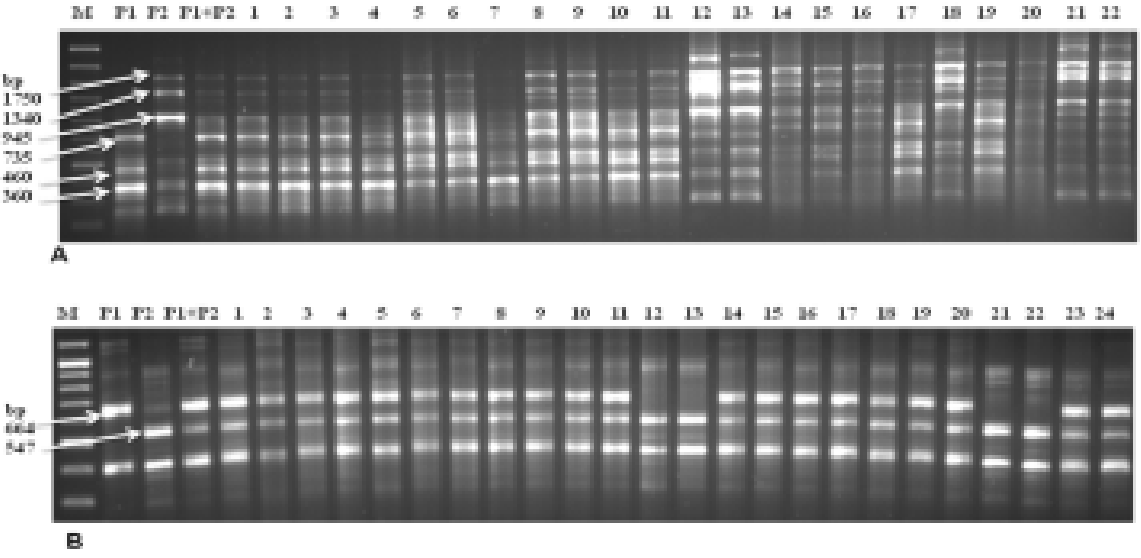


Fig. 23. Molecular profiles of potato somatic hybrids of C-13 (+) S. etuberosum generated by ISSR markers. Primer ISSR1 (A) and ISSR2 (B). M=100 bp ladder, P1=C-13, P2=S. pinnatisectum, P1+P2=Pooled parental DNA, Conformed somatic hybrids (Nos. 1 to 11, 14-20 and 23-24).

Chloroplast and mitochondrial characterizations of somatic hybrids

Twenty-five plasmon (chloroplast and mitochondria) specific primers namely H1, H2, H3, NTCP3, NTCP4, NTCP6, NTCP7, NTCP8, NTCP9, NTCP10, NTCP12, NTCP14, NTCP18, NTCP39, nad1B, rpS14, A14-1, T11-1, T11-2, T11-3, NSm1, pumD, NSm2, NSm3 and NSm4 were used to analyze the somatic hybrids of S. tuberosum dihaploid C-13 (+) *S. pinnatisectum*, and C-13 (+) *S. etuberosum*. The primers amplified a variable fragment length in the somatic hybrids and their corresponding parents. For example, primer pairs NTCP9 amplified 300 bp in C-13 and 255 bp in *S. pinnatisectum* parents. Primer NSm2 showed 630, 750 and 1090 bp amplicons in C-13, and 600 and 967 bp in *S. etuberosum*, whereas both the somatic hybrids amplified varied degree of amplifications (Fig. 24).

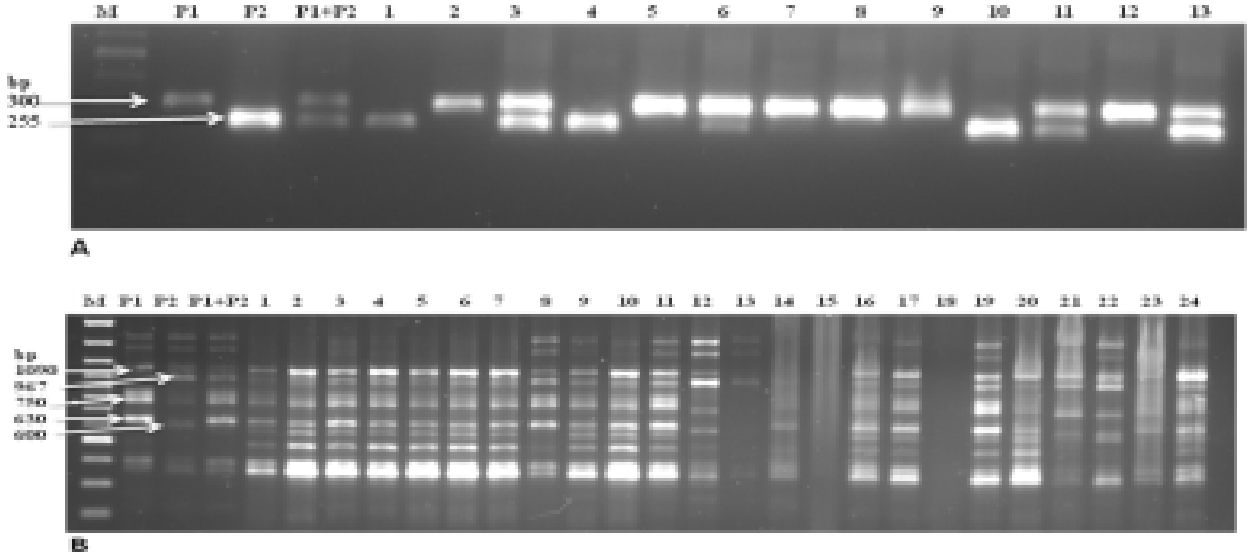


Fig. 24. Plasmon characterization of potato somatic hybrids of C-13 (+) S. pinnatisectum (A), and C-13 (+) S. etuberosum (B) generated by chloroplast and mitochondrial specific primers NTCP9 and NSm2, respectively. M=100 bp ladder, P1=C-13, P2=S. pinnatisectum, P1+P2=Pooled parental DNA.

Foliage late blight resistance assay

Thirteen somatic hybrids of C-13 (+) S. pinnatisectum were evaluated for foliage late blight resistance in the field conditions during the 2011 at CPRS, Kufri (Fig. 25). Among the somatic hybrids viz., P1, P3, P12 and P13 were highly resistant (HR); P5, P8 and P9 were moderatly resistant (MR); and P2, P4, P6, P7 and P10 were resistant (R) compared to control varieties, Kufri Himalini and Kufri Jyoti.

Fig. 25 Tuber multiplication of potato somatic hybrids Late blight resistance assay of somatic hybrids of C-13 (+) S. pinnatisectum (A), and control Kufri Jyoti (B).

In-vitro plants of somatic hybrids of C-13 + *S. pinnatisectum*, and C-13 + S. etuberosum along with parents were multiplied under net house conditions during 2010-11 and 2011-12 at CPRIC, Modipuram. The crop view of somatic bybrids and theri tuber forming ability is reflected in the Fig. 26 and 27.

Fig. 26. Somatic hybrids of S. etuberosum: field view (A, B, C), parent S. etuberosum (D), parent C-13 (E) and somatic hybrid etb 6-2 (F)

The tuber yield of ten somatic hybrids namely P1, P2, P3, P4, P5, P6, P7, P8, P9 and P10 was higher (126 to 248 g/plant) as compared to parents *S. pinnatisectum* (15 g/plant) and C-13 (63 g/plant). Eleven somatic hybrids (P1, P2, P3, P4, P5, P6, P8, P9, P10, P11 and P14) produced tuber number (12 to 23 tubers/plant) higher than the parent *S. pinnatisectum* (11 tubers/plant). Twelve somatic hybrids (P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P12 and P13) produced average tuber weight (4 to15 g) higher than the parents *S. pinnatisectum* (1 g) and C-13 (3 g).

Fig. 27. Somatic hybrids of S. pinnatisectum: field view (A, B, C), Parent S. Pinnatisecturm (D), Parent C-13 (E) and somatic hybrid P-8 (F)

Somatic hybrids of C-13 + S. etuberosum showed variable range of tuber formation in the plants. Out of 18 genotypes, tuber formation was observed in the 13 somatic hybrids (E1-1, E1-3, E1-4, E2-1, E2-2, E2-3, E2-4, E2-6, E2-7, E6-2, E6-3, E8 and E12), whereas there was no tuber formation in the 5 somatic hybrids viz., E1-2, E1-5, E11, E17-1 and E17-2. The tuber yield ranged from 6 to 213 gram/plant in 13 somatic hybrids, however only five somatic hybrids (E2-2, E2-4, E2-6, E2-7 and E6-2) produced higher yield (64 to 213 g/plant) than the parent C-3 (63 g/plant). Four somatic hybrids (E2-2, E2-4, E2-6 and E6-2) produced higher tuber number/plant (21-41 tubers/plant) than the parent C-3 (19 tubers/plant). The high average tuber weight (4 to 5 g) was recorded in six somatic hybrids (E2-2, E2-7, E6-2, E6-3, E8 and E12) than the parent C-3 (3 gram).

In 2011-12 the tuber yield of six somatic hybrids namely P2, P3, P6, P8, P9 and P10 was higher (78 g/plant to 138 g/plant) as compared to parents *S. pinnatisectum* (5 g/plant) and C-13 (75 g/plant). Six somatic hybrids P2, P3, P4, P7, P8 and P10 produced higher tuber number (8 to 12 tubers/plant) than the parent *S. pinnatisectum* (4 tubers/plant) and C-13 (7 tubers/plant). Five somatic hybrids (P5, P6, P8, P9 and P10) produced higher average tuber weight (11 to13 gram) than the parents *S. pinnatisectum* (1 g) and C-13 (10 g).

The tuber yield of eighteen somatic hybrids of C-13 + *S. etuberosum* (E1-1, E1-2, E1-3, E1-4, E1-5, E2-1, E2-2, E2-3, E2-4, E2-6, E2-7, E6-2, E6-3, E8, E11, E12, E17-1 and E17-2) ranged from 5 to 108 g/plant and only five somatic hybrids (E1-1, E2-2, E2-6) produced higher yield (82 to 108 g/plant) than the parent C-3 (75 g/plant). Nine somatic hybrids (E1-1, E1-2, E1-4, E1-5, E2-1, E2-2, E2-6, E2-7, E8) produced higher tuber number/plant (8 to 26 tubers/plant) than the parent C-3 (7 tubers/plant). None of the somatic hybrid could produce the higher average tuber weight than the than the parent C-3 (10 g). The parent *S etubrosum* and other non-hybrid plants exhibited stolon formation but tuber formation was not successful.

Division of Crop Production

Resource management and information technology in potato based cropping systems

The cropping systems based on climate, soil and water availability have to be evolved for realizing the potential production levels through efficient use of available resources as the increased cropping intensity is a key strategy for future gains in crop production. These objectives could be achieved by adopting intensive cropping which includes multiple and intercropping. The aim of this programme is to evaluate existing cropping systems for the productivity/profitability and to develop/standardize package of production practices for emerging cropping systems in different potato growing areas. It also aims to develop information technology tools viz. decision support systems, remote sensing, geographical information systems and crop modeling for efficient potato production.

Resource management in potato based cropping systems

Evaluation of potato based inter-cum-relay cropping systems under Eastern Indo Gangetic plains of Bihar

A field experiment was conducted at Patna to study the associative effect of intercrops on potato yield and the productivity/ profitability in potato + onion/radish–sponge gourd/bottle gourd/tomato relay inter cropping systems. Results revealed that all inter-cum-relay cropping systems produced higher potato equivalent yield (PEY) than sole potato-vegetable system. The PEY (65.5 t/ha) was highest in potato + onion (1:2) - bottle guard system followed by potato + onion (1:1) - bottle gourd system (64.6 t/ha).

Nutrient management in maize + potato inter cropping system under Eastern Indo-Gangetic plains of Bihar

Intercropping of potato and maize is very popular in potato growing areas of north Bihar districts as it is economically more viable compared to sole potato or sole maize. Nutrient management in intercropping system plays an important role on the productivity of the system. Hence, the present experiment was conducted to find out the suitable nitrogen management strategy for maize + potato intercropping system under different planting situations. Results revealed that in a potato + maize (1:1) intercropping system, where potato was supplied recommended NPK, maize required only 50% of recommended N for optimum PEY of 42.2 t/ha. Application of N to maize in three splits (½ at planting + ¼ at knee high stage + ¼ at tasselling stage), produced highest maize grain yield (8.9 t/ha) and PEY (43.1 t/ha).

Intercropping system for potato and nutrient economy in crop sequences through use of residual fertility of potato in NEH region

A field experiment was conducted at Shillong to evaluate potato based cropping systems. Potato was the main crop during summer season while succeeding crops were taken during autumn season. Potato equivalent yield (44.3 t/ha) was highest under potato-cabbage followed by potato-radish (36.5 t/ha) and potato-cauliflower (30.83 t/ha) crop sequences. In another experiment, application of 50% recommended NPK to potato through fertilizers and 50% N through FYM and 100% RDF to subsequent crop brought out significant improvement in PEY over rest of the treatments in potato – potato/maize/cabbage/ carrot systems. In another experiment on potato based intercropping systems, potato + radish (1:1)

intercropping system was most remunerative compared to potato + French bean/maize systems as it recorded highest land equivalent ratio (1.23) and PEY (24.5 t/ha).

Introducing new intercrops with potato in southern hills

Potato + broadbeans intercropping: Inter cropping of potato with broadbeans was found advantageous in comparison with that of sole potato crop under both the varieties of potato. The yields obtained with variety Kufri Neelima were higher in comparison with that of Kufri Giriraj both under sole and intercrop stands (Table 1). Growing

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

	PEY (t/ha)	
Treatment	**Kufri Giriraj**	**Kufri Neelima**
Potato + Broadbeans (1:1)	18.1	26.0
Potato + Broadbeans (2:1)	13.8	18.6
Potato + Broadbeans (3:1)	11.5	13.2
Broadbeans	14.1	15.2
Potato	9.8	26.2
Mean	13.5	19.9
	SE d	CD at 5%
Varieties (V)	0.92	1.97
Treatments (T)	1.5	3.1
VXT	2.1	4.4

Potato+rosemary intercropping: Growing rosemary as intercrop with PCN (potato cyst nematode) susceptible potato variety Kufri Giriraj was found beneficial. Potato+rosemary intercropping in 1:1 row proportion recorded higher PEY (11.82 t/ha). In case of resistant potato (Advance Hybrid OS/93-D-204), growing of sole potato was more advantageous both in terms of PEY as well as nematode population.

Potato+thyme intercropping: Intercropping of potato with thyme was not much beneficial with both-PCN susceptible as well as PCN resistant varieties. The highest PEY was recorded with Kufri Neelima as sole crop closely followed by intercropping with thyme in 3:1 row proportions. There was no advantage of growing thyme as intercrop for the control of potato cyst nematodes as it could not reduce the PCN population either in sole stand or in intercrop combinations.

Resource management in garlic–potato crop sequence in north western hills

To find out suitable crop geometry of garlic and potato in garlic–potato sequence, seven treatments with population density of garlic ranging from 40 to 100% were tested at Shimla. The highest yield of garlic (5.0 t/ha) was obtained in garlic–late potato sequence, which was significantly higher over other treatments, whereas the potato yield was highest in garlic–potato relay sequence. PEY (32.8 t/ha) was higher in garlic–late potato sequence and was 13.2% higher over second best treatment garlic–potato relay system (28.4 t/ha).

Resource conservation in potato through minimum tillage

Conservation agriculture technology development has a golden ray to sustain the natural resources.

Keeping this in view, a field experiment was conducted at Patna to study the effect of tillage and N level on potato production after the rice fallow. Tillage significantly influenced potato emergence and potato tuber yield. However, reduced tillage resulted in significant yield losses as the maximum tillage (mould board ploughing + one harrow + one tiller + one planking) gave the highest tuber yield (28.6 t/ha). Application of 150 kg N/ha produced significantly higher tuber yield (24.2 t/ha) as compared to 120 kg N/ha (21.8 t/ha).

Predicting N recommendations based on soil nitrate content

Excess nitrogen application can result in environmental degradation. If a correlation can be established between soil nitrate content and yield response, it will be convenient to formulate fertilizer recommendations based on it. With this objective, a trial was conducted at Ooty. Results revealed that a perfect correlation existed between the nitrate nitrogen of 0 to 30 cm and 0 to 90 cm depth, more quantity being accumulated at deeper layers. It indicates that this can be used as a measure to identify the soils with high nitrate nitrogen accumulations at deeper layers. Varietal differences also existed in accumulation of nitrate nitrogen at different levels of nitrogen application. Hence, regression equations were calculated for each variety separately and the nitrate nitrogen levels were estimated at optimal levels of nitrogen doses.

Identification of *kharif* potato locations in plateau region

Potato area under plateau region is 7 per cent of India but the production is only 4 per cent. This is mainly because of poor sunshine, high minimum temperature and erratic rainfall prevailing during the rainy season when the potato is grown here. At the outset, the locations between 300-1300 m above msl were identified using GIS. Thereafter, the meteorological data sets of the locations were prepared. The locations spreading in different states *viz*. Andhra Pradesh, Maharashtra, Karnataka and Madhya Pradesh were screened for growing *kharif* potato. The INFOCROP-Potato model was run for four different planting dates (1st June, 15th June, 1st July and 15th July) to estimate the yield potential and to find out the optimum time of planting for each location. The analysis showed that latitude of the region greatly influenced the length of growing period, start of planting season and also the yield. In Andhra Pradesh, *kharif* potato can be grown in Arogyavaram by planting it on 1st to 15th of July and it could give around 66 to 71 days of long growing period. In Karnataka, out of 12 locations screened, except two *i.e.,* Belgaum and Medikeri, all other locations are suitable for growing potato in *kharif* season and planting can be taken up from 1st of June to 15th of July in these locations. In Maharashtra, out of 13 locations analysed, 10 were found suitable for growing *kharif* season potato if planted on 15th of July and 3 were suitable with 1st July planting. A wider window (1st of June to 15th of July) for planting of *kharif* season potato is available in Miraj, Pune, Ahmednagar and Mahabaleshwar. In Madhya Pradesh, Panchamarhi is suitable for growing *kharif* season potato right from 1st June to 15th July and about five more places (Jagdalpur, Indore, Ginabahar, Seoni and Jashpurnagar) are suitable for 15th July planting.

Estimation of potential yield of *kharif* potato

The potential yield of different locations for *kharif* potato was estimated through INFOCROP-Potato model (Table 2). Among the locations in plateau region, Balehonnur and Hassan in Karnataka and Pune in Maharashtra, are expected to have highest yield potential. In most of the locations the potential yield ranged between 20 to 40 t/ha.

Table 2. Classification of *kharif* potato growing locations according to potential yield (t/ha)

< 10	10-20	20-30	30-40	> 40
Mahbubnagar	Ginabahar	Arogyavaram	Shimoga	Hassan
Hyderabad (A)	Seoni	Jeur	Gadag	Pune
Belgaum	Jashpurnagar	Miraj	Bidar	
Medikeri (Mercara)		Kolhapur	Chitradurga	
Beed (Bir)		Nasik	Belgaum Samra (A)	
Baramati		Buldana	Mysore	
Aurangabad		Ahmednagar	Bangalore (A)	
Sagar		Mahabaleshwar	Bangalore	
Chhindwara		Jagdalpur	Sangli	
Jhadol		Indore	Panchmarhi	

Development of best management practices (BMPs) for *kharif* potato

Agro-techniques need to be developed for realizing the production potential in the locations suitable for potato production by overcoming the biotic and abiotic stresses. With this objective a field experiment on evaluation of suitable variety and standardization of optimal planting date for *kharif* potato in Karnataka was conducted at Hassan, Karnataka during *Kharif* 2011. The results indicate that potato variety Kufri Surya performed consistently better over all the four dates of planting closely followed by Kufri Himalini and Kufri Jyoti. Among the different planting dates, June 10th proved to be more suitable for all the varieties.

Evaluation of potato varieties under different dates of planting for Kharif potato at Hassan.

Yield stability in potato under varying soil management strategies in southern hills

In Nilgiris, the average yields of potato remained almost constant since last 15 years, despite improvement in availability of varieties, application of fertilizers and pesticides. The present investigation was initiated during 2006 with four different soil management strategies using two different potato cultivars. Yield stability was estimated with the help of certain statistical measures using the data of four years on fixed plots.

The PEY had shown an interesting trend over the last four years in different systems. In mono-cropping with susceptible potato variety (Kufri Giriraj), PEY had shown decreasing trend with a very high CV value of 15.6 per cent. Among the different combinations, growing of resistant potato advance hybrid (OS/93-D-204) as intercrop along with French beans followed by cabbage in autumn season recorded the highest yield along with

minimum variation in terms of CV value (1.6). The recommended practice of growing potato with French beans intercropping (3:2) in summer season followed by cabbage crop in autumn season had shown more stable yield levels in comparison with all other combinations of cropping (Table 3).

The environmental variance (Sti^2) and superiority index (Pi) should have minimal values against the stable treatments. The treatment in which resistant potato was intercropped with French beans and followed by cabbage in autumn season recorded nil values for these measures, indicating more stability in yield over the years. This is because of better control of PCN through eco-friendly management in this treatment which was possible both by growing resistant variety and also intercropping with non-host French beans along with soil enrichment through legume intercropping. The higher values for these two indices in mono-cropping of susceptible potato variety to PCN represent poor stability in yield over the years. In contrast, the GAI (geometric adaptability index) and SI (stability index) should have higher values for the stable treatments. The same treatment in which the CV, Sti^2 and Pi recorded lower values the GAI and SI recorded the highest values indicating that the treatment is more stable in producing sustainable yields over the years.

Table 3. Potato equivalent yield (PEY) as influenced by different soil management strategies at Ooty

Treatment	PEY (t/ha)				
	2008	2009	2010	2011	Mean yield
Monocropping of potato with PCN susceptible variety (Kufri Giriraj)	23.5	20.6	18.5	16.3	19.7
Monocropping of potato with PCN resistant advance hybrid (OS/93-D-204)	26.3	24.3	23.2	21.6	23.8
Potato (PCN susceptible) – cabbage (Farmers' practice)	24.2	22.9	21.1	19.6	21.9
Potato (PCN resistant) – cabbage (Farmers' practice)	27.1	26.9	24.8	23.1	25.5
Potato (PCN susceptible) – cabbage (20 t FYM/ ha for potato) amended soil	24.6	25.3	26.8	29.2	26.5
Potato (PCN resistant) – cabbage (20 t FYM/ ha for potato) amended soil	29.2	28.4	31.2	32.1	30.2
Potato (PCN susceptible) + French beans intercropping - cabbage	30.1	29.6	28.6	27.3	28.9
Potato (PCN resistant) + French beans intercropping - cabbage	33.4	32.9	34.2	33.9	33.6
SE d					
Varieties	1.34	0.95	1.07	1.23	
Treatment	1.90	1.35	1.51	1.75	
Varieties x Treatment	2.69	1.91	2.14	2.47	
CD 5%					
Varieties	2.8	2.0	2.3	2.6	
Treatment	4.0	2.8	3.2	3.6	
Varieties x Treatment	5.6	4.0	NS	5.1	

Weed management strategies for potato crop

Evaluation of post emergence herbicide (Propaquizafop) in potato crop

Field experiments were conducted at Modipuram to evaluate post-emergence herbicide (propaquizafop) in potato. Propaquizafop 0.781 kg/ha was most effective in controlling weeds under ridge and furrow method, sprinkler and drip irrigation systems. Propaquizafop at 0.781 kg/ha as post-emergence in potato crop was also found effective at Gwalior under ridge and furrow method of irrigation in controlling the weeds in potato crop.

Evaluation of controlled release formulations of metribuzin

The controlled release formulations of metribuzin were evaluated for weed control in potato cv. Kufri Surya at Modipuram. The dose of 0.5 kg/ha of metribuzin as pre-emergence spray was kept constant for all herbicide formulations. CMC-metribuzin 2G and CMC+ Kaolin- metribuzin 2G recorded comparable yields (19.4 t/ha) as compared to metribuzin (21.1 t/ha) and weed free plots (20.4 t/ha). Weed intensity declined tuber yield by 10.3% in weedy check under ridge and furrow method of irrigation over weed free plots.

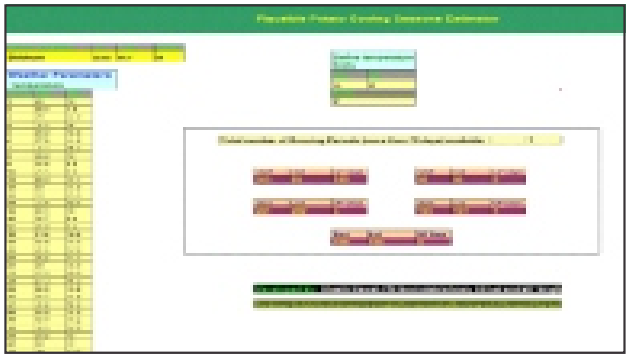
Weed management in potato in NEH region

Field experiment was conducted during summer season of 2011 at Shillong. Maximum tuber yield of 29 t/ha was recorded in weed free check followed by 28 t/ha in treatment having metribuzin 1 kg/ha as pre-emergence and one hand weeding at 40 days after planting.

Development and use of decision support systems/tools

Plausible Potato Growing Seasons Estimator (PPGSE) and Yield Estimator

This decision support system was developed for spatial and temporal diversification of potato cultivation. It gives the growing seasons and their durations, climatic features of the seasons and estimate yield potential for important locations in India totalling about 1,500. With this software,

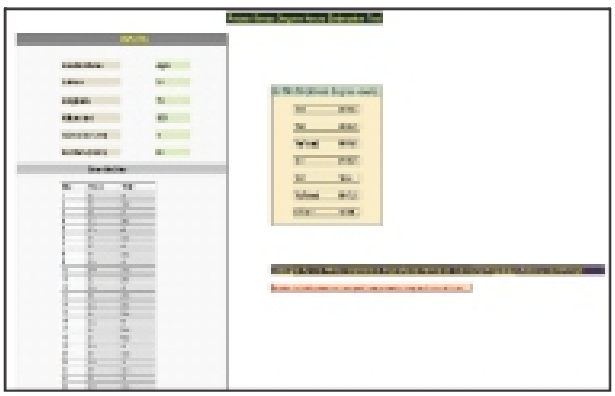


potato growing seasons and climate based yield potential can be estimated for any location. It has been used to advice scientists of International Potato Centre at Uzbekistan for identifying possible growing seasons in some of their places. It is also used to advice the scientists of International Potato Centre for site suitability for screening trials for heat tolerance in Gujarat and Pepsi officials on potential sites for seed production in Tamil Nadu.

Algorithms to screen the maximum and minimum temperature records of any location according to threshold limits set by the user and extract those periods which meet the criteria continuously for a period of more than 70 days are displayed along with the start and end of the season.

Potato Temperature Stress Degree Hours Estimation tool

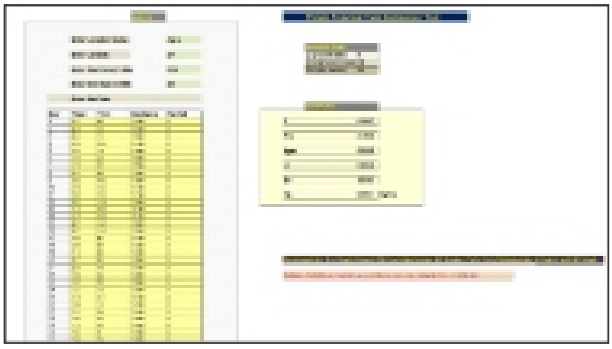
This tool screens the temperature database and estimates the duration during each 24 hour period the ambient temperatures being above the optimum temperatures for each day and this is summed over the whole growing period. This is indicative of the magnitude of heat stress at any location/season. This tool is useful in evaluation of genotypes tolerant to heat stress and also for



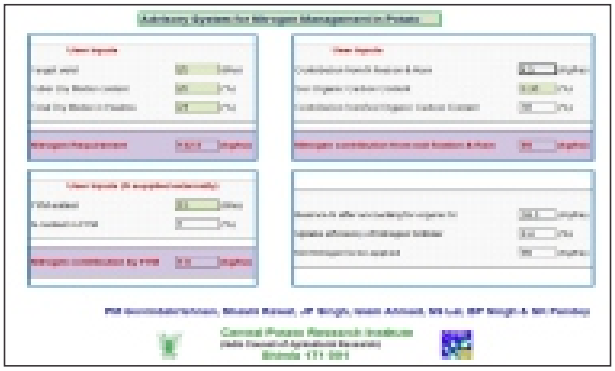
identifying their target sites for deployment and in manipulating date of planting with minimum stress.

Potato Potential Yield Estimation tool

This tool estimates the potential potato yield based on the FAO Agro-ecological Zones model or any location on the basis of weather data, geographical location, and season. It provides information on the expected yield and thus the



yield gap which is useful for developing agro-techniques to narrow the yield gap.



The N advisory system was redesigned and the bugs were removed which were present in the initial version of NDSS.

Potato production in relation to weather parameters

In order to derive a relationship between agro-meteorological parameters and potato production for use in decision systems, a field experiment was conducted at Shimla. Potato was planted at 4 different dates (6th April, 18th April, 26th April and 6th May 2011) and the haulms were cut on 20th July 2011. The accumulated day-degrees were calculated above a base temperature of 4 degree Celsius from planting to haulm cutting, *i.e.* cessation of bulking. The respective accumulated day-degrees for different dates were 2031, 1839, 1696 and 1478, respectively with corresponding tuber yields of 15.8, 14.4, 11.5 and 10.3 t/ha. A significant, positive correlation (0.969*) was observed between accumulated day-degrees and final tuber yield.

Assessing the performance of different agro-ecosystems agronomically and environmentally through AEPAT

Determining the effects of management practices on agro-ecosystem functions is necessary to determine the sustainability of agricultural production systems. The performance of agro-ecosystem functions is best characterized over multiple years. A large amount of high quality data is needed for output from the procedure to be useful. Consequently, data from long-term experiments are most suitable for use with the Agro-ecosystem Performance Assessment Tool. The data from yield stability analysis has been analysed with this performance tool and the results indicated that growing PCN resistant potato with French beans (3:2) as intercrop in summer followed by cabbage during autumn season has been the most sustainable system under Nilgiri conditions and monocropping of PCN susceptible potato is the most unsustainable system.

Acreage and production estimation of potato using remote sensing and GIS

Analysis for winter potato acreage estimation for 2011-12 was done using IRS-P6 AWiFS data in collaboration with Space Applications Centre (ISRO), Ahmedabad. For remote sensing estimates, the IRS-P6 AWiFS multi dates data were used. Image analysis was done on TM tiles of 2 X 2°. For potato crop acreage estimation, NDVI (normalised difference vegetation index) values were used in algorithms. Multidate images were used and were subjected to isodata multidate unsupervised classification. On the basis of signature matching and ground truth data, images were classified for potato, wheat, sugarcane,

mustard and other crops. The numbers of pixels classified as potato were thus multiplied with the area and the potato acreage was worked out in these tiles.

Weather data from Jalandhar, Modipuram, Agra, Varanasi, Patna and Kolkata were collected and used for running the INFOCROP-POTATO model and yield estimates of Punjab, Uttar Pradesh, Bihar and West Bengal were derived. These data were used for production forecast of winter potato for 2011-12. The acreage forecast under winter potato during 2011-12 in Punjab, Uttar Pradesh, Bihar and West Bengal was 90.6, 516.0, 322.5 345.0 thousand hectares, respectively, while the total production was predicted as 2071.1, 11439.7, 5262.4 and 8266.2 thousand tons, respectively.

Nutrients and water management

One of the goals of sustainable agriculture is to strive to keep producing uniformly at all levels. This goal can be achieved through site specific nutrient management (SSNM), by formulating a

long term fertilization policy and by developing nutrient/water use efficient cultivars. Keeping these in view, the current programme was formulated with aims to develop SSNM practice, developing spatial maps of available nutrients and identify nutrient and water use efficient potato varieties.

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

Spatial distribution of soil available nutrients in the potato growing area of Hoshiarpur, Punjab: On the basis of analysis of soil samples collected from different farmers fields of Hoshiarpur, GIS maps of available nutrients of potato growing fields were generated (Fig. 1). Results revealed that area under medium, high and very high available P was 10, 39 and 51% , respectively. In fact no sample was deficient in available P. Less than 2% samples were found to be high in available K, whereas, 79% samples were low (<105 ppm) and remaining 19% samples tested medium in available K status for potato. None of the soil samples were found high in available N. 63% of soil samples were in low range (< 150 ppm N) and remaining 37% were in medium range (150- 280 ppm N).

Site-specific nutrient management technique

Site specific nutrient management (SSNM) tested at Modipuram with omission plot technique and over fertilized reference (OFR) in potato cultivar Kufri Pukhraj indicated that the tuber yield was reduced by 28.64 t/ha in N omission plot. After N omission plot, the greatest effect was recorded in K omission plot (9.76 t/ha).

Chlorophyll content index and its relationship with stage and N application rate in potato: At Shimla, mean chlorophyll content index (CCI) in the leaves increased by 16.3%, two days after the application of second dose of N, as compared to chlorophyll content observed three days before application of second dose of N. Later, CCI declined with advancement of growth. A positive correlation was observed between CCI and N application rate, up to 16 days after application of second dose of N (Fig. 2). N application rate was highly correlated with the final tuber yield. The results showed that CCI is a good index and can be used to work out supplementary N requirement of potato.

At Patna, the trend of highest nitrogen level (240 kg/ha) for six cultivars showed that as the growth advanced the chlorophyll index decreased however, soon after top dressing the index improved. There was differential response of recovery of index in different cultivars after top dressing.

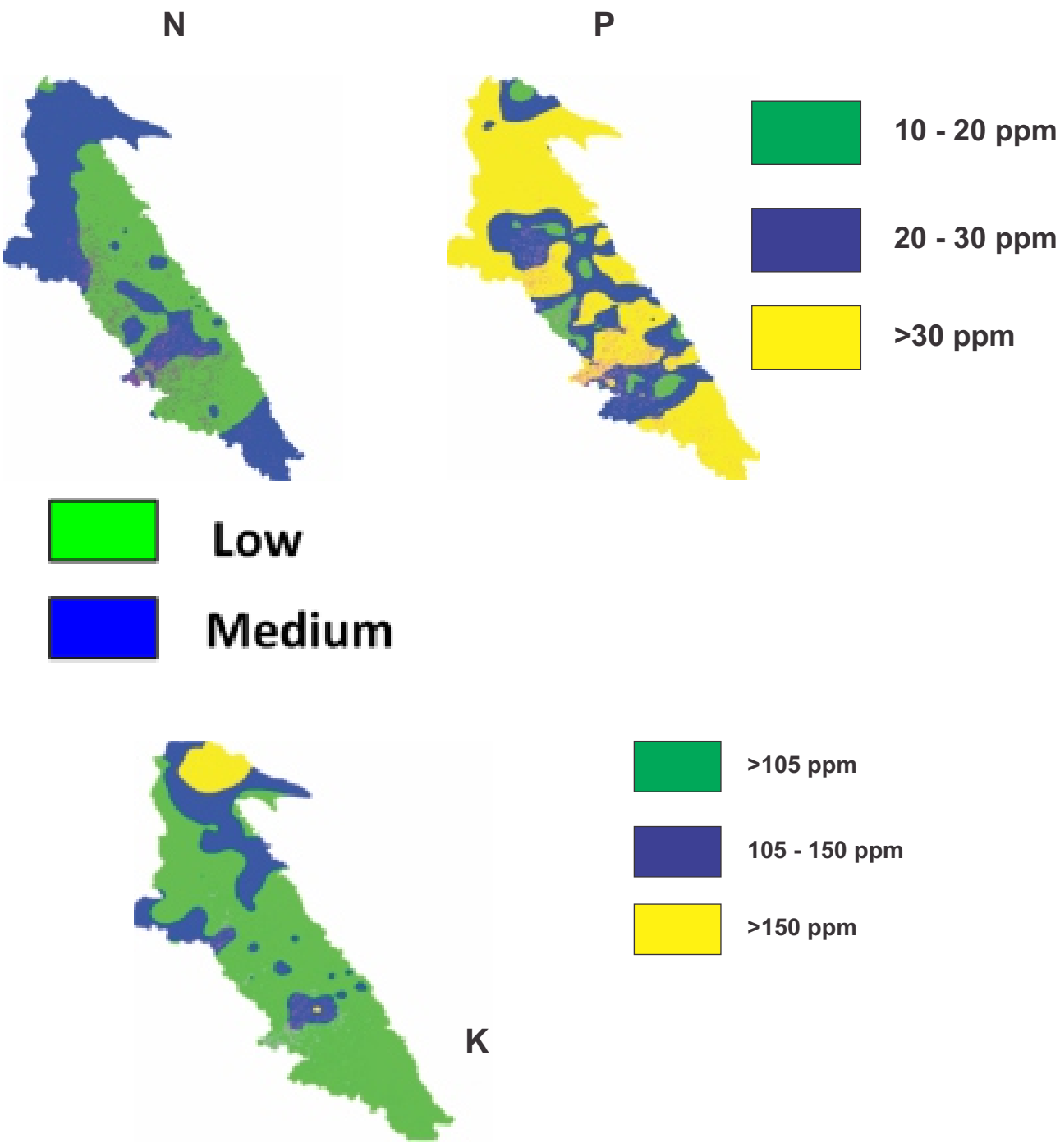


Fig. 1. Spatial distribution of available N, P and K in potato growing pockets of Hoshiarpur district of Punjab (pink pixels represent potato area)

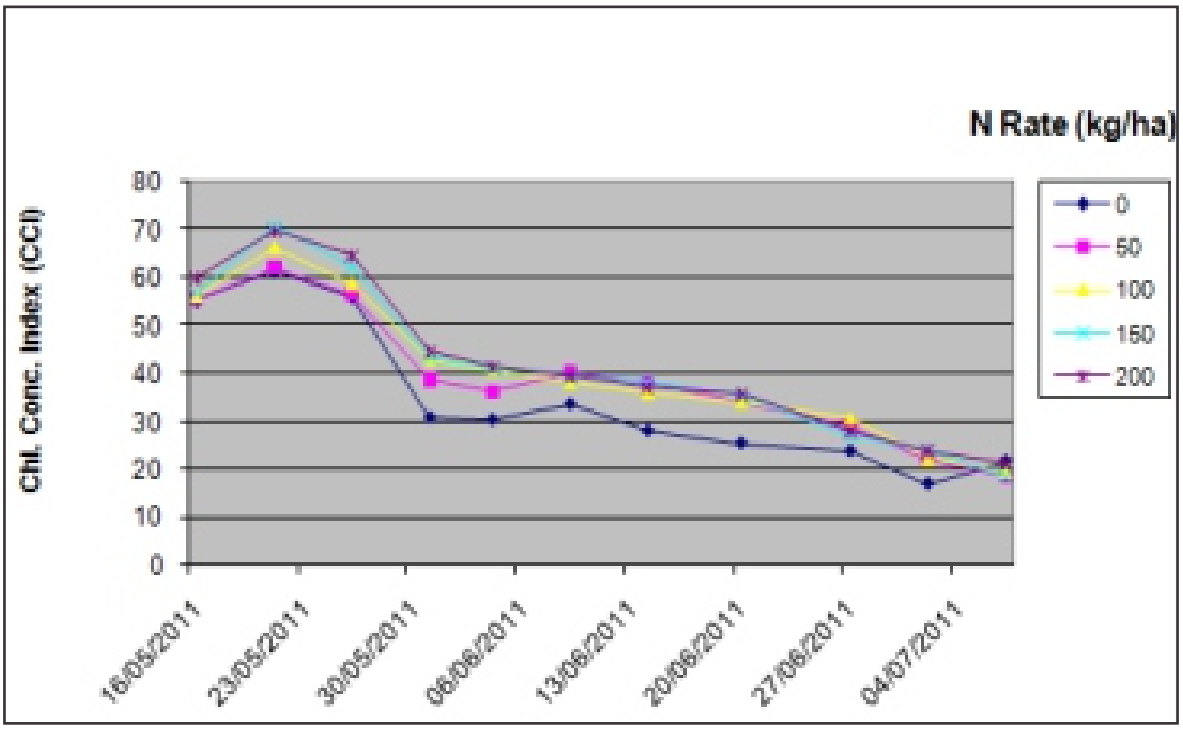


Fig. 2. Screening of Chlorophyll concentration index (measured by chlorophyll content meter, model CCM-200 of Optiscience make) as influenced by N application rates at different growth stages of potato

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

Breeding

Hybridization: A total of 8,209 seeds of 19 crosses and 52690 seeds of 18 crosses were obtained at Kufri and Jalandhar, respectively.

Raising of seedlings: A total of 12,046 F1 seedlings obtained from germination of 49,378 seeds were transplanted in field with no additional nutrient supplied and 3543 selections were made on the basis of tuber characters such as color, shape and eye depth.

Evaluation in clonal generations: A total of 6,603 F_1C_1 clones were planted. Based on tuber characters, such as shape, skin color and eye depths, 837 clones were selected. Out of 752 F_1C_2 clones planted, 331 were selected. The yield range of the selected clones was 490 to 1000 g/plant as compared to 460 g/plant of control Kufri Gaurav.

Screening of hybrids/ cultivars for water and N use efficiency

Patna: Among six cultivars grown, the highest agronomic efficiency (t tubers/kg N) was observed for Kufri Gaurav (0.11) followed by Kufri Arun (0.09), Kufri Pukhraj (0.08), Kufri Pushkar (0.07), Kufri Jyoti (0.06) and Kufri Khyati (0.06).

Shillong: Based on the control yield (No P applied) and dose of P required to produce fixed tuber yield in the same field, Kufri Girdhari was most P efficient followed by cvs. Kufri Giriraj and Kufri Jyoti.

Table 4. Rates of N required by different germplasm to obtain fixed tuber yields

S. No.	Germplasm/cultivar	N rates (kg/ha) for fixed yields of				
		20 t/ha	25 t/ha	30 t/ha	32.5 t/ha	35 t/ha
1	JX-254	94	176	np	np	np
2	K. Anand	50	86	140	np	np
3	J-92-159	41	80	135	182	np
4	JTH/C-107	106	200	np	np	np
5	MS/82-398	40	74	120	158	np
6	K. Jyoti	182	np	np	np	np
7	JX-123	131	215	np	np	np
8	E-4486	57	98	165	np	np
9	JV-67	np	np	np	np	np
10	JD/A-3-4	96	np	np	np	np
11	JX-214	75	137	np	np	np
12	K. Pukhraj	53	89	147	np	np
13	JW-160	50	90	150	210	np
14	E-4451	80	np	np	np	np
15	JN-1197	83	148	np	np	np
16	JF-4841	73	136	np	np	np
17	JV-62	np	np	np	np	np
18	K. Gaurav	49	82	124	153	154
19	J-93-98	41	69	103	125	125
20	JX-455	73	133	np	np	np
21	J-95-221	87	149	np	np	np
22	JP-132	92	150	239	np	np
23	JX-1757	131	np	np	np	np
24	K. Pushkar	62	98	149	192	np
25	JX-1157	41	20	np	np	np
26	EB/C-543	160	np	np	np	np
27	K. Kuber	101	185	np	np	np
28	83/P-142	64	101	162	np	np
29	MS/82-717(K. Anand)	37	68	112	150	np
30	K. Badshah	65	112	200	np	np
31	JENV/0-30	89	177	np	np	np
32	MS/82-638	47	78	116	140	140

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

Modipuram: The 35 of the advanced numbers out of 66 tested under plot-wise trial produced equal/higher yield than popular varieties Kufri Bahar and Kufri Pukhraj at all irrigation levels *i.e.* 20, 25 and 30 mm cumulative pan evaporation (CPE) and have been selected for testing under replicated trial next year.

Jalandhar: Germplasm evaluation for nitrogen efficiency in third year replicated field trial indicated that the germplasm, J-93-98, MS/82-638 and MS/82-398 appear to be more N efficient than previously identified most N efficient cultivar, Kufri Gaurav, based on nitrogen requirement for getting equivalent yield (Table 1). The 6 germplasm out of 28, having mean tuber yield higher than 16.3 t/ha have been selected for further testing under replicated trial for next year. The 12 germplasm out of 20 having either control yield more than 9.7 t/ha or mean yield more than 17.2 t/ha were selected for plot wise trial for next year.

Root studies of different potato cultivars: At Jalandhar, most nitrogen efficient hybrid JX 576 had significantly higher mean root length (2503 cm/plant) and mean root volume (5.72 cm^3/plant) than least N efficient cultivar Kufri Jyoti which had mean root length of 1909 cm/plant and mean root volume of 4.52 cm^3/plant. At Patna, root volume was higher in Kufri Gaurav (6.53 cm^3/plant) than Kufri Arun, Kufri Jyoti, Kufri Khyati, Kufri Pushkar and Kufri Pukhraj. In a sand culture pot experiment with seven cultivars at Patna, efficient cultivars like Kufri Gaurav and Kufri Pushkar had higher root/shoot ratio as compared to inefficient cultivar Kufri Jyoti.

Improving water use efficiency through micro-irrigation

Water use efficiency: Water use efficiency of cv. Kufri Pukhraj was 166, 132 and 94 kg tubers/ha-mm water with drip, sprinkler and furrow irrigation method, respectively.

Phasic water need: Irrigation at 1.00 time of CPE up to stolen formation (SF), 1.50 times CPE from SF to tuber initiation (TI), 1.50 times CPE from TI to early tuber bulking stage and 1.25 times CPE up to maturity produced significantly higher tuber yield (33.8 t/ha) under drip irrigation. Similarly, the irrigation at 1.25 time of CPE up to SF, 1.50 times CPE from SF to tuber initiation, 1.50 times CPE from TI to early tuber bulking stage and 1.25 times CPE applied up to maturity gave maximum yield (34.5 t/ha) under sprinkler irrigation than other treatments. While in case of furrow method of irrigation, the potato yield was significantly higher (31.8 t/ha) when irrigations were applied at 20 mm CPE water level as compared to 25 and 30 mm CPE water level.

The drippers with 2 litre per hour water discharge placed at 20 or 30 cm distance produced significantly higher yield in comparison to other treatments under drip irrigation system.

Comparison of different types of sprinkler irrigation systems: The yields of all potato cultivars were higher, when potato crop was raised under mini-sprinkler (Turbo Hammer Medium Volume Mini-sprinkler) with water discharge of 170-350 lph, placed at 7x7 m distance in comparison to mini-sprinkler placed at 8x8 m distance. While the irrigation system, Metal Impact/Impact Plastic sprinklers with water discharge 360-720 lph, placed at 10x10 m distance produced significantly higher yield than 12x12 m distance. Similar trend was also observed for water use efficiency.

Phasic nitrogen requirement of potato under drip and sprinkler irrigation

Nitrogen fertilizer given in two splits 50% at planting+50% at earthing-up/or stolen formation stage gave higher yield (29.2 t/ha) followed by three splits (1/3 at planting+1/3 at earthing-up/ or stolen formation stage+1/3 at 15 days after earthing-up/ or tuber initiation stage) as compared to other treatments tried under drip irrigation. Similarly, the nitrogen applied in two splits 50% at planting+50% at earthing-up /or stolen formation stage gave higher yield (29.4 t/ha) followed by three splits (1/3 at planting+1/3 at earthing-up/ or stolen formation stage+1/3 at 15 days after earthing-up/ or tuber initiation stage) as compared to other treatments under sprinkler method of irrigation. Similar trend was also observed in case of water and nutrient use efficiency under drip and sprinkler irrigation methods.

Role of poly-mulch in conserving soil water, moderating soil temperature and enhancing potato yield under north western hills

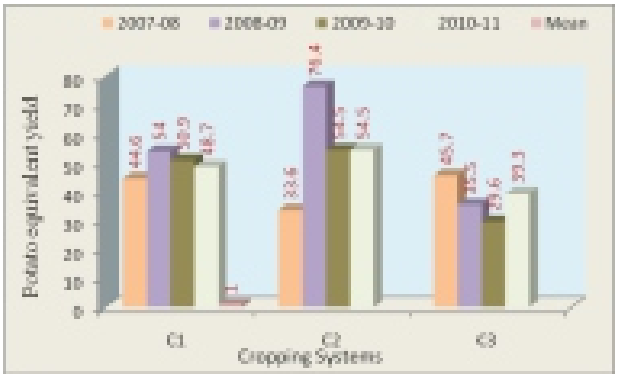
Field trial was laid out during *rabi* season of 2011 at Shimla. Soil moisture contents remained 10 -15% higher in poly-mulch treatment in comparison to no mulch condition during crop growth periods. Soil temperature varied differently under different poly-mulch. Transparent poly-mulch retained heat, thereby increased day time temperature by 4-6°C at 5 cm depth and by 3-5°C at 10 cm depth in comparison to bare soil condition. Black polythene mulch also increased surface soil temperature by 1.5 to 2.8°C at 5 cm depth and 1.2 to 1.5°C at 10 cm depth compared to bared soil condition. On the other hand, silver poly-mulch reduced soil temperature by 0.8 to 1.0°C at 5 cm depth and 0.2 to 0.4°C at 10 cm depth relative to no mulch condition because it reflects most of the incident radiation. Plant height, number of leaves/plant and tuber number/plant were significantly higher under transparent poly mulch in comparison to other treatments. Black poly mulch also showed favorable effect on plant growth parameters in comparison to the silver and no much condition. On an average the extent of increase in tuber yield was in the order of 132.3%, 97.7% and 41.71% under transparent poly mulch, black poly mulch and silver poly- mulch, respectively in comparison to no mulch condition.

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

Long term study on nutrient dynamics in relation to system productivity is the important feature of acropping system. It aims at increasing total production and profits, besides developing practices for sustaining resources over the time, without deteriorating the soil health. The programme aims to study the effect of application of organic manures, crop residues and inorganic fertilizers on crop productivity and quality of produce along with soil health on long term basis in major potato based cropping systems.

Long term manurial and fertilizer experiment on potato based cropping systems

The results of three promising cropping systems viz. C_1: potato–wheat–paddy; C_2: potato–onion-maize and C_3:potato–green gram–sesamum raised since 2006 -07 on same site revealed that the yield of wheat, potato, onion and maize crops were highest where 100% recommended NPK was applied through inorganic fertilizers. However, in case of paddy, green gram and sesamum, yields were at par in organic and inorganic treatments during 2010-11. Application of secondary nutrients along with 100% NPK to potato crop increased the yield of paddy, potato, maize and there was no effect of secondary nutrients on yields of wheat, onion, green gram and sesamum. Among the three systems, the mean highest potato equivalent yield (PEY) of 55.3 t/ha was recorded in maize-potato-onion cropping system followed by paddy-potato-wheat (48.8 t/ha) and sesamum-potato-green gram (37.0 t/ha). In general, PEY of each system decreased over the years. The highest PEY (54.5 t/ha) using inorganic fertilizers was recorded in maize-potato-onion cropping system followed by paddy-potato-wheat (48.7 t/ha). The lowest PEY (39.3 t/ha) was obtained in sesamum-potato–green gram cropping sequence (Fig. 3). The system productivity of inorganic treatments was 40-70% higher than organic treatments.



Where C_1 = Potato–Wheat–Paddy, C_2 = Potato–Onion–Maize, C_3 = Potato–Green gram–Sesamum
Fig. 3, Year wise potato equivalent yield (t/ha) of different potato based cropping systems

Organic farming for potato production

With the objectives to study the impact of organic and inorganic sources of nutrients on soil fertility and its physico-chemical and biological properties and on the quality of crop produce under organic and inorganic sources of nutrients, field experiments were conducted at Modipuram. Vermicompost was found to be a better source of organic manure than FYM. In permanent organic trial, continuing since 2002-03, response to different nutrient options varied with cultivars. The highest tuber yield (47.2 t/ha) from vermicompost was recorded in Kufri Chipsona-3 followed by Kufri Pukhraj (46.2 t/ha), Kufri Bahar (37.9 t/ha), Kufri Chipsona-1 (31.8 t/ha) and Kufri Surya (26.0 t/ha). In case of FYM, the corresponding yields were 40.4, 38.3, 36.0, 35.4 and 24.7 t/ha, respectively. Quality parameters like dry matter, specific gravity,

chip color and surface shining were better when raised organically.

Among the three cultivars, Kufri Surya developed early yellowing/senescence than Kufri Pukhraj and Kufri Bahar, resulting in 38 and 28% lower yields, respectively. The soil analysis revealed that organic manuring increased the electric conductivity, organic carbon, available nitrogen, phosphorus, potassium and DTPA extractable Zn, Cu and Fe, while the pH decreased slightly. The application of nutrients through organic manure and fertilizers did not affect the tuber yields significantly after seven years. In Kufri Anand, the aggregate tuber yield from fertilizers and organic manure was 44.9 and 42.6 t/ha and the corresponding yields in Kufri Chipsona-1 were 34.3 and 34.7 t/ha. The highest yields (47.0 and 35.1 t/ha in Kufri Anand and Kufri Chipsona-1, respectively) were obtained, when 25% nutrients were applied through organic and remaining 75% through fertilizers. The organic potato production in Kufri Khyati, Kufri Bahar, Kufri Chiposna-3 and Kufri Pukhraj was 41.2, 34.9, 31.7 and 29.8 t/ha, respectively.

Effect of different combinations of ferilizers and vermicompost

Tuber yield was maximised in both the cultivars *viz.* Kufri Anand and Kufri Gaurav with the application of vermicompost (25%) + NPK fertilizers (75%). Kufri Gaurav performed better than Kufri Anand.

Effect of bio-fertilizers on tuber production

The use of bio-fertilizers B-5, both with organic manure (vermicompost) and fertilizers, on tuber yield revealed that tuber yield increased significantly only in Kufri Khyati, when raised organically.

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

Among the seven treatments, dry matter content was highest in treatment receiving 100% nutrients through vermicompost, which was at par with treatment receiving 50% organic+50% inorganic and 100% NPK+micro and secondary nutrients. Application of 100% NPK+micro and secondary nutrients increased the potato yield in all three cropping systems *viz*. rice-potato-wheat, maize-potato-onion and sesamum-potato-green gram.

The soil analysis after potato harvest revealed that incorporation of crop residue as well as use of organic manure, with or without fertilizers improved the organic carbon content of soil as well as microbial biomass carbon. The soil analysis after potato harvest revealed that mineral N content was at par in all the three cropping systems, however, there was great difference in organic and inorganic treatments. Incorporation of crop residues slightly increased the mineral nitrogen. The treatment-wise microbiological analysis of rhizosphere of all the three cropping systems after harvest of *kharif* crops revealed that maximum population of bacteria was found when all NPK were applied through organic manure and minimum in control, where no nutrients were applied. In contrast, the maximum population of Actinomycetes was recorded in treatment receiving all NPK through fertilizers along with micro and secondary nutrients. Unlike bacteria, the Actinomycetes population was minimum in organic manure treatment. In general among the three cropping systems, the bacterial population was maximum in potato–green gram–sesamum while *Actinomycetes* were minimum in potato–wheat–paddy cropping system.

For nutrient dynamics studies, treatment-wise soil was analyzed before and after potato harvest after six complete cycles. In potato-wheat-paddy cropping system, except control, there was an increase in soil electrical conductivity in all treatments after potato. Organically treatment plots had more electrical conductivity than conventionally fertilized plots. The soil pH decreased significantly in control after harvest, while no definite trend was recorded in treatments involving different sources of nutrient supply. The present soil organic carbon and available N, irrespective of treatment, decreased after potato

harvest. The reduction was more, where conventional fertilizers were used. In contrast, the available phosphorous and potassium recorded an increase of 15.9–95.7 and 29.2–52.3%, respectively after potato harvest. The available P increase in organic/integrated nutrient supply and inorganic treatments varied from 45.7-95.7 and 15.9–26.5% and the corresponding values for available potassium were 25–52.3 and 23.8–42.5%, respectively.

In case of micronutrients, DTPA zinc recorded 2.3–9.7% decrease, where no zinc was applied. In contrast, treatments receiving zinc either through organic manure or crop residue recorded an increase of 2.3–23%. The copper content of soil decreased by 35% in control, while in other treatments the percent increase varied from 5.6–52.7.

The carbon (C) sequestration study revealed that among the three cropping systems, paddy–potato–wheat and maize–potato–onion showed higher C stocks in soil than sesamum–potato–green gram cropping system. The incorporation of organic amendments (*viz.* vermicompost/crop residue) resulted in higher stock of C as well as C sequestration rate in all the cropping systems (Fig. 4,). In contrast, application of secondary and micronutrients along with 100% NPK produced similar or lesser C stocks than 100% NPK. The integrated application of organic amendments along with fertilizers worked out to be the best management practice for enhancing C sequestration in soil for sustainable crop productivity.

The incidence of severe mosaic, apical leaf curl and hopper burn was recorded on potato crop. The 100%organic plots of potato showed low incidence of severe mosaic, apical leaf curl and hopper burn as compared to 100 % NPK plots of potato or control.

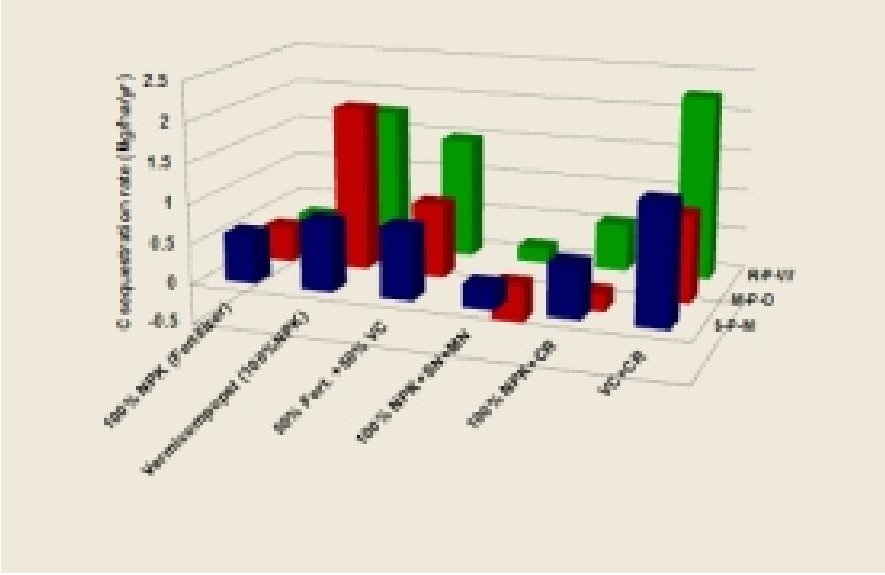


Fig. 4. Impact of nutrient management and cropping system on carbon sequestration rate inInceptisol Where R-P-W= Rice-potato-wheat, M-P-O= Maize-potato-onion and S-P-M= Sessamum-potato-Moong. VC= Vermicompost, SN= Secondary nutrients, MN= Micronutrients and CR= Crop residue.

Climate change impact and adaptation strategies for potato crop

Global temperature is believed to rise by 1 to 3.5^{0}C between now and the year 2100. Global climate change will definitely affect agriculture. Anticipated changes in global rainfall and temperature patterns together with the increase in atmospheric CO_2 will affect the production of crops, including potato, throughout the world. To meet these challenges, this programme was formulated to quantify the effect of climate change on potato in different states/potato growing pockets, study the impact of climate change on incidence of major potato diseases and change in population dynamics of important insects/vectors and develop management strategies to combat climate change threat on potato production.

Model calibration for climate change studies

WOFOST (World Food Studies) crop growth model estimates the growth of an annual crop in a given set of specific soil and weather conditions. The simulation of crop growth in this model is based on eco-physiological processes. The major processes are phenological development, CO_2-assimilation, transpiration, respiration, partitioning of assimilates to the various organs, and dry matter formation. This model is to be used for potential production of potato crop under Indian conditions for impact studies of climate change and also for the development of suitable adaptation strategies. For this purpose, WOFOST was calibrated and validated for long duration potato cultivar Kufri Badshah and medium duration cultivars, Kufri Jyoti and Kufri Bahar. The time course data on potato crop growth parameters generated at Jalandhar during 1999-2000 and 2000-2001 were used for calibration and validation of WOFOST model. The model parameters used for calibration were; AMAXTB (Maximum leaf CO_2 assimilation rate), DTSMTB (Daily increase in thermal time as function of average temperature), TMNFTB (Reduction factor of gross assimilation rate as function of low minimum temperature), DVS (Development stage of crop), FLTB, FOTB, FSTB (Fraction of above ground dry matter increase partitioned to leaves, tubers and stems, respectively, as a function of development stage), SLATB (Specific leaf area as a function of development stage), SPAN (Life span of leaves growing at 35ºC), TEFFMX (Maximum effective temperature for emergence), TSUMEM (Thermal time from sowing to emergence), TSUM1 (Thermal time from emergence to tuber initiation), and TSUM2 (Thermal time from anthesis to tuber initiation).

A close match was observed between simulated and observed results for total dry matter production and tuber dry matter yield (Fig 5). The statistical performance analysis applied to model predictions (Maximum error, Root mean square error, Coefficient of residual mass, Modelling efficiency and Coefficient of determination) also indicated that the performance of model was satisfactory. For estimating the genetic coefficients of Indian potato cultivars, field experiments were conducted at Modipuram (Kufri Sadabahar and Kufri Khyati) and Patna (Kufri Kanchan and Kufri Arun). The crops were planted at different dates and data on emergence, tuber initiation and crop growth (LAI, fresh and dry weight of leaves, stems, tubers and roots) and final yield were recorded at 10 days interval starting from 30 days after planting, till maturity. Climate data (Minimum and maximum temperature, sunshine hours *etc.*) of crop growth period was also recorded on daily basis for entire crop season. This data will be used to calibrate and validate the potato crop growth models.

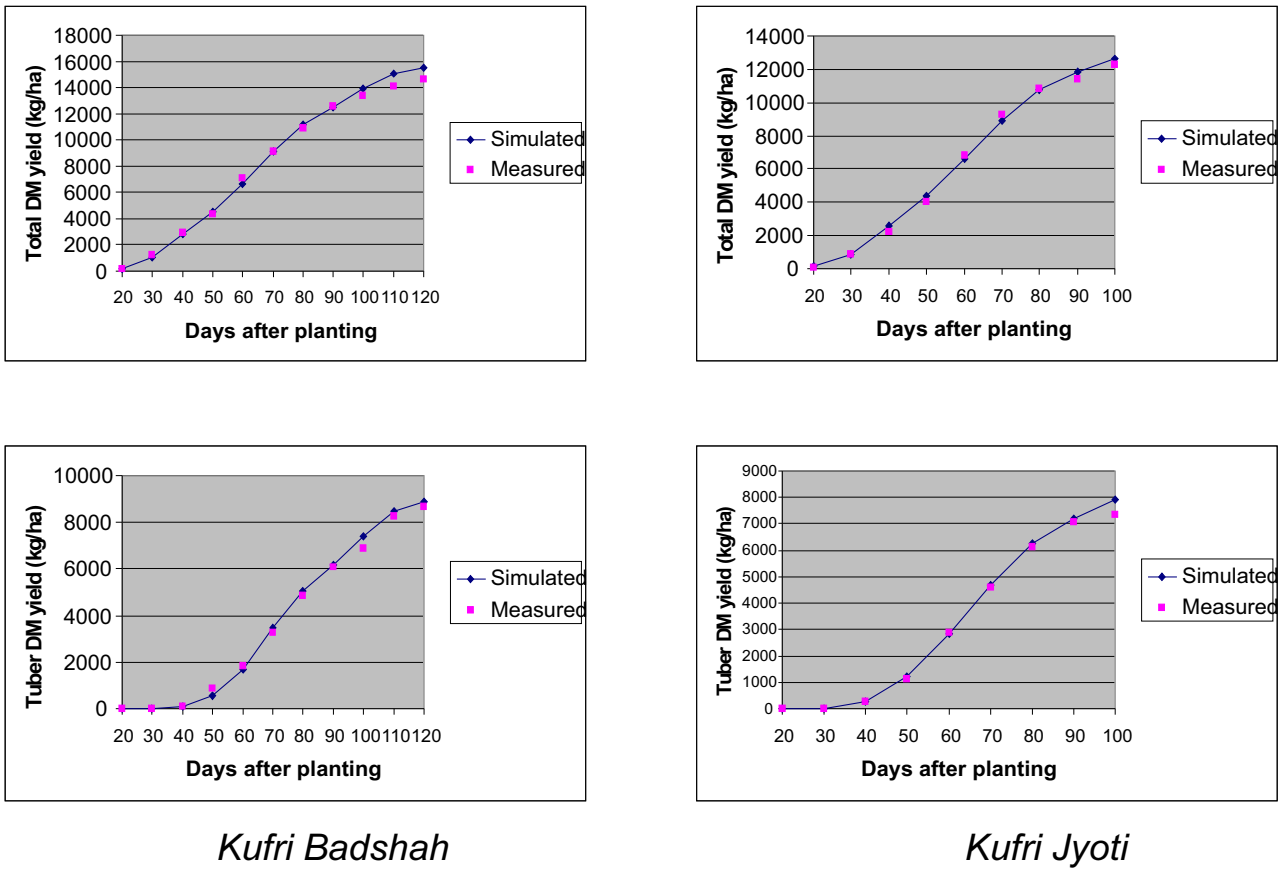


Fig.5, Comparison between measured and simulated total and tuber dry matter yields of potato cultivars.

An experiment was conducted at Modipuram to study the effect of temperature on the epidemiological component of *Phytophthora infestans.* At lower temperature (10ºC) incubation period was more (92 ± 1 hrs) and lesion area was less (0.58 cm^2) while at 20ºC, incubation period was less (26 ± 1 hrs), lesion area was more (8.04 cm^2) and sporulation was also more. A positive correlation was observed between incubation period and lesion area development. JHULSACAST model was also validated at Modipuram during 2011-12 crop season. The probable date for appearance of late blight was between 25th December, 2011 to 3rd January, 2012 and disease actually appeared on 27 December, 2011, hence the model is working satisfactorily for Modipuram conditions.

In a field experiment at Modipuram, observations were recorded on population of whitefly (*Bemisia tabaci*), leafhopper (*A. b. biguttula*), *Aphis gossypii* and percent burning due to feeding of leafhopper and mite in potato crop planted on 5 different dates at 5 days interval starting from 20th September 2011. Leafhopper population was highest during 41 to 46 days after planting in all crops planted at different dates whereas hopperburn started around 20th November. Crops planted on 20th, 25th and 30th September burned completely in 55 days, however, crop planted on 5th and 10th October burned in 60 days, which could be due to falling temperatures later in the season or migration of leafhopper to main crop. The average population of leafhopper remained highest (1.97/leaf) in 25th September planted crop, whereas whitefly population was highest (0.38/leaf) in 30th September planted crop followed by 10th October (0.35/leaf) and 25th September (0.32/leaf) planted crop; *Aphis gossypii* remained highest in 20th September planted and lowest in 10th October planted crop when average minimum and maximum temperatures remained 15.9 and 28.8°C and morning and evening RH were 76.3 and 42.9%, respectively.

Farm machines for potato cultivation

Potato is an input intensive crop and mechanization helps in timely conduct of various farm operations and economizing the cost on labour input. The objectives of the research programme were to develop potato grader, the harvesting and collection systems of tractor operated potato combine harvester, an aeroponic system and potato treatment and handling systems.

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

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

The harvesting and collection system of an experimental 2-row tractor operated potato combine harvester was designed and fabricated; It consists of six major units *viz*. main frame, digging system, elevator conveyor, side delivery/discharge conveyor, power transmission and transport system (Fig.6). The prototype functions to dig out, separate dug tubers from soil mass, conveys, elevates and fill in a trolley. The brief description of each unit is given below.

Main frame: It is rectangular in shape with rear side projected upward and is fabricated using MS channels and MS angles. The sides of the frame are covered with MS sheet. The frame houses and supports the digging blades, differential gear box, elevator rod chain conveyor, shafts of side pulleys, vibrators, main drive sprockets and the pneumatic transport wheels.

Digging system: It consists of two HC steel blades of triangular shape with side discs and a central set of discs, supported with the main frame. The width of each blade is kept 400 mm and blade to blade spacing is kept 600 mm, thus making the prototype suitable to harvest crop planted at 600 mm row spacing. The blades are supported from their lower surface with the main frame with 50x25 mm size curved supports. The stone deflectors system is provided behind the digging blades.

Elevator conveyor: The elevator conveyor is rod chain type similar to that used in the fabrication of potato elevator digger except that it is made extra long with length of 5200 mm, consisting of 135 rods. It is made of 12 mm MS rods with end pressed, drilled and fitted at a spacing of 30 mm from adjacent rods on the 50 mm x 4 ply rubber belt from both sides and also at the centre. The rod chain is supported from the rear with drive supports and from the front with digger pulleys. Two numbers of agitator sets are provided at even interval. The first set with more eccentricity provided more agitation than the rear set with small eccentricity to get better sifting of soil and to reduce roll back of moving tubers. The supports are also provided below the chain to reduce excessive sag.

Side delivery/ discharge conveyor: The tuber collection and lateral conveying system to fill in a tractor trolley of the combine harvester was fabricated and integrated with the prototype harvester. The design consists of a swan neck shaped elevator conveyor, which functions to receive the dug tubers along with the soil mass left with tubers after sifting on the primary conveyor, transports, elevates and drops it in the trolley. It consists of an angle iron frame made of 75x75x9 mm angle iron sections curved at 2 places to give it a Z- like shape. It supports a rod chain conveyor which is made 3900 mm long and 600 mm wide. It is made of 12 mm rods riveted on both sides over a 3 ply and 5

cm wide rubber belt. The spacing between adjacent rods is kept as 15 mm. The rod chain is supported at both ends with the help of specially designed and fabricated 11 teeth and 150 mm diameter sprockets and also in between at both the bends. The rod chain conveyor is provided with supports from upper and lower side. The chain is also supported from below with PVC rollers. The sprockets with special platform is also provided on the first curve to the chain, to tight press the chain and keep the first portion as horizontal. The second portion is provided steep inclination, while the third portion is given mild inclination only. The lateral tuber conveying system as developed separately was integrated from behind the main digging and conveying system of the research prototype. The system is attached to main system with channel and angle iron supports but with nut bolts and is thus kept detachable.

Power transmission system: It consists of a differential gear box which is driven with the PTO of the tractor through a cross. The power is provided from the gear box to the rear of main elevator chain through V- Belt pulley drive. The power to the side conveyor is provided with the help of suitable sprocket and chain arrangement.

Transport system: The transport system of the experimental prototype consists of two pneumatic wheels size 19.6x25 provided at a spacing of 1800 mm. One of the wheel is fitted below the main frame, while the second one if kept off- set and fitted 600 mm from the nearer main side of main frame. The power to the system is provided from the common differential gear box shaft and through chain-sprocket systems. For proper balancing of the machine during field operation and transportation, ground wheel on the right from front was fitted at 1800 mm in place of usual 1200 mm from the other ground wheel for sharing the weight of the projected conveyor. This reduced the chances of overturning of the machine and gave required balancing to the machine system during transport and field operation. The prototype machine was made suitable for operation along with trolley, moving on left side from front for filling of dug tubers, as received from the machine. The important specifications of the experimental research prototype are given in Table 5.

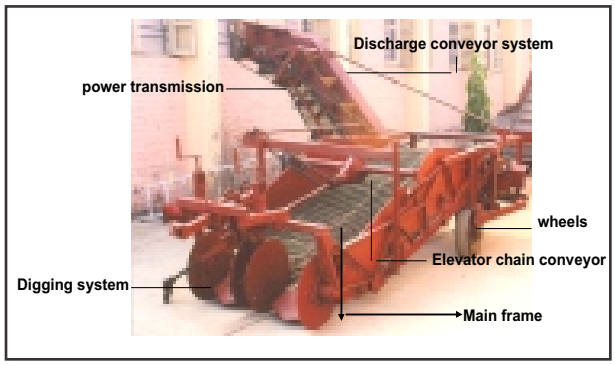


Fig. 6. A view of the experimental tractor operated potato combine harvester

Working : During actual field operation two tractors are required; one to operate the machine and the second one to carry the trolley to receive the dug material. The machine digs out the 2 adjacent potato ridges simultaneously with the help of digging blades or lifter shares. The soil potato mass is passed on to the rod chain type elevator conveyor. The discs set at the sides and in the centre facilitate the flow of dug material to the elevator conveyor. The material is lifted, conveyed and separated from the soil by sifting through the rod gaps. The elevator chain is agitated with the help of eccentric vibrators at two different locations of the chain conveyor. The potato tubers separated from the soil mass are passed on to the side conveyor, also made of rod chain. The material is moved to the side and then taken upward while separating the left over soil. The tubers along with some small soil and trash, gets dropped into the trolley. (Fig. 7)

Testing and field evaluation:

(I) Laboratory testing and improvements: This lateral discharge elevator conveyor was tested for conveying of potato tubers. The conveyor was operated with an experimental set up. The system was operated with an engine at the speed desired in the field. It was observed that the small size tubers were found to be sieved down or got struck in the gap between the adjacent rods of the rod conveyor. It was felt necessary to reduce the gap between rods from 25 mm to 15 mm. This was achieved by attaching 6 mm dia MS rod in between the 12 mm rods provided previously. Upon re-evaluation the system was found to work satisfactorily. The side walls of the conveyor were also found to bruise and cut tubers. The walls were adjusted and refitted with minimum gap from the sides of chain rods conveyor. The sharp edges on the walls were removed. Thus, the tuber damage and bruising by way of compression, shear and penetration were substantially reduced. The digging and conveying system was also tested in the field under simulated conditions to find out effect of chain conveyor inclination on the flow of material. The material flow was found to be smooth. The length of PTO shaft was found some what less which was increased to eliminate its tendency to detach from the tractor PTO during operation and during lifting at turns. The improved system was found to work satisfactorily.

(ii) Field evaluation : The preliminary testing and evaluation of the experimental prototype under the actual field conditions to harvest and collect the early as well as main crop was carried out. There was satisfactory collection with negligible tuber loss even under early crop having weeds and high soil moisture content. The need to improve soil separation and removal of trash was felt and the work was undertaken to improve accordingly. The improved prototype was tested and evaluated in the actual field conditions under different soil and field conditions. The prototype functioned satisfactorily under the sandy to sandy loam soils with optimum soil moisture and weed free conditions at harvest. The performance was adversely affected under weed infested and clod forming soil conditions. It was found that minimum soil cushion is necessary to eliminate tuber bruising. The prototype needs to be improved further for better performance under the different soil and field conditions, to reduce soil and trash and tuber bruising in the final collection. The performance evaluation results of experimental potato combine harvester in fields with different types of soils is given in Table 6.

Fig. 7. Tractor operated experimental potato combine harvester during actual field operation

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

Design and fabrication work of the required number of dies for preparing MS/GI wire square openings for their subsequent use in making square wire meshes for the potato grader, was carried out. The newly fabricated dies abolish the use of hydraulic power press for the wire bending purpose. Bending system of the fabricated dies is made mainly out of high carbon steel. MS wire (8 SWG) when inserted in the die can be easily bent, as desired with the help of a hand actuated lever. The dies can be very easily fitted on any work bench with the help of nuts and bolts and are easily operatable. All the wires so bent with the help of these specially designed and fabricated dies, when assembled together with the help of GI sheet clamps, they get the shape of squares at regular intervals throughout the width of the grading belt. Both ends of the wire belt shall be subsequently clamped together thus making it an endless screen. The work of bending of the wires with the help of these dies (to get the desired shape), has also been initiated. Grader shall consist of the mainframe, grading, conveyor belt and power transmission systems. A survey of the potato

Table 5. Some important specifications of the experimental prototype of potato combine harvester

S. No.	Items	Specifications
1	Type	2-row tractor operated semi mounted type
	Overall Dimensions	
	Overall length (mm)	4250
	Overall width (mm)	3750
	Overall height (mm)	2150
	Ground clearance (mm)	150
	Approx. weight (kg)	1050
	Tractor power requirement (HP)	45
2	Main Frame	
	Length (mm)	3850
	Width (mm)	1370
	Height (mm)	1020
3	Digging system	
	Type	Twin fixed blades with side and central discs
	Blade width (mm)	390
	Disc dia (mm)	470
4	Elevator chain	
	Type	Rod chain conveyor, with provision for shaking of chain with eccentric vibrators, power sprockets, side pulleys
	Chain Length (mm)	5200
	Chain width (mm)	1170
	Number of rods in chain	135
5	Side delivery chain	
	Type	Rod chain conveyor, swan neck type with wooden flights
	Length Total (mm)	4010
	Chain inclination (degree)	42 (max.)
	Width (mm)	590
	Rod gap (mm)	20
	Compartments in chain (No's)	21
	Size of each compartment (mm)	(360x385x 120)
	Height of chain Max/Min (mm)	2150 /520
6	Power transmission	From tractor PTO shaft through differential gear box to chain conveyors using V-belt pulleys (B -124) and chain sprockets
7	Transport system	Machine supported on two pneumatic wheels (19.6x25.0) fitted to main frame 1800 mm apart with right wheel from the rear located 600 mm from right wheel of tractor

Table 6. Performance evaluation results of experimental potato combine harvester in actual field conditions under different types of soils

S No	Item	Soil Type		
		Light	Medium	Heavy
1	Optimum speed of operation (km/hr)	3.0	2.8	2.5
2	Effective field capacity (ha/hr)	0.3	0.25	0.23
3	Soil mass: Potato mass ratio in the collected material	1.5	2.4	5.0
4	Field losses (%)	2.0	1.5	1.3
5	Tuber bruising (%)	8.5	5.5	4.2
6	Labour requirement (Nos.)	4-5	4-5	4-5
7	Tractor power requirement (HP)	35	40	45

graders developed/available in and around Jalandhar, was also carried out. Design work of the major systems of the grader, identification and selection of the materials required for their fabrication was continued. Fabrication work of the improved square wire mesh type of potato grader shall be continued.

Design, development and evaluation of small grader for potato experimental plots and for small farmers

The fabrication work of a potato grader for experimental plots and small farmers was undertaken. Fabrication of the frame, grading and power transmission systems of the grader for potato experimental plots and for small farmers, was carried out. The prototype grader consists mainly of main frame, grading mechanism and power transmission system. The main frame of the grader consists of a rectangular box made from angle iron (Size 50x5 mm & 38X5 mm). For easy transportation of the grader to any desired destination, two pairs of solid rubber lined wheels, shall be provided at front and rear sides of the frame. Grading unit consists mainly of two numbers of grading sieves having 50 mm & 35 mm size square openings made out of 8 SWG MS wire. Wire belt vibrators, consisting mainly of MS rod (25 mm diameter), MS flat (size 38x12 mm) and wooden rollers (size 50x50 mm) provided in both the wire belts render gentle shaking to the wire belts so as to have proper grading and movement of the potato tubers, during operation of the grader. These vibrators have been installed on the frame of the unit with the help of bearings (number 6204) and brackets. Whereas the wire belt having 50 mm size opening moves along the length of the grader, the other wire belt having 35 mm size opening moves perpendicular to it. These grading sieves were properly aligned so as to keep a check on their sideways movement. Wooden rollers (drive and driven) have been fitted with bearings (number 6205) and brackets at appropriate locations in both the grading belts for proper movement and tightness of the grading belts during operation. The driven wooden rollers, provided at the bottom of the grading sieve belt, have been provided with tension springs in order to keep proper tension of the grading belt. One number of GI pipe roller (of pipe diameter 50 mm) has also been fitted on the frame with the help of bearings and brackets (size 6205) for this purpose. One of the wooden rollers (of diameter 150 mm) provided in the wire belt having 50 mm size square opening, receives power from the power transmission system of the prototype through an arrangement of belt and two number of pulleys (of diameters 450 mm and 100 mm) and rotates the grading belt. Rest of the wooden rollers act as driven rollers and keep rotating as the grading belt moves. Power is further transmitted to other grading belt (having 35 mm size square opening), with the help of chain and sprockets arrangement. MS shaft (25 mm size) that receives the power, rotates the grading sieve (35 mm size square opening) with the help of bevel gear arrangement. Bevel gear arrangement provided in the system helps to transmit power at right angles. Wooden/GI sheet fenders are also being provided on the sides of the grading sieves, to avoid spilling of produce. A handle made up mainly of MS flat (size 50X10 mm) and MS rod (diameter 25 mm) has been provided for manual rotation of both the grading sieves. Further fabrication and preliminary testing of the grader is under progress.

Survey to assess the mechanization need of the potato farmers

A survey was conducted to find out the mechanization requirements of potato farmers. The potato farmers of Jalandhar and Hoshiarpur districts of Punjab representing large and medium farmers, respectively, and Kangra district of Himachal Pradesh representing small farmers were surveyed after their random sampling. A proforma was developed to find out the existing status and future needs of mechanization of potato farmers. Farmers were found to face acute shortage of farm labour and were keen to adopt suitable machines that could reduce their labour dependence. About 41% of the farmers were found to use semi automatic planters and 17% more were interested to buy such planters. In case of automatic planters 10% farmers were found to use automatic planter (CPRI design), while looking into the savings on labour and time hence

the cost of operation, a sizeable number of farmers 51% were interested to adopt automatic planter. Among harvesting equipment 61% farmers were found to use elevator digger for potato digging and 20% more were interested to buy such digger. If available 44% of the farmers were found interested to opt for advanced potato digging machines with provision for collection of dug tubers i.e. combine harvester, anticipating substantial reduction in labour and time required for collection of dug tubers. None of the farmers was found to use grader for pre cold storage of potato, but 19% farmers were using grader after cold storage of potato. About 57% of farmers were found interested to adopt grader if found suitable for grading before cold storage. In case of small farmers in hills, 3% farmers were found to use power tiller in potato cultivation. 24% more farmers showed interest to adopt power tiller in potato cultivation. The farmers opined that power tiller can be more useful if suitable and low cost attachments for various operations in potato crop are made available.

Development of farm machines and systems for seed potato cultivation

Comparison of different grow boxes for aeroponic system

Two aeroponic systems developed from locally available materials were compared for potato mini tuber production in soilless environment. Both the systems had common nutrient solution tank, pump, cyclic timer and identical nozzles. Difference was in the design and materials used for fabrication of grow boxes. First type of box was made from 50 mm thick thermocol sheet from all the sides, bottom and top. Box was lined with black polythene sheet from inside and were covered with black poly sheet at the top as well. Second type of box consisted of polythene sheet from all the four sides. Top of this box was provided with a non reacting black fabric sheet of thickness 2-3 mm and bottom was supported with a corrugated asbestos sheet below polythene.

An experiment was conducted under net house conditions. Variety Chipsona-3 was raised in both the systems. In polythene box 30.9% more number of tubers were obtained as compared to thermo box when all the conditions were similar (Table 7). This seems to be because of difference in temperature variation in root zone of different systems. Root zone temperature variation was observed quicker in polythene boxes followed by thermocol box and it was least in soil.

Table 7.Crop performance in different grow boxes under aeroponics

Parameter	Thermo box	Poly box
Variety	Kufri Chipsona-3	Kufri Chipsona-3
Duration of crop	19 November, 2011 to April, 2012	19 November, 2011 to April, 2012
Survival of micro plants	100%	95%
Root initiation (DAP)*	4	4
Tuber initiation (DAP)	37	37
Average root length (50 DAP)	45.6 cm	43.1 cm
Av. plant height (50 DAP)	60.5 cm	61.2 cm
Total number of pickings	11	11
Average no. of MT**/plant	55	72
Average weight/MT**	4.26 g	3.40 g
Avg. weight of MT/plant	234.3 g	244.8 g

*** DAP-Days after planting, ** MT- Mini tubers**

Development of system for loose handling and treatment of seed potatoes

Fork lift assisted handling and treatment of potato in plastic trays involves a lot of human labour, of course less than complete manual work with jute bags. To reduce the human labour requirement and increase the rate of work and efficiency of man and machine, new pallet was designed for loose handling of potato. This pallet was tested in actual working conditions. During testing a major short coming was observed in platform opening mechanism. Opening was non uniform from both the ends and it was dropping potatoes on floor in heaps. Pallet design was improved by modifying the opening and closing mechanism. System was tested again in actual working conditions after incorporating modifications. Improvement was observed in terms of uniform opening but still there was certain portion of tubers which didn't flow down and got stuck in between two floor parts. Also tuber bruising was observed while washing and treatment. Pallet needs further improvement and testing.

Division of Plant Protection

Management of late blight

Population structure, epidemiology and management of Phytophthora infestans

Potato late blight appears in almost entire potato growing areas in India. However, with change in climate, it has been observed during last few years that the disease is appearing late in the season both in the hills and plains causing limited yield losses. The pathogen is known to change quickly and adapt to the new environmental conditions including host resistance. Therefore, it is a matter of time that *Phytophthora infestans* mutates and develops new races and cause epidemic. Hence, it becomes imminent to track the changing pathogen as well as durability of host resistance genes vis-à-vis climate change. Besides, new chemicals need to be identified and spray schedules devised as part of integrated disease management essentially based on a comprehensive disease forecasting and decision support system.

The disease appeared on 27th June, 2011 on cv. Kufri Jyoti in Shimla hills with 50-90% severity. In Meerut it appeared on 27th December, 2011, on cv. Kufri Bahar with 5-10% severity while in Punjab it appeared on 15th December with 0.1% severity in village Budewadi, district Hoshiarpur. A survey was conducted during 11-15 January, 2012 in western and central districts of UP where the severity ranged from 5-95% highest being in Mainpuri district. As per the status of mating types is concerned, the frequency of occurrence of A1 mating type was cent percent in western and central plains (Punjab, Rajasthan UP and Bihar) while frequency of A2 mating type was cent percent in hills and plateau regions. The results of prevalence of physiological races revealed that the pathogen population consisted of most complex races (11 genes). Analysis of *P. infestans* populations collected from different parts of the country for metalaxyl sensitivity revealed that a total of 83% population in Meghalaya and 80% in Tamil Nadu exhibited tolerance up to 400 ppm, 100% in Bihar, 67% in Rajasthan, 60% in Assam, 56% in Karnataka and 28% in Himachal Pradesh exhibited tolerance up to 300 ppm, while 67% population in Punjab and 10% population in UP exhibited tolerance up to 200 ppm. A set of population from Himachal Pradesh, UP and Uttarakhand was characterized for mt DNA haplotying and observed that 100% isolates belong to mt DNA Ia haplotype (Fig.1) meaning that the new population introduced during

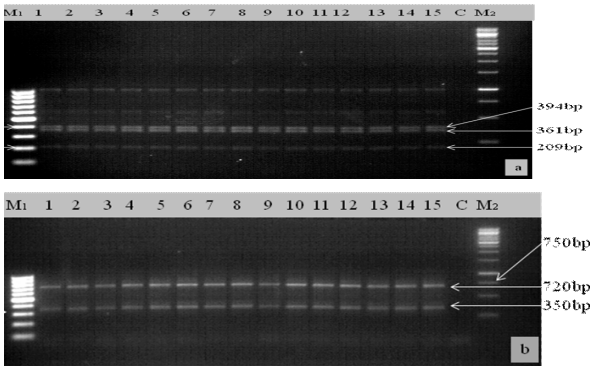


Fig.1. Restriction digestion of PCR products amplified from P. infestans isolates with primer pair (a) P4+ EcoRI, and (b) P2+ MspI. Lane: M1- 100bp gene ruler and M2 1KB, Lane: 1-15 - P. infestans isolates, C-negative

2002 has displaced the old population at least in the isolates of present study. Fifty seven isolates of *P. infestans* collected from Himachal Pradesh over three years (2008-10) were analyzed using 14 SSR markers. A total of 146 polymorphic bands were obtained that were analyzed by NTSYS-pc. Maximum similarity of 90% was observed between the isolates Pi09H22 & Pi09H23. Cluster analysis at 60% similarity separated 57 isolates into 20 clusters (Fig. 2). No association between year of collection or origin of place was obtained which indicated that genetic diversity level of *P. infestans* population was very high.

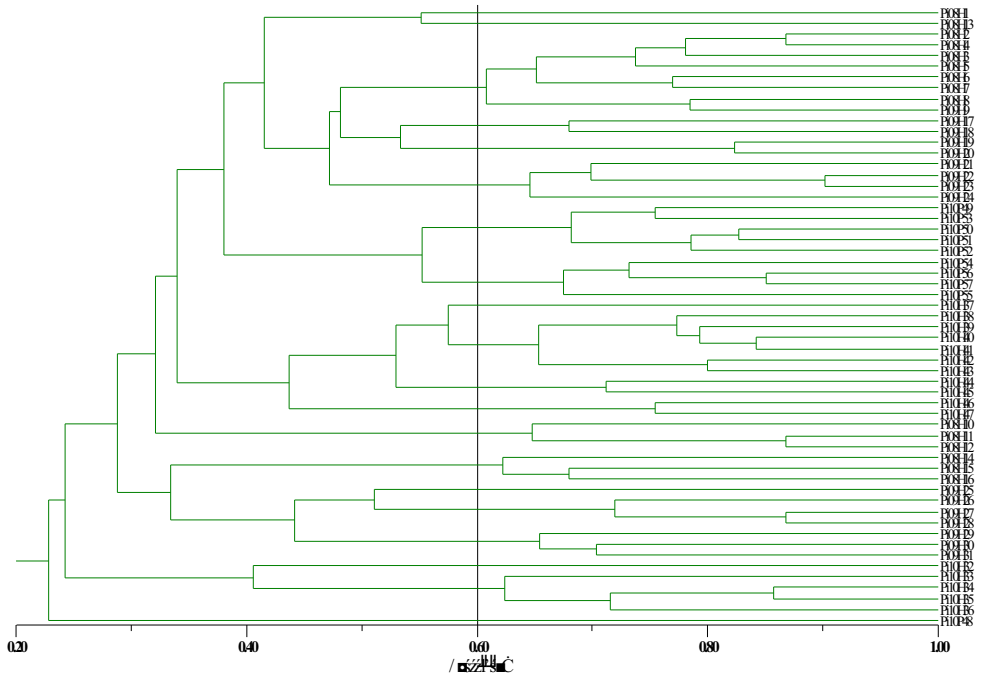


Fig. 2. Dendrogram of P. infestans using SSR marker

Aggressiveness and host speficity

The aggressiveness of *P. infestans* isolates sampled from potato and tomato fields was determined through cross-inoculation experiments *in vitro.* Data for incubation period (IP) and latency period (LP) revealed that there were no significant effects of isolates, host or isolate x host interaction. No host specificity to potato and tomato within the *P. infestans* populations was observed. Irrespective of the origin of the isolates, larger lesions were produced on potato than tomato. Highest lesion size (4.74 cm^2) on potato was produced by isolate Jht11-1 followed by HP10-71 (4.32 cm^2), a tomato isolate. On tomato, maximum lesion size (2.93 cm^2) was produced by the isolate HP10-71 followed by HP10-72. In general, isolates collected from tomato fields produced more lesion area on either of the hosts than the isolates collected from potato fields.

Determination and quantification of *P. infestans* inoculum in soil

It is well established that oospores can survive in the soil where both mating types can co-exist and can reproduce sexually giving rise to more virulent races able to break host resistances. Therefore, the pathogen needs to be tracked even in the soil to devise screening and breeding strategies to control late blight. Hence, PCR protocol published earlier was validated in artificially infested soil and up to 20 oospores per gram of soil could be detected (Fig. 3).

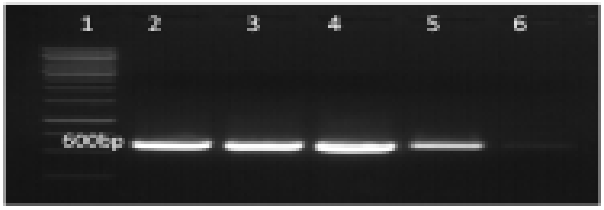


Fig. 3. Detection of P. infestans oospores/g soil with primers INF FW2/ REV Lane 1: Marker, Lane 2: 50 oospores, Lane 3: 40 oospores, Lane 4: 30 oospores, Lane 5: 20 oospores, Lane 6: 10 oospores

Disease epidemiology

JHULSACAST model was once again validated during the current crop season. The model forecasted late blight appearance during 25 December, 2011 to 3 January, 2012 and blight actually appeared on 27th December, 2011. A Decision Support System developed earlier was also validated. The results revealed that the software based fungicidal applications showed less severity than recommended spray schedule. An equation to predict yield losses due to late

blight developed earlier was validated in this crop season. Results revealed that deviation between observed and predicted yield loss ranged from 0 to 9.69%.

After successfully predicting late blight appearance under Modipuram conditions, it has been decided to extend this model to other potato growing regions in the country. Therefore, an attempt was made to validate the model with minor modifications under Punjab conditions by using the data from Jalandhar w.e.f. 1997-98 to 2007-08. The model successfully predicted disease appearance coinciding with the actual date of disease appearance in all the years demonstrating that JHULSACAST can be successfully used in Punjab conditions also.

Disease management

Host resistance forms the backbone of any Integrated Disease Management programme. However, the changing climate especially higher temperatures during the crop season may threaten the efficacy of the R-genes imparting resistance. Therefore, an experiment was conducted to examine the performance of R-genes at elevated temperatures under controlled conditions. Results revealed that lesion area was more in R1 and R1.2.3 genes carrying differentials clearly demonstrating that resistance can break down if the pathogen adapts to higher temperatures and cause infection.

Varietal specific chemical management of late blight is needed according to the level of varietal resistance. In this effort, three different combinations of fungicides with six treatments were tested on two cultivars i.e. Kufri Bahar and Kufri Badshah. Amongst these, treatment combination of chlorothalonil–cymoxanil-Metalaxyl based was highly effective on cv. K.Bahar and K. Badshah before the appearance of late blight while same treatment was less effective when applied after appearance of disease. Micronutrient boron was tried with different combinations of fungicides for management of late blight and one of the combinations *i.e*. Metalaxyl - 1.5 kg/ha + boron 700mg/L (3sprays) gave positive results. However, these results need to be confirmed in the next crop season.

Bio-control agents are the only source for management of diseases in organic potato farming. In this context, two isolates of *Pseudomonas aeruginosa* were tested and found promising for bio- control properties tested against *P. infestans* under in vitro studies i.e. detached leaf method and tuber slices method. Besides, two plant species were also found highly effective for late blight management *in vitro.*

Management of late blight with single control measure is very difficult due to fast spreading nature of the pathogen. Therefore, an experiment was conducted for integrated management of late blight. Among 10 treatments, treatments combination- *Bacillus subtilis* (B5) +*Trichoderma viride* (before disease appearance) - Cymoxanil based (at disease appearance) and subsequently *Bacillus subtilis* (B5) +*Trichoderma viride* spray was highly effective with lowest disease severity (14.5%) compared to control (87.5%).

Multiplication and preliminary screening of Avr3a (RNAi and amiRNA) transgenic

siRNA and amiRNA encoding *Phytophthora infestans* effector Avr3a gene was transformed into cv. Kufri Pukhraj and Kufri Khyati by *Agrobacterium* mediated transformation method. Putative transformants were multiplied *in-vitro* and analyzed by Reverse transcriptase polymerase reaction (RT-PCR). Based on RT-PCR analysis, 12 and 7 lines were positive for nptII gene (amplicon size of 750 bp) for both the Kufri Pukhraj and Kufri Khyati, respectively. In case of amiRNA transgenic plants (amiRNA2 construct transformed Kufri Khyati) 12% lines showed the amplification for the nptII gene (750 bp).

Late blight infected field at Mainpuri (UP) during 2011-12

Breeding cultivars for multiple disease resistances for Indian hills and plateau region

The breeding programmes at the Institute were able to develop and deploy blight resistant varieties for different potato growing regions at regular intervals ever since the establishment of the Institute. But the pathogen could overcome these resistances by developing new matching virulences as elsewhere in the world and the durable resistance still remains elusive. Based on the experience so far, a new consensus has emerged that both major and minor genes are required to provide durable resistance. It has been amply demonstrated at molecular level also that both major and minor genes are same part of the genome and if genes are combined together in a single host back ground will lead to higher level of resistance, which may be durable also. Besides, there is a need to develop varieties with region specific multiple disease resistances. The conventional breeding at the institute had been strengthened with marker assisted selection and is expected to develop such varieties in few years.

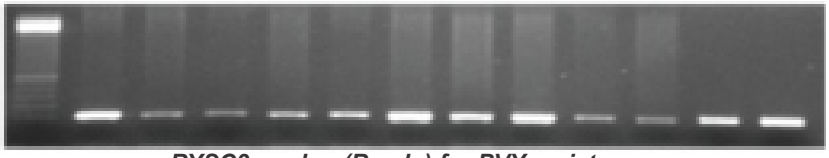
About 62,550 hybrid TPS were produced from 49 successful crosses between selected late blight resistant parental lines at Kufri/ Shimla/ Shillong. During the period under report, 16,800 seedlings from twelve crosses were screened against late blight and 2066 resistant ones were selected for further evaluation under field conditions. The highest number of resistant seedlings were obtained in the cross CP-2379 x SM/94-44

(21.3%) followed by CP-3776 x CP-2407 (19.0%), CP-2370 x SM /94-44 (17.0%), SM/95-43 x K. Himalini (16.4%) and CP-2011 x LBY-17 (15.2%). At harvest 506 clones were obtained at Shimla and 850 clones have been selected from 28 crosses based on tuber characteristics and resistance to late blight at Shillong. In preliminary generations (F_1C_1-F_1C_5), 619 hybrids were evaluated and 124 hybrids were selected. In advanced generations, 10 hybrids were evaluated and all hybrids were retained for further evaluations. Four hybrids with three controls were evaluated in a replicated trial at Kufri and three hybrids i.e. SM/03-13, SM/03-45 and LBY-2 yielded significantly higher than the best control Kufri Girdhari and were at par in resistance with the best control. Four LBY hybrids along with advanced hybrid, SM/92-338 were evaluated at Modipuram for adaptability along with Kufri Jyoti, Kufri Bahar and Kufri Sadabahar as controls. The results revealed that hybrid, SM/92-338 produced significantly higher yield than the best control Kufri Bahar. Besides, three LBY hybrids with combined resistance to late blight and PVY viz., LBY-15, LBY-17 and LBY-24 yielded at par with the best control. Based on their consistent performance over the years, three advanced hybrids i.e. LBY-15, LBY-17 and SM/92-338 were introduced into AICRP (P) for multi-location trials. At Shillong, 11 hybrids with 3 controls were evaluated and ten were retained for final yield evaluation. Similarly, at Ootacamund, seven hybrids were evaluated with Kufri Girdhari and Kufri Jyoti as checks. Among them, 2 hybrids viz., SM/02-07 (57.9t/ha) and SM/02-01 (51.5t/ha) out yielded the best control K. Girdhari (40.5t/ha). The performance of the hybrid SM/02-07 was superior in yield and field resistance to late blight during the previous year also.

126 clones of the mapping population (SC) developed upon crossing diploid wild species *S. spegazinii* (SS 1725-87) x *Solanum chacoense* (SS 1671-1) were maintained in the glass house at Kufri. The DNA fingerprinting of advanced hybrids has been completed using ten SSR markers i.e. Stu 6, Stika, STM007, STINHW, STM0037, STM1052, STM1053, STM1104, STM0031 and STM5121.

Multiple disease resistance breeding

Late blight and other biotic stresses viz. viruses and nematodes are causing yield reduction. Therefore, the present day cultivars need to be fortified with multiple disease resistances which so far were difficult to achieve through conventional breeding methods owing to the tetrasomic inheritance in potato. However, with the advent of reliable molecular markers, it is now feasible to combine multiple resistance genes using Marker Assisted Selection (MAS) in the breeding programmes. Following this strategy at CPRI, Shimla molecular markers, RYSC-3 & 4 (SCAR) for potato virus Y; TG689 and Gro1-4 for *Globodera rostochiensis* pathotype Ro1, 4 and HC (SNP) for *G. pallida* pathotype Pa 2/3 were first validated in the respective germplasm accessions. Later, 165 genotypes consisting of parental lines, commercial cultivars and advanced stage hybrids were screened using these markers. 18 genotypes with Potato Virus Y resistance gene (Ryadg), 84 genotypes with late blight resistance genes (R1 and R3a) & 79 genotypes with cyst nematode resistance genes (HC, H1 and Gro1-4) were identified. Besides, sixteen potato genotypes (10 germplasm accessions: CP 2067, CP 3771, CP 4039, CP 4042, CP 4046, CP 4047, CP 4052, CP 4054, CP 4055, CP 4056; 3 commercial cultivars :Kufri Jawahar, Kufri Sherpa and Kufri Alankar; three advanced potato hybrids:MP/97-625, MP/97-921 and MP/04-578) were also identified possessing multiple (at least two) resistance genes for late blight (R1 and R3a-Fig.4), Potato Virus Y (Ryadg) & cyst nematode (HC, H1 and Gro1-4 Fig.5). These genotypes are being used as elite parental lines in resistance breeding programmes and the selections are being effected based on markers in the initial generations. Finally few selected hybrids will be challenge inoculated for confirming the resistances. Simultaneously, these elite parental lines have been inter-crossed to combine multiple resistance genes into single host background.



RYSC3 marker (Ryadg) for PVY resistance

R_1 AS marker for late blight resistance

Fig. 4. Markers associated with PVY and late blight resistance

R3a-1380 marker for late blight resistance

HC marker for G. pallida Pa 2/3 resistance

Fig. 5. Markers associated with late blight and cyst nematode resistance

Molecular characterization, detection and management of potato pathogens

Maintenance and mass multiplication of potato viruses for antisera production

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

Screening of germplasm accessions for virus resistance through DAS-ELISA

Fifty nine germplasm accessions were planted in the glass house and screened for resistance to PVY and PVX through mechanical inoculation followed by ELISA. Out of which, 12 germplasm accessions were found having combined resistance to PVX and PVY. Seventeen and nine accessions showed resistance to PVY and PVX, respectively.

Virus testing of potato samples

Three hundred leaf samples of fourteen varieties of M/s Technico Agric Science Pvt. Ltd., four *in-vitro* samples of three potato varieties from Horticulture Training Institute, Uchani, Karnal and 1580 leaf and *in vitro* samples of M/s Pepsico India Holding were tested for the presence of PVX, S, Y, A, M, PLRV, CMV, PMTV, TMV, TNV, TRSV, TSV, TSWV, PYDV by DAS- ELISA and PSTVd by RT-PCR. All the samples were found negative to the viruses and viroid. Twenty six samples from Seed Technology Division were tested for PALCV through PCR and for PLRV, PVX, PVY and PVS through RT-PCR. All were found negative for PLRV and PVX but four samples were positive for PALCV, 17 for PVY and all the 26 for PVS. Twenty five samples received from CPRIC, Modipuram were tested for PALCV and PVY and twenty samples received from CPRS, Patna for PALCV through PCR. Fifteen mericlones of potato were tested for potato virus A by RT-PCR received from Crop Improvement Division and eight lines were found positive. Seven mericlones of LBY-17 from Crop Improvement Division were tested by RT-PCR for the presence of PVS. All were infected with Potato virus S.

Post entry quarantine testing

Seven potato varieties of M/s Technico Agri Science Pvt. Ltd., 76 *in-vitro* potato cultures and 96 TPS samples of Crop Improvement Division and ten potato varieties of M/s Mahindra and Mahindra Pvt. Ltd. were planted in the quarantine glass house for expression of symptoms, if any, and also tested in laboratory for the presence of PVT, PYDV, AVB, APMoV, APLV, TRV, TRSV and *Clavibacter michiganensis* ssp. *sepedonicus* through ELISA kits. All the cultures were found free from above listed quarantine pathogens. All these samples were also tested for PSTVd through RT-PCR. All the tested samples were found free except seven *in-vitro* and five TPS samples of Crop Improvement Division.

Validation of dipstick assay for the detection of different potato viruses

Dipstick kits for PVX and PVA were supplied to regional stations and AICRP centres for validation. So far the test result have been received from five

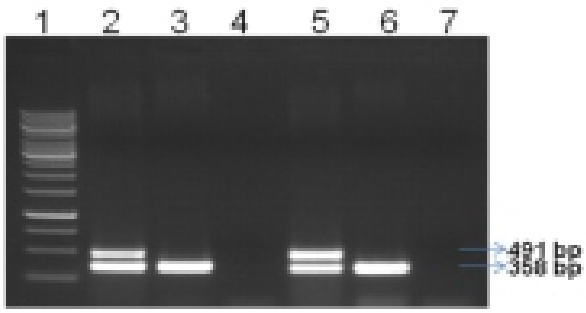
centres viz., Bhubneshwar, Faizabad, Gwalior, Deesa, Kalyani and the results are being collected and compared with DAS-ELISA.

PCR protocols for detection of potato viruses

The polymerase chain reaction (PCR) is a powerful technique for detecting very small quantity of potato viruses in plant tissue. An attempt was made to standardize the robust PCR protocol for the detection of Potato virus A in infected plants. Three sets of primers w.r.t. coat protein (CP) were designed using Primer3 Input (version 0.4) software. Gradient PCR was performed with different primers (three sets) with varying annealing temperature i.e., 54°C, 56°C, 58°C, 60°C and 62°C by using thermal cycler to select the best primer with its annealing temperature. Out of these primers one set of primer and annealing temperature of 62°C showing expected size of band in the infected samples without any non-specific bands in healthy control was selected. Selected primer set was validated by checking across 15 mericlones under micro propagation in CPRI. Wherein only specific band in positive control, no band in negative control was found and eight mericlones were found positive. Hence, this primer set was selected for detection of PVA in infected plant tissues.

Similarly for detection of Potato virus M (PVM) by RT-PCR, four sets of primers w.r.t. coat protein (CP) were designed using Primer3 Input (version 0.4) software. Gradient PCR was performed with different primers (four sets) with varying annealing temperature i.e., 56°C, 58°C, 60°C and 62°C by using thermal cycler to select the best primer with its annealing temperature. Out of these primers one set of primer and annealing temperature of 62°C showing expected size of band in the infected samples without any non-specific bands in healthy control was selected. Selected primer set was validated by checking across 26 lines under micro propagation in CPRI. Wherein only specific band in positive control, no band in negative control was found and specific band in different lines were found positive. Hence, this primer set was selected for detection of PVM in infected plant tissues.

The PCR protocol for PALCV detection was validated with eighty infected samples from eleven different potato growing states and forty suspected samples from Modipuram and Patna. The PCR primers could detect the virus in symptomless micro plants also. PCR analysis may sometimes lead to false negative results primarily due to presence of inhibitors in DNA preparation or human error. Co-amplification of plant internal control would help in resolving this discrepancy. Urease gene from potato was used as internal control and developed a duplex PCR protocol for effective detection of PALCV (Fig. 6). The integrity of the amplicons from duplex PCR analysis, 491 bp (CP region) and 358 bp (Urease gene) fragments were confirmed by sequencing.



Lane 1. 1Kb ladder, Lane 2, 5- Infected sample, Lane 3, 6- Healthy sample, Lane 4, 7 Water control

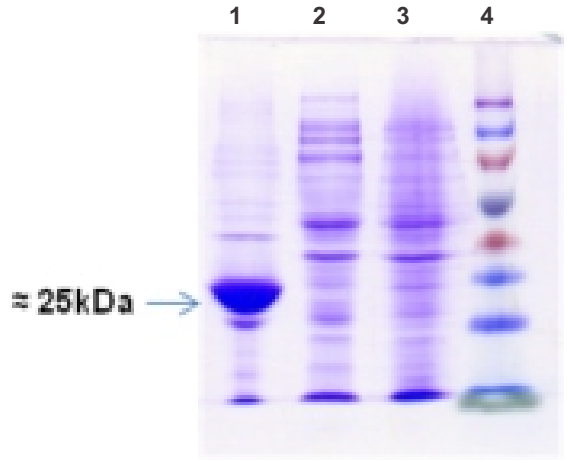
Fig. 6. Duplex PCR detection of PALCV with urease gene of potato

Real time PCR for detection of potato viruses

Ordinary PCR based protocols are incapable of accurate quantification of virus load in infected tissues. On the contrary, Real-time PCR also known as quantitative PCR (qPCR), offers an accurate and rapid procedure to quantify virus concentration. Accurate quantification is necessary for carrying out experiments on host resistance, vector transmission, epidemiological studies etc. It can also distinguish between different strains of a virus and even can detect point mutations in the virus genome. The major advantage of real-time PCR is that analysis of resulting products using gel electrophoresis is not required. This means that real time PCR can be implemented as a high-throughput technique for sample screening. Real Time PCR protocols based on TaqMan chemistry have been standardized for Potato spindle tuber viroid.

Recombinant coat proteins for antisera production

The coat protein gene of PVX was amplified using gene specific primers with restriction sites and proof reading enzyme. The amplified products were purified and restricted to generate cohesive ends for ligation into the expression vector pET-28a(+). The ligated products were used in transformation of *Escherichia coli* strain BL21 by heat shock method. The recombinant colonies were identified through colony PCR and finally confirmed through sequencing. Over expression of these recombinant clones was carried out by using inducer Isopropylthio-ß-galactosidase (IPTG). Expression of coat protein of PVX was observed as insoluble fraction in SDS-PAGE analysis of crude protein extract of recombinant *E. coli* expressing coat protein gene of PVX (Fig. 7).



Lane 1. Insoluble fraction, Lane 2. Soluble fraction, Lane 3. Uninduced culture, Lane 4. Protein marker

Fig. 7. SDS-PAGE analysis of crude extract of E. coli expressing coat protein of PVX

Production of antibody against CP protein of PALCV and PVY

Purified CP protein of PALCV and PVY was injected in rabbits at weekly interval for antibody production and the serum was collected after booster injection. IgG was purified from the serum and was labelled with alkaline phosphatase enzyme by conventional method to prepare ELISA kit. In Checker board method 1:100, 1:200 and 1:500 dilutions of both IgG and IgG enzyme conjugate was used to find out the titre of the antisera. The antisera reacted with PALCV and PVY in DAS-ELISA up to 1:500 dilution.

Transgenic for virus resistance

Potato apical leaf curl is emerging as a serious disease problem in the vast Indo-Gangetic plains of India. The virus causing this disease belongs to Geminiviridae and is similar to tomato leaf curl virus. Since no conventional source of resistance to this virus is available in potato, transgenic approach is being pursued to develop resistant variety. The replication-associated protein gene (AC1) of the virus is being used for engineering pathogen derived resistance in two popular potato cultivars Kufri Pukhraj and Kufri Badshah. Six lines from each construct were selected for further evaluation in the glass house through grafting. Three replicates of each transgenic line were kept and two of them were successfully grafted with one replicate of each line serving as a control. Transgenic plants showed varied resistance against PALCV as compared to untransformed control plants. One line of GTLC2 (GTLC2-127) (Fig. 8), and three of the KPLC2 (KPLC2-37, KPLC2-44, KPLC2-53) transgenic lines showed complete resistance (Fig. 9). Among GTLC1 lines, four lines showed moderate resistance and all KPLC1 transgenic lines showed attenuated symptom or delayed symptom development (Fig. 10) and three showed moderate resistance. But none of the line was completely resistant to infection. Symptom expression was noted and viral load in each plant was quantified by real time RT-PCR analysis of the CP gene using TaqMan assay. The real time PCR analysis was repeated three times and average Ct (Threshold Cycle) value was calculated.

Fig.8. GTLC2-127 showing resistance as compare to non transgenic control plant.

Fig.9. KPLC2-37 transgenic plant showing resistance as compared to non transgenic control plant.

Fig. 10. KPLC1-5 showing susceptible phenotype.

Calculation of copy number of AC1 gene in PALCV transgenic plants

Only lines which showed resistant phenotype in the glass house were selected for copy number estimation. Based on the TaqMan reaction the SDS 2.4 Software (Applied Biosystems) was used to detect the accumulation of PCR product by fluorescence detected during each PCR cycle. Copy number was quantified in terms of cycle threshold Ct with respect to a house control gene Elongation factor 1-alpha. Reproducibility of the experiment was confirmed by repeating in triplicate, which further validated the accuracy and stability of our experiment. Copy number varied from 8 (GTLC2 127) to 3(GTLC2 90) per tetraploid genome of potato.

Comparative genome analysis of potato pathogens

The coat protein gene sequences of eighty PALCV isolates were manually corrected and phylogenetic analysis was performed and compared with the sequences of other geminiviruses (Fig.11). Eight isolates from Jalandhar (1), Modipuram (2), Haryana (1), Hisar (1), Gwalior (1), Deesa (1) and Faizabad (1) were selected for whole genome sequencing based on the variation in coat protein gene region. RCA was performed with templiphi kit to amplify the DNA A and DNA B components and the products were digested with Xba I enzyme and cloned in pUC18 vector. The recombinant colonies were selected by blue-white selection by X-gal-IPTG and further confirmed by colony PCR and restriction digestion. The clones were sequenced through primer walking in ABI 3500 genetic analyzer.

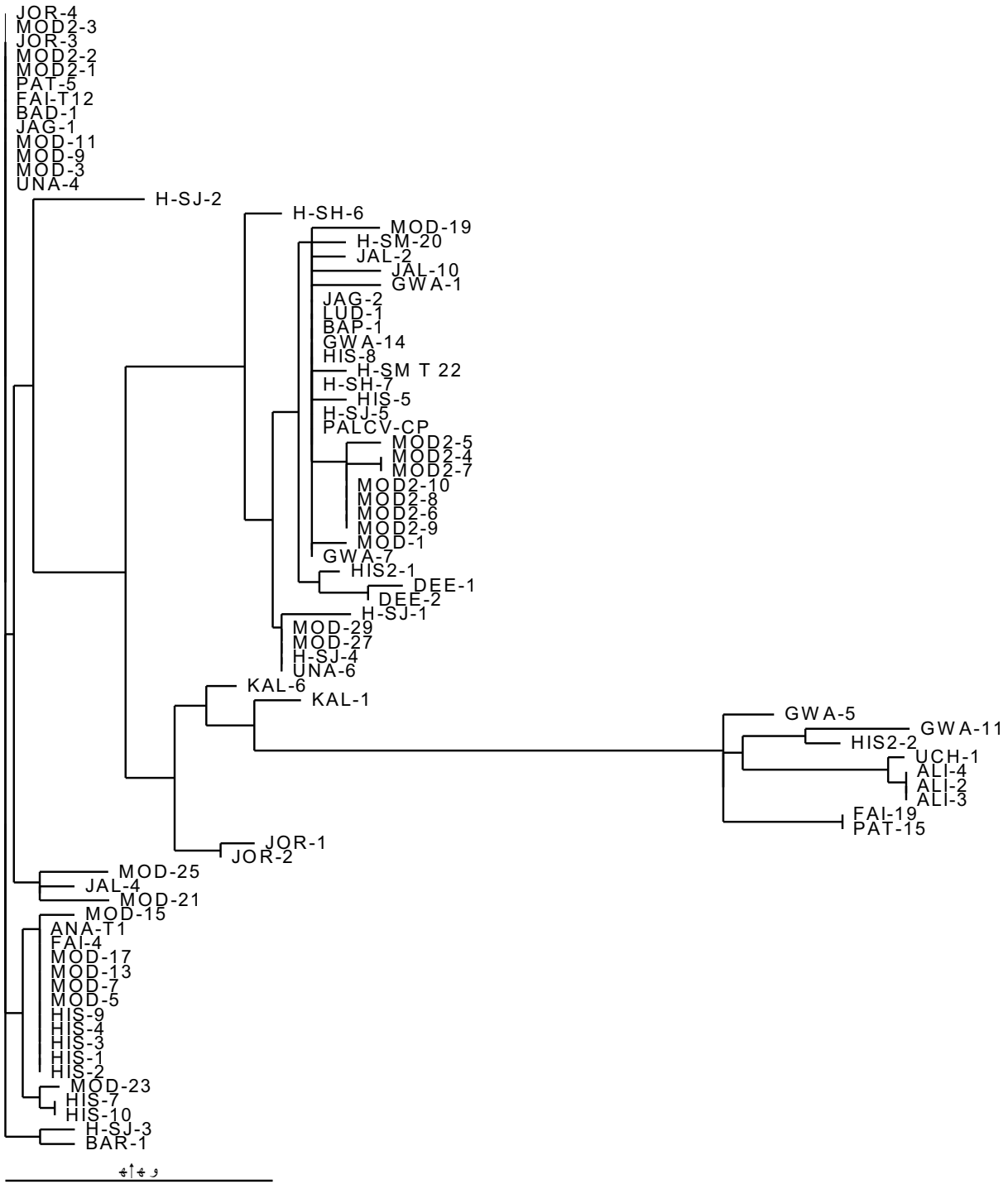


Fig. 11. Phylogenetic tree of eighty isolates of PALCV collected from different potato growing region of India

The tubers maintained in glass house showing the symptoms of tuber necrosis was tested for PVY and found positive w.r.t PVY and the same has been further sequenced and subjected to BLAST and found 99% homology with PVY^{NTN}. Potato virus A (PVA) and Potato virus M (PVM) coat protein gene has been sequenced and was analysed by BLAST and found hitting only with PVA and PVM, respectively.

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

Soil and tuber diseases of potato such as bacterial wilt, common scab and black scurf are major tuber borne diseases prevalent in different parts of the country and affect quality and marketability of the produce. Bacterial wilt of potato caused by *Ralstonia solanacearum* is limiting potato production in many parts of India. Understanding local pathogen diversity is the foundation of successful disease management programme. Therefore, the present study was undertaken to determine the genetic diversity of *R. solanacearum* causing bacterial wilt, *Rhizoctonia solani* causing black scurf and *Streptomyces* spp. causing common scab diseases of potato. Characterization of anastomosis groups of R. solani in India is not well understood. The current study was also aimed to sequence the ITS-5.8S rDNA region of *R. solani* in isolates representing different potato growing regions and place them into AGs based on alignments with existing rDNA sequences of *R. solani*. Common scab is spreading in major potato growing regions of the country. Present study was aimed at isolation and collection of *Streptomyces* species from major potato growing region, their molecular characterisation, identification and study variations of different *Streptomyces* strains to different level of moisture. There is a need to develop seed priming formulations which can be applied to seed tubers to take care of major potato tuber borne diseases, manage sucking pests and increase yield as a single capsule treatment. Many suitable formulations were prepared and evaluated in field trials to achieve this objective.

Characterization and detection of tuber borne pathogens of potato

A total of 39 isolates of *Ralstonia solanacearum*, 13 isolates of *Rhizoctonia solani* and 40 isolates of *Streptomyces* species were collected from different parts of the country, purified and maintained in the laboratory for further study. A total of 48 isolates of *R. solanacearum* collected during the year 2010 and 2011 were characterized into biovars on the basis of their ability to utilize disaccharides and to oxidize hexose alcohols. The study revealed that 87.5% belonged to biovar 2 (i.e. race 3), 6.25% to biovar 3 (race1) and 6.25% to biovar 4 (race1) of the pathogen. The biovar 2 was dominant in Madhya Pradesh, West Bengal, Meghalaya and Odisha whereas biovar 4 and biovar 3 were encountered only in Himachal Pradesh at a ratio of 50:50.

Identification and phylotype affiliation of 90 isolates of *R. solanacearum*, collected during 2009 to 2011, determined through multiplex PCR (Pmx-PCR). The study confirmed all the isolates to be *R. solanacearum* as expected 280-bp fragment resulted in all the isolates following PCR amplification using the *R. solanacearum* specific universal primer 759/760. Further the Pmx-PCR also revealed that phylotype I (Asian), phylotype II (American) and phylotype IV (Indonesian) were prevalent in India. Of these, 65.6% isolates belonged to phylotype II, 30% to phylotype I and 4.4% to phylotype IV (Fig. 12).

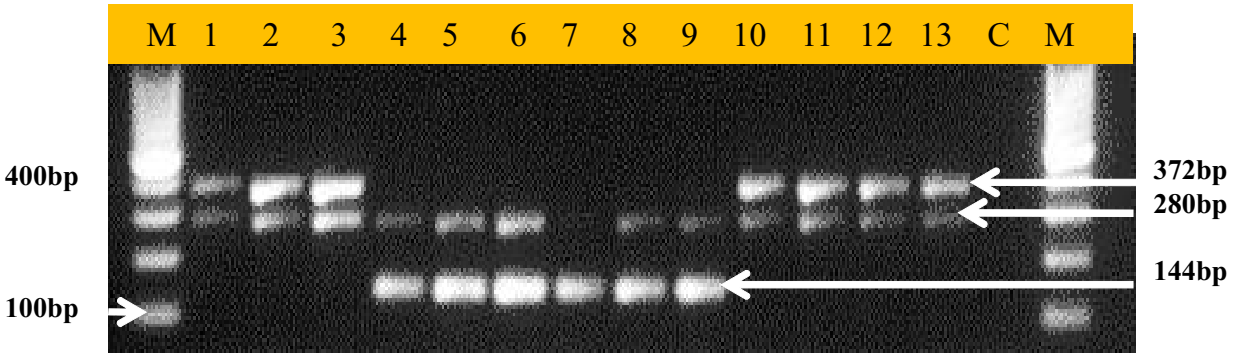


Fig. 12 . Pmx-PCR using phylotype-specific primers showing PCR products of 280bp (i.e. R. solanacearum) amplicons for all thirteen isolates, 144bp (i.e. phylotype I) for six isolates from Himachal (lane 4-9) and 372bp amplicons (i.e. phylotype II) for three isolates from Meghalaya (lane 1-3) and four isolates from Madhya Pradesh (lane 10-13)

All the phylotype II strains were further identified as sequevar I (R3bv2) because the characteristic R3bv2 specific 278-bp band was amplified using the primer pair 630/631 (Fig. 13).

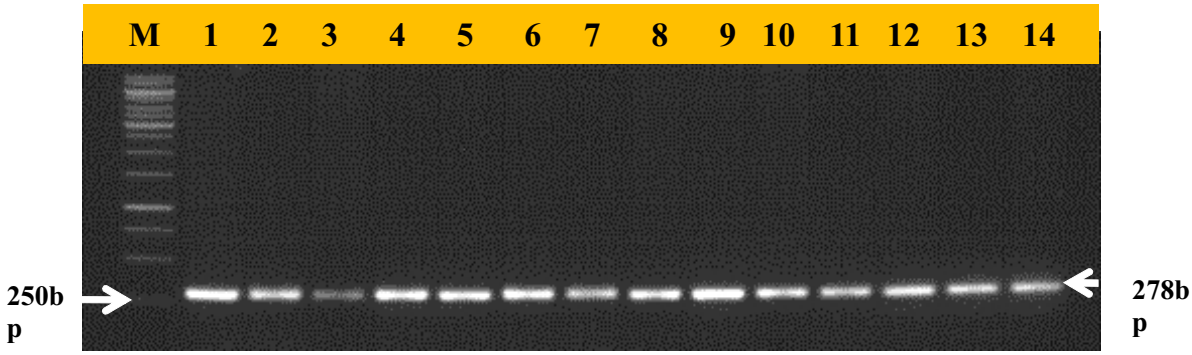


Fig. 13. PCR amplification of 278bp race 3 biovar 2 (r3/bv2) specific fragment using the primer pair 630/ 631 (Lane M=1 kb ladder, lane 1-14= representative isolates of R. solanacearum belonging to phylotype II

Amplification of egl and hrpB region of thirty five isolates of *R. solanacearum* DNA was done using EndoF/ EndoR primers for egl gene and hrpBf/ hrpBr primers for hrpB region. The PCR amplification generated a single band of the predicted size, i.e. 850bp for egl and 1434bp for hrpB genes. Partial egl and hrpB gene sequences were generated of 35 *R. solanacearum* strains to produce the phylogenetic trees (Fig. 14 & 15). Sequences from reference strains were added to the trees in order to position the new strains within the known phylogenetic structure. The phylogenetic position of the strains was entirely consistent with their phylotype on the basis of Pmx-PCR, and 630/631-PCR. All strains that clustered with the reference strain FJ561168 amplified the expected target strand with the primer pair 630/631 specific for the potato brown rot pathogen. The phylogenetic analysis clearly distinguished strains clustered in phylotype I, II and IV.

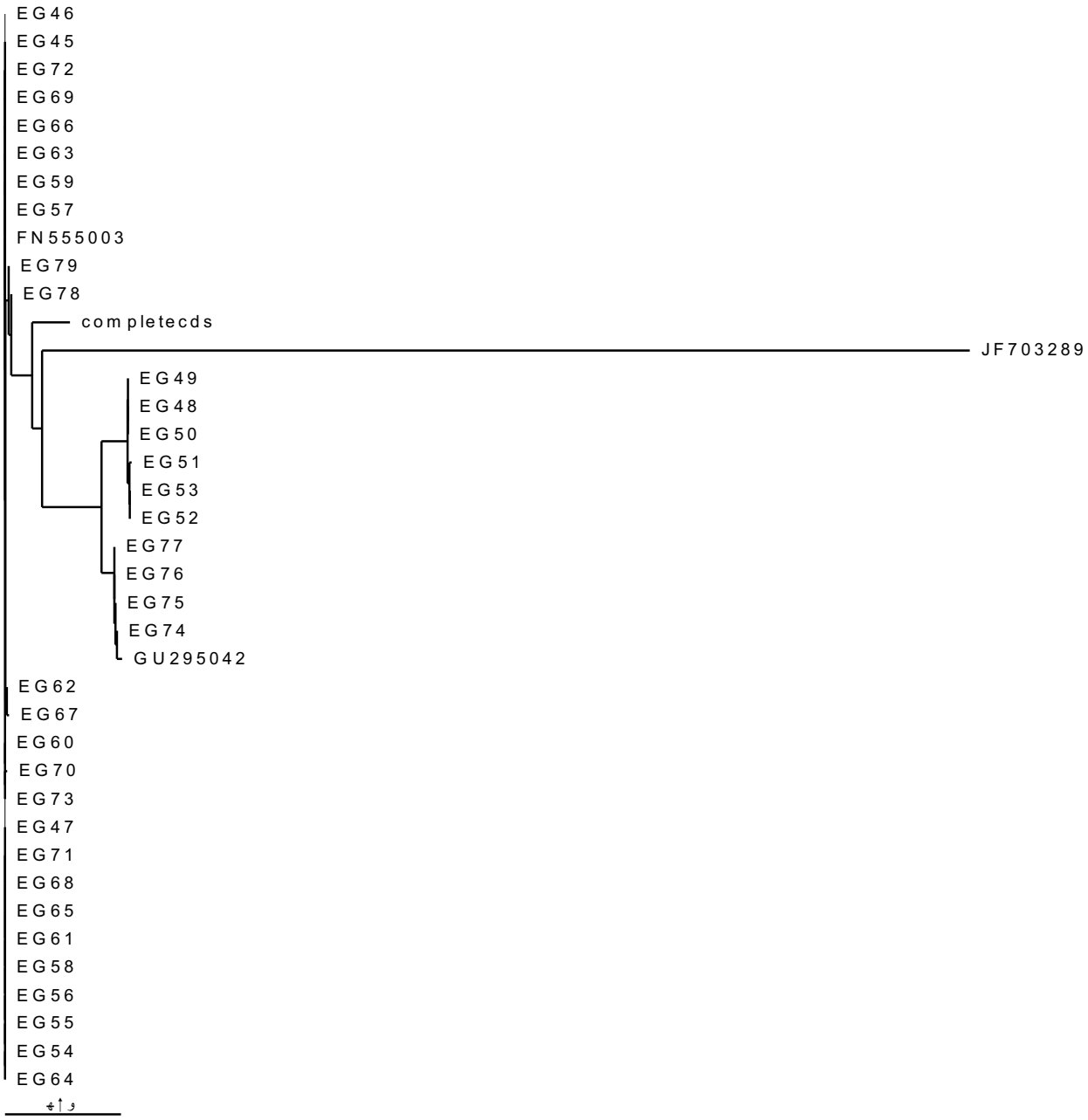


Fig. 14. Phylogenetic analysis based on the partial endoglucanase (egl) gene sequences of 35 strains of Ralstonia solanacerum

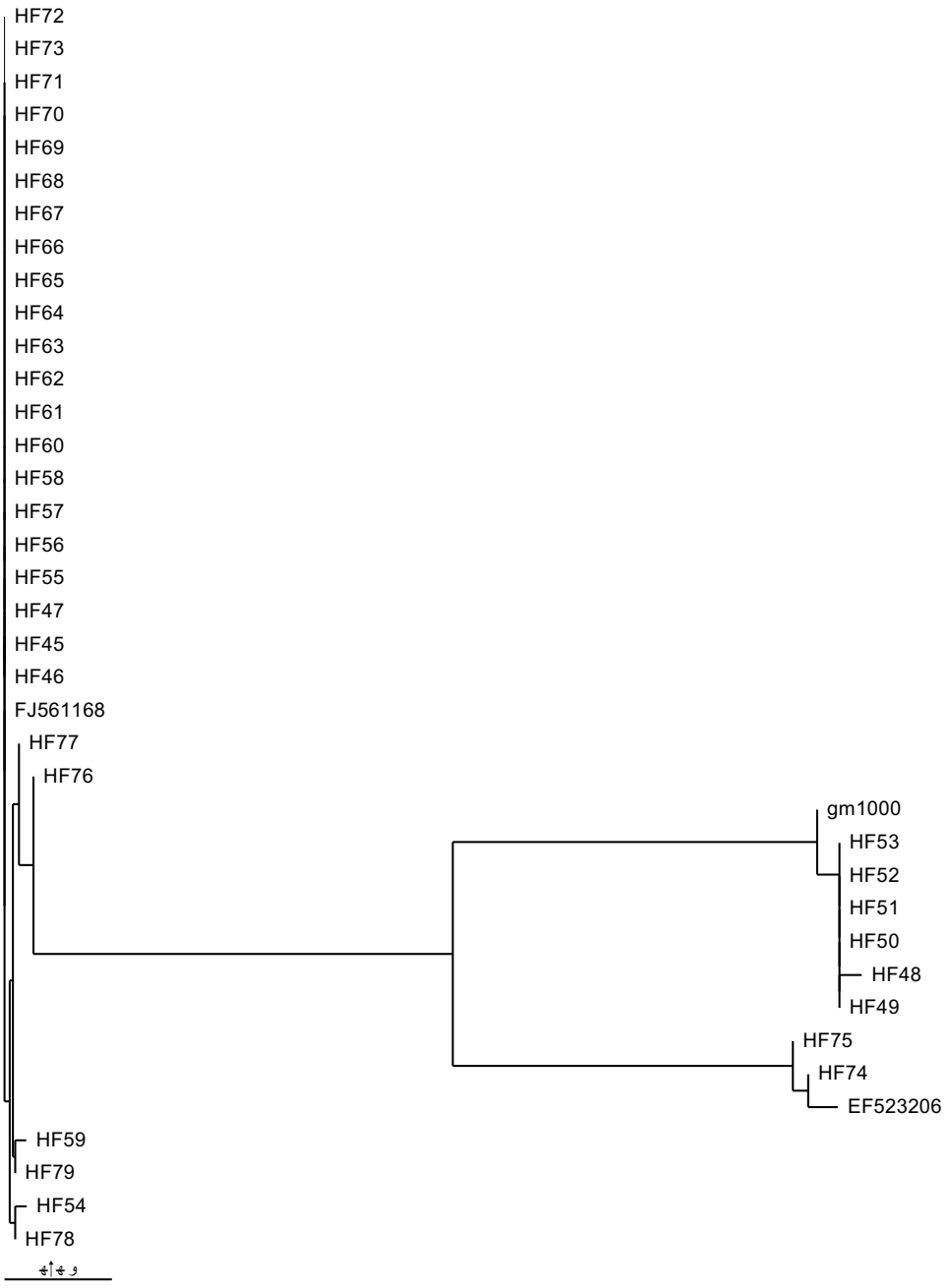


Fig. 15. Phylogenetic analysis based on the partial endoglucanase hrpB gene sequences of 35 strains of Ralstonia solanacerum

Taqman real time PCR protocol was standardized based on the 280bp sequence information of amplicon of *Ralstonia solanacearum*. The protocol could detect the isolates belonging to phylotype I and II but could not detect phylotype IV because of slight variation in nucleotide sequence in probe region (Fig. 16).

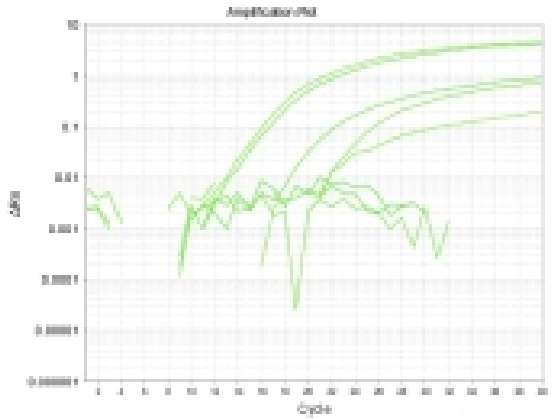
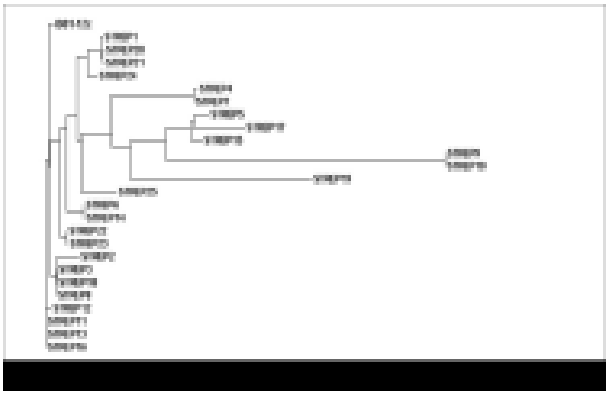


Fig. 16. Real time PCR detection of Ralstonia solanacearum isolates belonging to different phylotypes

Total genomic DNA was extracted using Plant Genomic DNA Mini Prep kit (Gen EluteTM, Sigma Life Sciences) following the manufacturer's guidelines. Amplification of the nuclear rDNA region of ITS including 5.8S rDNA of forty *R. solani* isolates showed 80.0 to 87.3 % similarity to the isolate ST 11-6 from potato (EF532825) and 74.9 to 82.4 % similarity to tobacco isolate (AB000004) both of which belong to anastomosis group, AG-3. Though all the isolates belong to AG-3, considerable variation was observed within the isolates. Per cent similarity within the forty isolates was from 81.1 to 97.5 % and they formed six different subgroups.

Common scab samples were collected from different parts of Bihar, Uttar Pradesh, Himachal Pradesh and Shillong. Isolation of *Streptomyces* was standardized with Starch Casein Agar culture media. PCR run with universal primer of 16s RNA of *Stretpomyces* (F:-5′ CATTCACGGA GAGTTTGATCC-3′ and R: 5′-AGAAAGGAGGTGATCCAGCC-3′) revealed that all the isolates belong to *Streptomyces* genus. Three pathogenicity primers viz. TxtAB (5′-CCACCAGGACCTGCTCTTC-3 and 5′-TCGAGTGGACCTCACAGATG-3′), Nec1 (Nf:5′-ATGAGCGCGAACGGAAGCCCCGGA-3′ and Nr: 5′-GCAGGTCGTCACGAAGGATCG-3′) and Tom A (Tom3: 5′-GAGGCGTTGGTGGAGTTCTA-3′ and 5′-TTGGGGTTGTACTCCTC- GTC-3′) were used to identify TxtAB gene responsible for the secretion of thaxtomin (phytotoxin), Nec 1 responsible for necrotic symptoms on the potato tubers and Tom A responsible for pathogenicity in potato tubers. Majority of the isolates (20) possessed Txt AB+, followed by nec1+ (5 isolates) and tom A+ (3). Specificity of the isolates determined using strain specific primers *viz*, *S. stelliscabiei, S. acidiscabies, S. turgidiscabies, S. aureofaciens* and *S. scabies* revealed that out of 25 isolates maximum (12) belonged to *S. stelliscabiei* followed by *S. scabies* and none belonged to *S. acidiscabies*, *S. turgidiscabies*, and *S. aureofaciens.*



Management of major soil and tuber borne pathogens of potato

Incidence of brown rot ranged between 5 to 10% in East Khasi hills districts of Meghalaya. Incidence was higher in fields where farmers used their own seed and local varieties. Incidence of common scab ranged between 0 to 23.7% in Meghalaya. Disease incidence was observed both in local varieties such as La Polin, Lah Arpor and Lah Saw Khasi and other varieties such as Kufri Chipsona 1 and Kufri Megha. Disease was observed in 9 out of 21 fields surveyed in Bihar. The incidence varied between 29 to 51% with disease severity ranging from 11.3 to 40.5%.

Eight seed priming formulations were prepared and evaluated in a field trial to manage potato tuber borne diseases, sucking pests and increase yield as a single capsule treatment. A combined treatment with *Bacillus subtilis* (@ 8g/kg seed) +*Trichoderma viride* (@ 4.5g/kg seed) + PSB (@12.5g/kg seed + Hoagland solution in vermiwash + 1.5% Boric acid +0.04% imidacloprid was effective for control of black scurf but significant declined crop emergence at 15 and 22 days after planting and resulted in decline in yield

at harvest. Among other alternatives a combination of 0.06% oxystrobulin + 0.006% thiomethoxam resulted in maximum control of black scurf and a significant increase in yield. This was followed by 1.15% pencycuron + 1.0% imidacloprid. These components can be used in development of the seed priming formulation.

Formulations which can control tuber diseases at par with 3% boric acid and also are safe to be applied to seed tubers at the time of planting were developed through combination of phosphorus acid, *Bacillus subtilis*, *Trichoderma viride*, zinc sulphate, Manganese sulphate and low dose of boric acid and evaluated in a field trial. Out of 20 such combinations evaluated, a combination of 0.1% phosphorus acid + 2% boric acid or combination of 2% boric acid +0.2% zinc sulphate + 0.05% manganese sulphate could control black scurf disease at par with 3% boric acid and in addition did not affect crop emergence when applied at the time of planting and thus has the potential to replace the 3% boric acid.

Pencycuron is an effective chemical used by many farmers for control of black scurf. To find out most economical dose and method of application the chemical was evaluated in different levels and methods in a field trial. The results revealed that a spray of 0.25% pencycuron (22.9%) on potato tubers at planting was the most economical and effective for management of black scurf disease of potato.

A study carried out with two strains of *Streptomyces* spp. under three moisture regimes revealed that strain *Streptomyces* STR-1 caused higher disease (Disease Incidence 3.01% and Disease Severity 0.60%) under high moisture regime than the moderate (DI 1.6%; DS 0.32%) and low moisture regimes (DI 1.12% and DS 0.19%). The strain STR-2 caused more disease under moderate moisture (DI 6.8% and DS 1.38%) but low disease under high (DI 3.9%% and DS 0.6%) and low moisture regimes (DI 0.53% and DS 0.10%). The observations indicate that strainal variations exist in *Streptomyces* spp in tolerance to soil moisture and the aspect needs further study to develop suitable recommendation for management of the disease

Population dynamics and management of potato pests

Monitoring of aphids (Myzus persicae & Aphis gossypii), whitefly

Monitoring of *Myzus persicae* was done on forty varieties planted in third week of October. *M. persicae* recorded in the first week of December (max. temp. 25.2°C and min. temp. 10.7°C) and crossed the critical level. Cultivars Kufri Ashoka, Kufri Badshah, Kufri Lauvkar, Kufri Girdhari, Kufri Himsona, Kufri Kuber, Kufri Neela and Kufri Shailja were among the few which recorded no population till third week of December. Kufri Chandramukhi, Kufri Chipsona-2, Kufri Kundan, Kufri Safed, Kufri Sheetman, Kufri Swarna, Kufri Alankar, Kufri Bahar, Kufri Pushkar, Kufri Sadabahar and Kufri Sherpa were the ones which had 20 aphids/leaf in first and second week of December 2011.

Whitefly infested crop

Aphid infested crop

The monitoring of *Aphis gossypii*, *Myzus persicae*, whitefly and leafhopper was done on Kufri Sadabahar planted in main season and results revealed that the population of whitefly and leafhopper continued to decline in December and January while that of *A. gossypii* increased till mid-December and then declined till third week of January and again started to increase after January. It was *M. persicae* which continued to increase December through January.

Management of potato pests

Efficacy of two chemicals i.e. Emamectin benzoate 5SG at CPRIC, Modipuram and Abamectin benzoate 1.9 EC at CPRS, Gwalior was tested against mites. Emamectin benzoate (5%SG) when sprayed after 24 days of planting at 3 doses (144, 192, 240 gm/ha) resulted in no symptoms of mite burn even after 30 days of spray as compared to control. Similarly, two applications of abamectin benzoate @ 1.25 ml/litre of water recorded lowest mite burn (2.63%), which was at par with abamectin benzoate (7.2 ml a.i./ha, 0.75 ml/l).

Foliar spray of thiacloprid (4ml/10lit) resulted in effective control of whitefly, leafhoppers and aphids. The efficacy was further improved when summer oil was added to thiacloprid.

White grub infested potato tubers

Apical Leaf Curl Virus

Hopperburn in unprotected crop

Management of potato nematodes

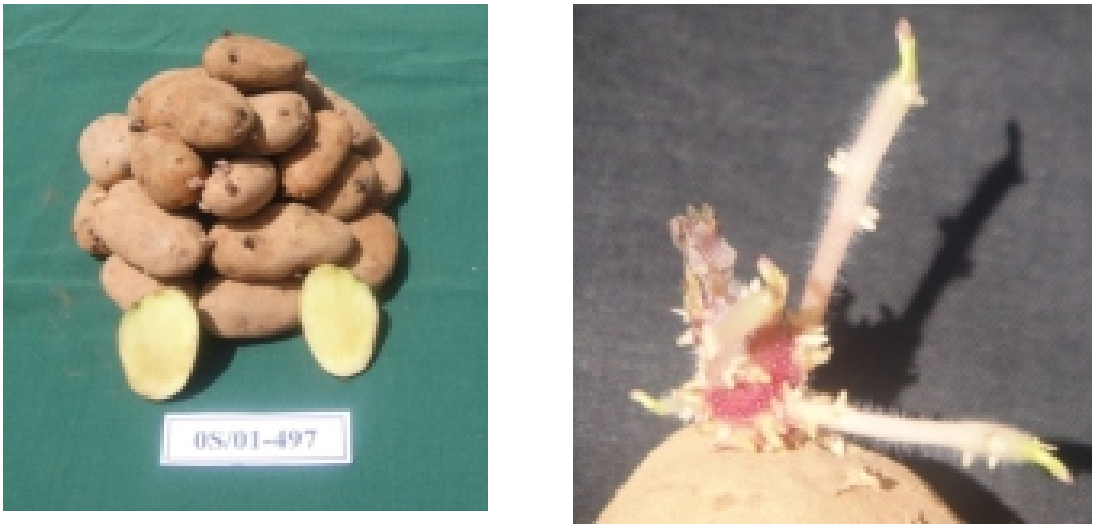
Potato cyst nematodes (PCN) *Globodera rostochiensis* and *G. pallida* and late blight (LB) disease, *Phytophthora infestans* are the major biotic constraints for potato cultivation in The Nilgiris region. These problems are managed by integrating pesticides, host resistance and alternating crop sequences. The programme aims at development of integrated nematode management package including host resistance and various management options for PCN combined with suitable agronomic practices to increase the potato production in The Nilgiris.

Breeding for combined resistance to late blight and potato cyst nematodes

During the year, 50,500 hybrid TPS were produced from 20 bi-parental crosses involving selected late blight and potato cyst nematode resistant parents. Nine thousand five hundred seedlings belonging to 7 cross combinations were transplanted in field /poly house and screened under natural conditions of late blight. On maturity the seedlings were harvested and 545 selections were made. In initial evaluation trials, one thousand three hundred and forty hybrids were evaluated in observational rows/single hill along with K. Girdhari and K. Swarna as check varieties. Of these, 591 hybrids were selected. Forty one advance generation hybrids were evaluated in five replicated trials along with Kufri Girdhari and Kufri Swarna as checks. Of these, thirty two hybrids were selected on the basis of agronomic traits and resistance to potato cyst nematodes and late blight. Five top yielding hybrids were: OS/06-5 (61t/ha); OS.01-497 (42t/ha); OS/05-155 (42.2t/ha); OS/01-161 (39.9t/ha) and OS/94-I-126 (34.5t/ha) as compared to the best control K. Girdhari (32.2t/ha).

Introduction of hybrid into AICRP

The promising hybrid OS/01-497 found to be consistently performing during the previous years was introduced into AICRP for multilocation tests in Nilgiris. It is a cyst nematode and late blight resistant hybrid with oval white tubers with yellow flesh (Fig.17). The hybrid yielded 25.4% higher than K. Girdhari.



Tubers *Sprout*

Fig. 17. Promising hybrid – OS/01-497

Evaluation of physical, cultural and chemical management options against PCN

Soil solarisation integrated with neem cake + *Trichoderma viride* recorded 64.99% increase in potato yield and 61.22% decrease in nematode multiplication. PCN multiplication was reduced by 58.08% and potato yield was increased by 54.11% in soil solarisation + carbofuran treatment.

Effect of biofumigation was evaluated by incorporation of brassicaceous crops viz., cabbage, radish and cauliflower residues on PCN multiplication. Incorporation of radish leaves @1 kg/m^2 with polythene covering recorded maximum yield of Kufri Giriraj and minimum PCN multiplication and was on par with carbofuran treatment. It was followed by other treatments with cabbage and cauliflower where covering with polythene sheets was more effective than those left uncovered (Fig.18).

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

As trap crops for PCN, *Solanum tuberosum* cv. Kufri Jyoti (susceptible to PCN) and Kufri Swarna (resistant to PCN) were evaluated in two spacings (60 x 20 cm^2 and 45 x 15 cm^2). The susceptible K. Jyoti (60 x 20 cm^2) attracted more juveniles than resistant K. Swarna and recorded 53% reduction in cyst population. K. Swarna recorded 32% reduction in cyst population. In the succeeding crop K. Girdhari, K. Jyoti as trap crop recorded 49.8 % increase in yield (Fig. 19).

In order to know the current status of PCN in The Nilgiris district and its population dynamics in various cropping systems, a survey was conducted in June, 2011 and all the major potato growing Taluks viz., Ooty, Coonoor, Kotagiri and Kundah, were surveyed. Forty six villages were covered and around 64 farmers were contacted. It was observed that PCN was prevalent in all the localities. However, the intensity varied mainly depending on the altitude and the number of potato crops taken up in a year. In Ooty taluk, very high intensity of nematodes (> 101 cysts/ 100 ml soil) was recorded in most of the villages surveyed except a few viz., Kookkal, Kaguchi, Iduhatti, Kodhumudi, Chinnacoonoor and Kadanadu which recorded from medium to high intensities. The mean number of cysts in potato-potato-potato cropping sequence was 489 per 100 ml soil. Leaving the land fallow for one season and growing of potato for one season in rotation with beet root/cabbage/beans for the other season recorded the minimum population of PCN as 50 cysts per 100 ml soil (Fig. 20)

Evaluation of cropping systems and agronomic practices on PCN

When K.Giriraj was intercropped with Broad beans, 1:1 combination recorded the lowest Rf value for PCN in comparison with other intercrop combinations and it was almost equal to that of sole crop of broad beans. In case of advance stage hybrid the lowest Rf value was observed in sole potato and it was closely followed by 1:1 intercrop combination with Broad beans.

Growing of rosemary as intercrop in susceptible potato (variety K.Giriraj) was found beneficial. The results indicate that the potato + rosemary intercropping in 1:1 row proportions recorded better potato equivalent yield as well as the lowest Rf value for nematode population. In case of resistant potato (adv. Hybrid OS/93-D-204), growing of sole potato was more advantageous both in terms of potato equivalent yield as well as nematode population (Fig. 21).

There was no advantage of growing thyme as intercrop for the control of potato cyst nematodes as it could not reduce the PCN population either in sole stand or in intercrop combinations. The highest potato equivalent yield was recorded with K. Neelima as sole crop and it was closely followed by intercropping with thyme in 3:1 row proportions (Fig. 22).

Evaluation of various soil management practices on PCN dynamics revealed that growing of resistant potato and French beans in intercropping during summer season and cabbage in autumn season is the more stable system of potato based cropping systems for southern hills. Negative correlation existed between PCN population and the potential yield of different treatments and 66% variation is mainly because of this only.

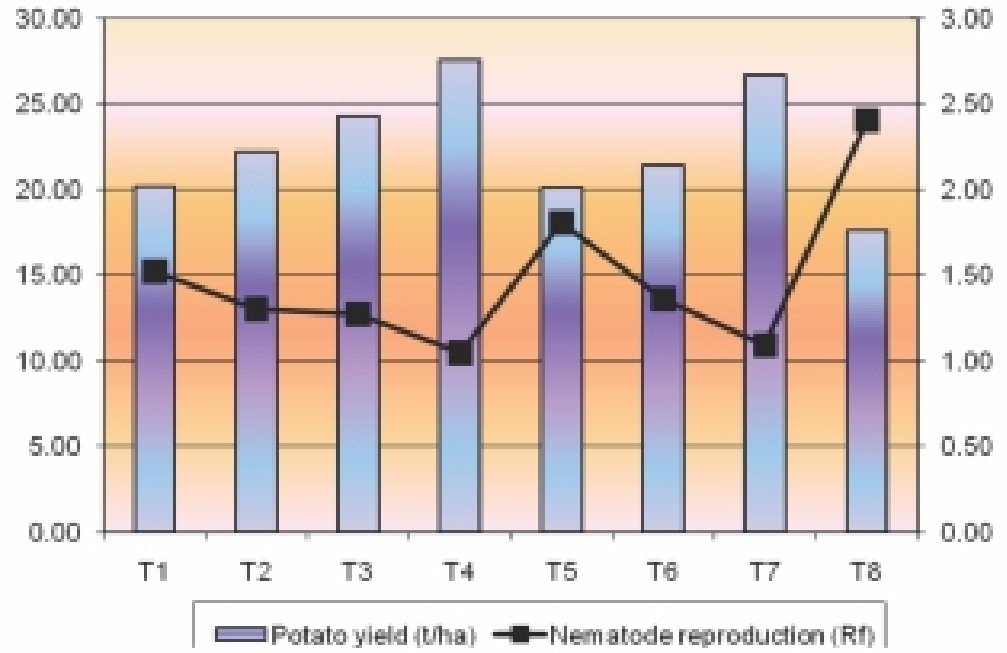


Fig. 18. Evaluation of biofumigation on potato yield and PCN multiplication

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

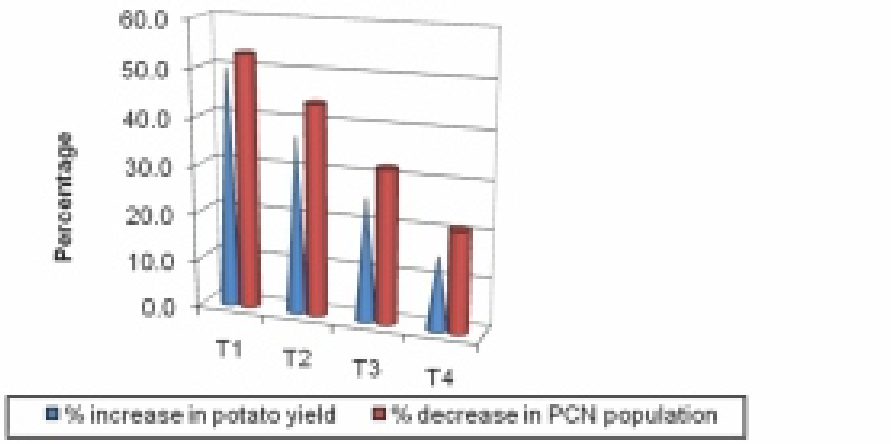


Fig. 19. Evaluation of trap crops on PCN and succeeding potato crop yield

T1 – Kufri Jyoti (60 x 20 cm2); T2 – Kufri Jyoti (45 x 15 cm2); T3 – Kufri Swarna (60 x 20 cm2); T4 – Kufri Swarna (45 x 15 cm2)]

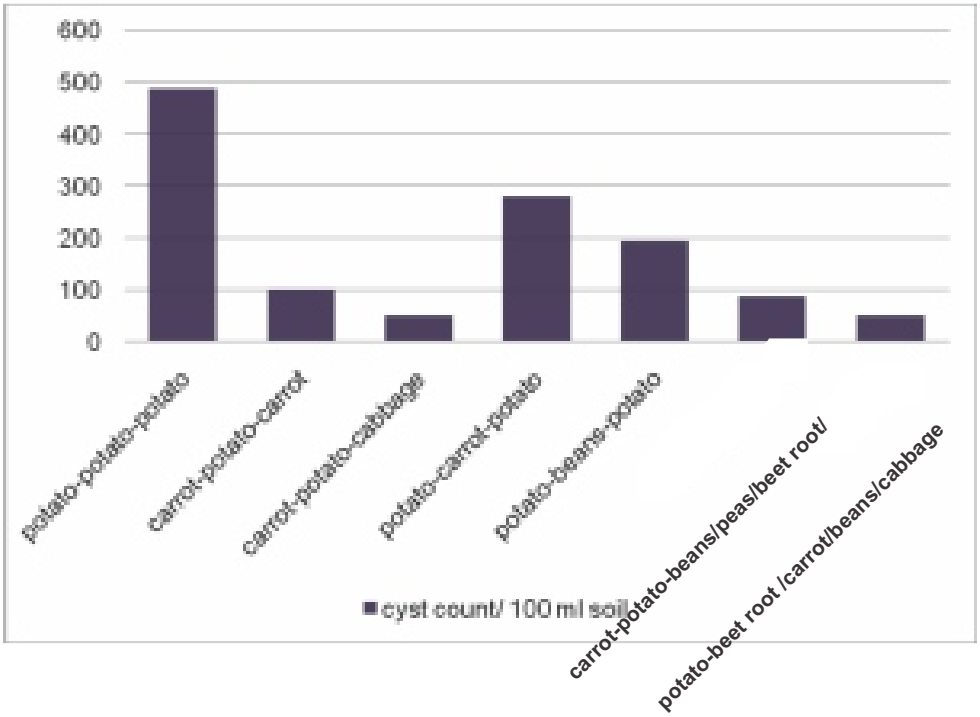


Fig.20. PCN dynamics in different cropping patterns in The Nilgiris district

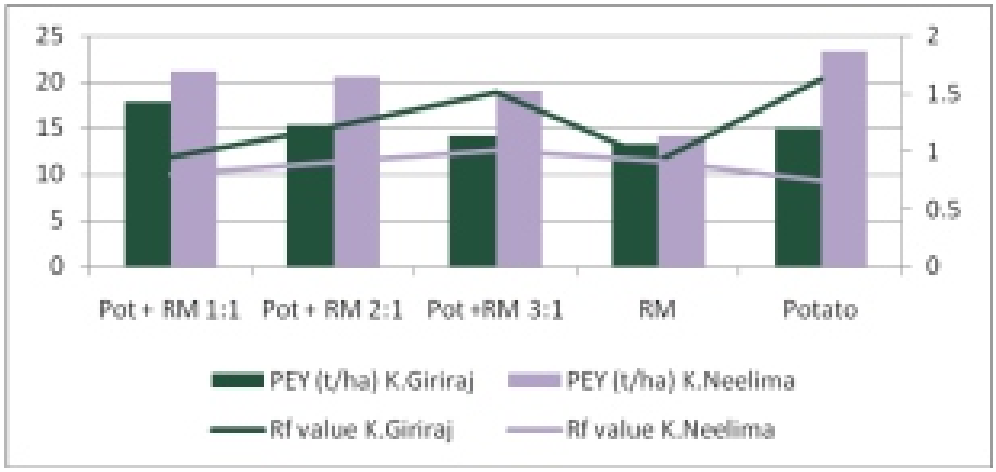


Fig.21. Potato equivalent yield (t/ha) and PCN populations (Rf) in potato + rosemary intercropping

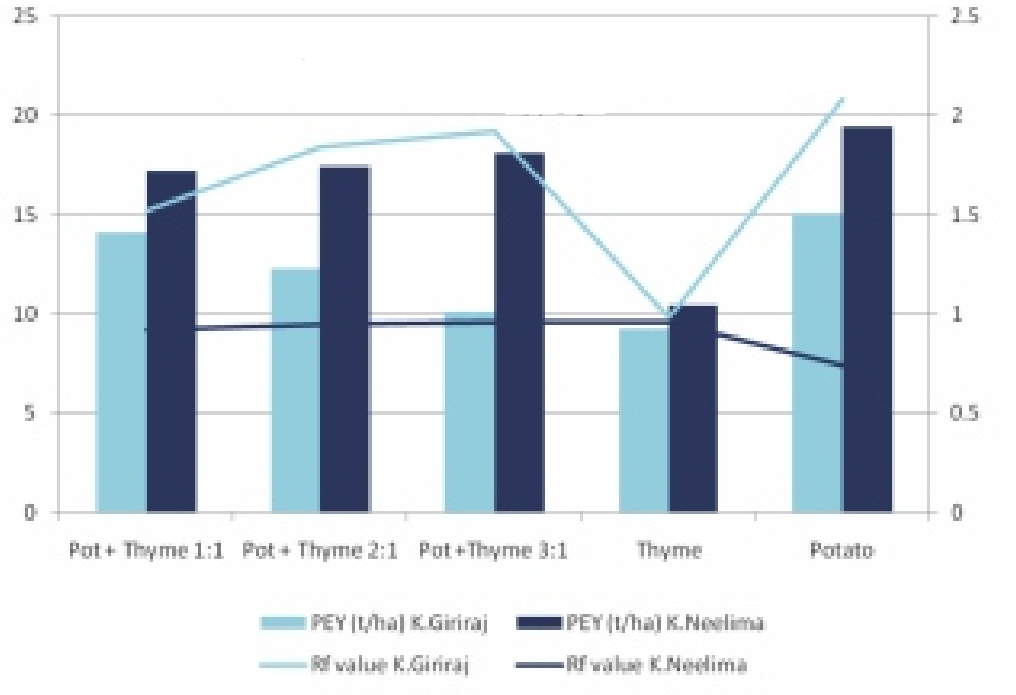


Fig.22. PEY (t/ha) and PCN (Rf value) of potato+ Thyme intercropping

Division of Crop Physiology, Biochemistry & Post Harvest Technology

Nutritional value of potato and potato products

Nutrients and antinutrients content in Indian potato varieties

Fresh tubers of forty four Indian potato varieties were analyzed for ascorbic acid and protein content. Ascorbic acid content varied from 13 mg to 25 mg/100g tuber fresh weight with minimum and maximum in Kufri Satlej and Kufri Surya, respectively (Table 1). The other five varieties with high ascorbic acid content were Kufri Chipsona-2 (25 mg/100g FW), Kufri Sindhuri (25mg/100 g FW), Kufri Himsona (24 mg/100g FW), Kufri Red (24 mg/100g FW) and Kufri Chandramukhi (23 mg/100g FW).

Protein content varied from 144 (mg/100g FW) to 299 (mg/100 g FW) with minimum values in Kufri Naveen and Kufri Pushkar and maximum in K. Arun. This was followed by K.Frysona (293 mg/100gfw), Kufri Chipsona-1 (287 mg/100g FW), Kufri Himsona (286 mg/100g FW), Kufri Chipsona-3 (275 mg/100g FW), Kufri Badshah (253 mg/100g FW) and Kufri Surya (255 mg/100g FW).

Table 1: Variability in ascorbic acid and protein contents in Indian potato varieties

Variety	Ascorbic acid (mg/100g FW)	Protein (mg/100g FW)	Variety	Ascorbic acid (mg/100g FW)	Protein (mg/100g FW)
Kufri Alankar	19	249	Kufri Khyati	20	158
Kufri Anand	20	200	Kufri Kuber	21	185
Kufri Arun	21	299	Kufri Kumar	22	182
Kufri Ashoka	19	159	Kufri Kundan	21	231
Kufri Badshah	14	253	Kufri Lalima	19	191
Kufri Bahar	19	207	Kufri Lauvkar	20	238
Kufri Chandramukhi	23	231	Kufri Megha	18	162
Kufri Chipsona-1	21	287	Kufri Muthu	21	165
Kufri Chipsona-2	25	244	Kufri Naveen	22	144

Variety	Ascorbic acid (mg/100g FW)	Protein (mg/100g FW)	Variety	Ascorbic acid (mg/ 100g FW)	Protein (mg/100g FW)
Kufri Chipsona-3	18	275	Kufri Neela	20	180
Kufri Chamatkar	19	191	Kufri Pukhraj	22	163
Kufri Deva	21	243	Kufri Pushkar	19	144
Kufri Frysona	23	293	Kufri Red	24	256
Kufri Girdhari	22	218	Kufri Sadabhar	19	175
Kufri Giriraj	21	156	Kufri Safed	20	207
Kufri Himalini	22	203	Kufri Shailja	23	247
Kufri Himsona	24	285	Kufri Sheetman	18	188
Kufri Jawahar	19	183	Kufri Sherpa	22	191
Kufri Jeevan	22	175	Kufri Sindhuri	25	213
Kufri Jyoti	21	180	Kufri Surya	25	255
Kufri Kanchan	20	166	Kufri Satlej	13	181
Kufri Khasigaro	22	265	Kufri Swarna	18	202

Anti-oxidants in some potato varieties

Freshly harvested potatoes of ten varieties from Kufri were analyzed for anti-oxidants viz. ascorbic acid, anthocyanin and total carotenoids. The ascorbic acid content was found to be the highest in Kufri Chipsona-2 followed by Kufri Surya. The anthocyanin content was maximum in Kufri Satlej, followed by Kufri Anand, Kufri Himalini and Kufri Surya, whereas, the carotenoids content was highest in Kufri Surya (Fig.1 and 2).

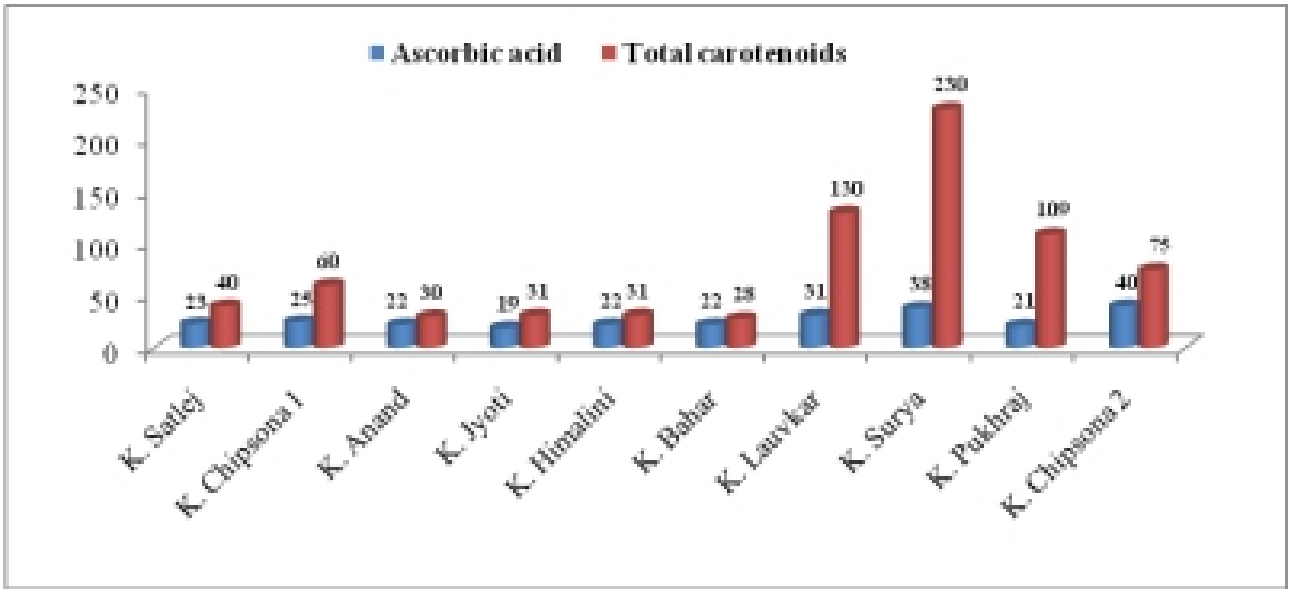


Fig.1.Ascorbic acid (mg/100g FW) and total carotenoids (µg carotene/100g FW) content in tubers of ten potato varieties

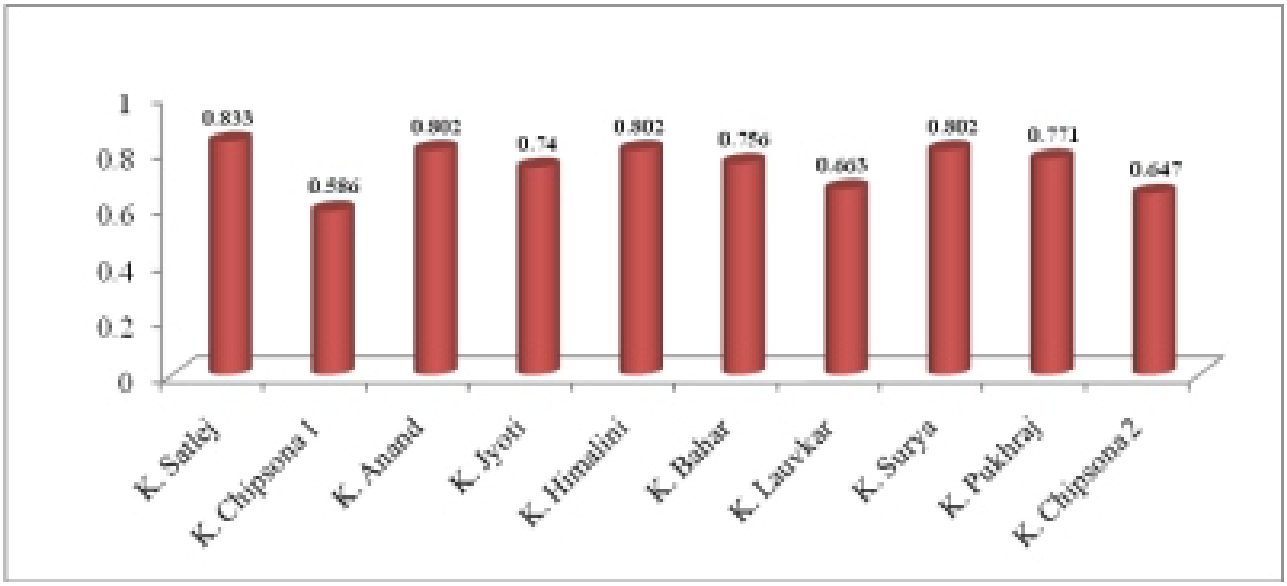


Fig.2.Anthocyanin (µg/g) content in tubers of ten potato varieties

Biochemical constituents in peels and flesh of potato tubers

Twelve potato varieties were analyzed for ascorbic acid, reducing sugar, sucrose, total phenols and free amino acids in peels and flesh of tubers. Peels were found rich source of antioxidants (phenols and ascorbic acid) while concentrations of reducing sugars and free amino acids were higher in flesh (Fig. 3). Results suggest the possibility of developing nutritionally rich potato products using unpeeled potatoes.

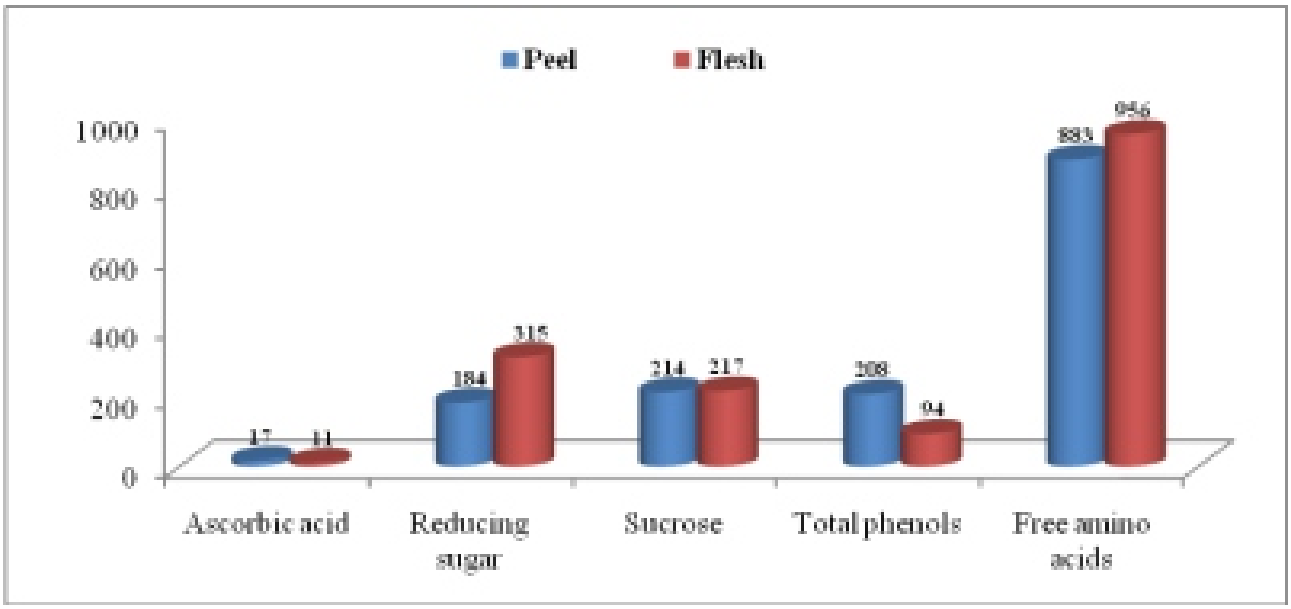


Fig. 3. Biochemical constituents (mg/100 g FW) of potato peels and flesh (averaged over twelve varieties).

Glyco-alkaloids in freshly harvested potatoes

The potato glyco-alkaloids solanine and chaconine were detected in peels of freshly harvested tubers. The maximum concentration of solanine was observed in cv. Kufri Lauvkar followed by Kufri Frysona, whereas, the minimum concentration was observed in Kufri Chamatkar (Table 2). The chaconine content was also the highest in Kufri Lauvkar and the lowest in Kufri Chamatkar. The ratio of solanine:chaconine was 43:57, which is according to the generally found ratio of 40:60.

Table 2. Glycoalkaloids content (mg/100g FW) in peels of potato tubers

Variety	Peel		
	a-solanine	a-chaconine	TGA
Kufri Kumar	53.5	152.8	206.3
Kufri Sherpa	75.7	64.4	114.8
Kufri Chamatkar	24.1	16.2	40.3
Kufri Alankar	118.8	161.2	280.1
Kufri Lauvkar	130.2	183.6	313.8
Kufri Frysona	127.2	101.9	229.2
Kufri Chipsona-1	31.3	27.6	58.9
Kufri Chipsona-2	70.9	113.8	184.8
Mean	78.9	102.7	181.6
Ratio (a-S:a-C)	43.4	56.6	100

Acrylamide in freshly harvested potatoes

Out of the forty three varieties tested, the minimum concentration of acrylamide was observed in processing variety Kufri Frysona (91 g/kg) followed by Kufri Chipsona-2 (112 g/kg). The table potato varieties had comparatively higher concentrations of reducing sugars in tubers and on frying they gave

dark coloured chips. The acrylamide concentration was also high in these varieties, the maximum being in variety Kufri Himalini. Other high acrylamide forming common varieties were Kufri Anand, Kufri Pushkar, Kufri Bahar and Kufri Ashoka. The study showed that the varieties identified as unsuitable for processing not only resulted in dark coloured chips, but also formed very high concentration of acrylamide. There was a positive correlation of acrylamide content with colour score and reducing sugars. Similarly, the reducing sugars showed positive correlations with colour score and sucrose content. The other correlations were non-significant .

Effect of storage on starch and sugar content

After 90 days of storage (DOS), starch content on dry weight basis was higher in potatoes stored at 12°C (78%) than at 4°C (74%) in Kufri Jyoti. The decrease in starch content at 4°C is due to conversion of starch to sugars at low temperature. The reducing sugar and sucrose content were more at 4°C than at 12°C, after 90 DOS. The reducing sugar content was 647 mg/100g FW at 4°C and 276 mg/100g FW at 12°C. Whereas sucrose content was 647mg/100g FW at 4°C and 276mg/100g FW at 12°C (Fig. 4).

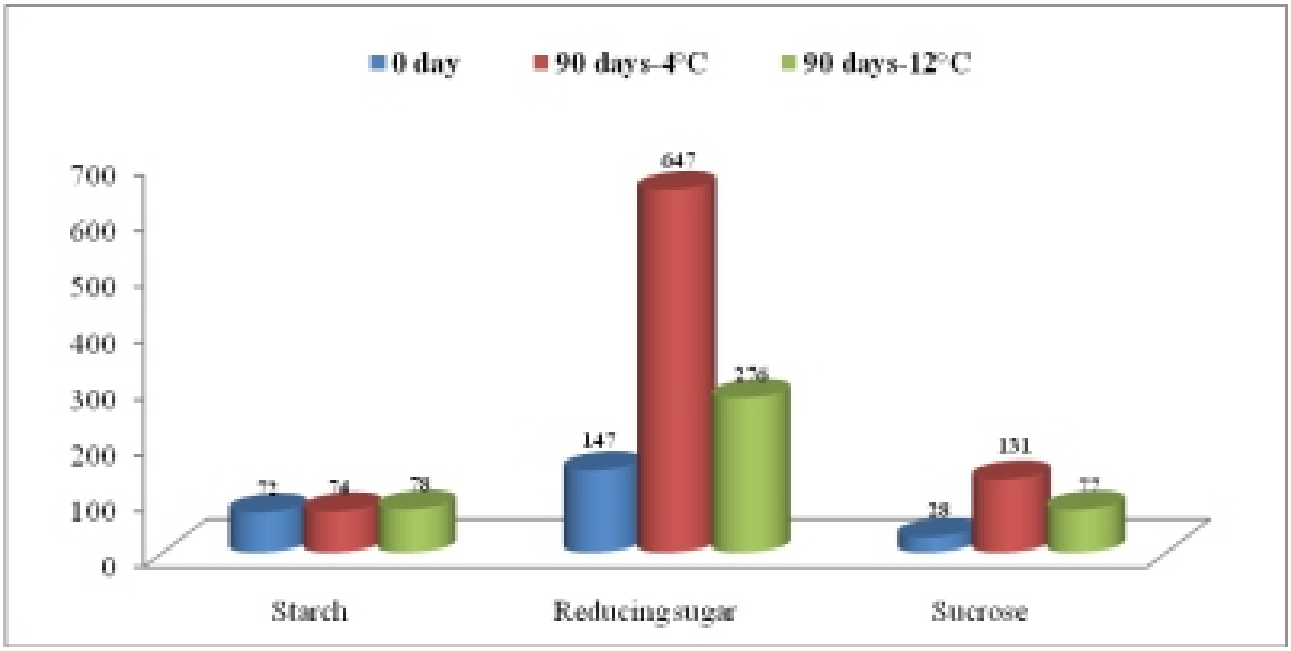


Fig.4. Changes in starch (mg/100mg DW) and sugar (mg/100g FW) content in tubers of Kufri Jyoti during storage at 4 and 12°C

Effect of storage on resistant starch content in three potato varieties

Tubers of three potato varieties viz. Kufri Jyoti, Kufri Sindhuri and Kufri Chipsona 1 were used for resistant starch estimation at 0, 90 and 180 DOS at 4°C and 12°C. Resistant starch content was minimum (0.8 to 1%) before storage in all the three varieties. The content of resistant starch was 1.2% and 1.3%, at 12°C and 1.5% and 1.4% at 4°C after 90 DOS in Kufri Sindhuri and Kufri Chipsona1 respectively (Fig.5). After 180 DOS, resistant starch content was in the range of 1.0 to 1.1% in all the three varieties. In Kufri Jyoti, resistant starch content was higher (1.4%) at 12°C as compared to 4°C (1.2%).

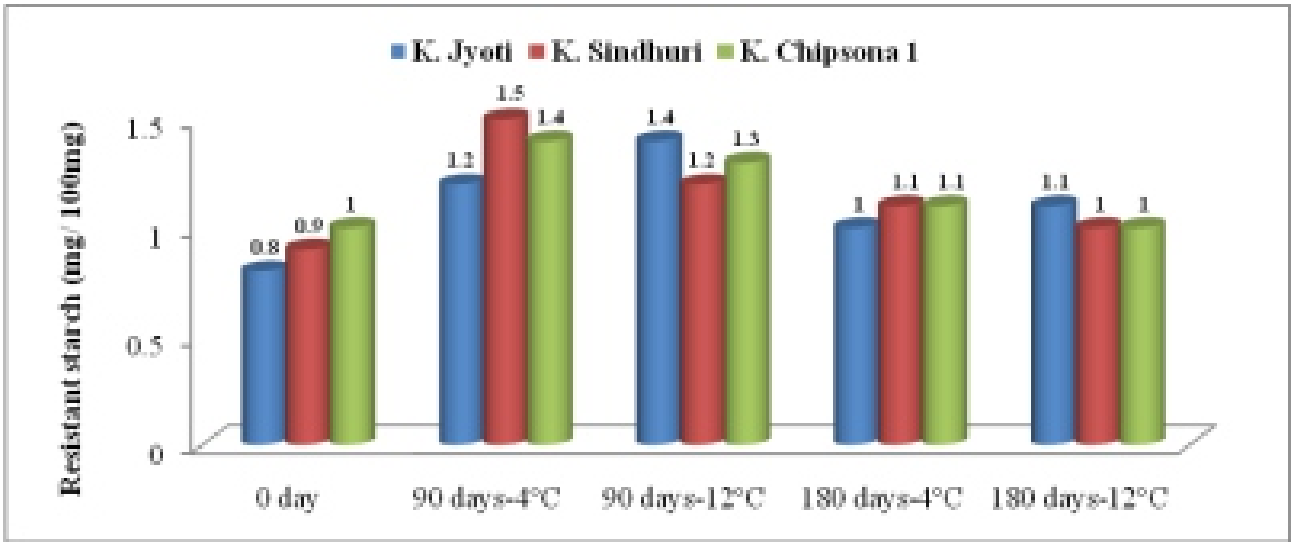


Fig. 5. Changes in resistant starch content in tubers of three varieties during storage at 4 and 12°C

Potato, banana and tapioca blend

To explore the possibility of fortifying potato based foods with nutrients from other sources, flours of potato (cv Kufri Pukhraj), banana (cv Nendran) and tapioca (cv Jaya) were blended in different proportions and were analyzed for their nutrients content. Lower starch and higher amylose contents were observed in potato flour, whereas, higher starch and lower amylose contents were observed in tapioca flour, with banana flour showing intermediate values (Table 3). The resistant starch content was comparable between potato and tapioca flours but lower in banana flour, and was highest in potato:tapioca blend (1:1 ratio). Reducing sugar and sucrose contents were higher in tapioca flour followed by banana and potato flours. Blending of potato flour with banana and tapioca flours resulted in increased starch, resistant starch, amylose, reducing sugar and sucrose contents. Generally, the increases were higher when potato flour was blended with tapioca flour as compared to potato: banana blend

Table 3. Starch and sugar contents of potato, banana and tapioca flours and their blends

Sl. No	Treatments	Starch (mg/ 100mg)	Amylose (mg/ 100mg)	Resistant starch (mg/100mg)	Reducing sugar (mg/100g)	Sucrose (mg/100g)
1	Potato	63.9	30.6	1.350	1358	367
2	Banana	82.9	29.3	1.180	2293	447
3	Tapioca	85.6	18.7	1.340	7900	4094
4	Potato+Banana 1:3	71.5	28.1	1.470	3123	862
5	1:1	76.4	31.1	1.370	1924	600
6	3:1	79.8	32.4	1.370	1037	643
7	Potato+Tapioca 1:3	77.8	28.1	1.486	3901	3206
8	1:1	80.0	32.2	1.536	2046	1507
9	3:1	83.5	33.6	1.308	3529	1858
10	Banana+Tapioca 1:3	82.5	18.8	1.370	3495	2864
11	1:1	87.5	24.4	1.381	4451	2545
12	3:1	91.7	31.4	0.960	3201	1510
13	Potato+Banana+Tapioca 1:1:1	92.0	32.6	1.030	2122	1950

Development of minimal frying/ microwaveable frozen potato products

Standardization of osmotic dehydration (OD) of potatoes was done with different sample: solution ratio (1:3, 1:4, 1:5) for different durations of dipping (1 h, 2 h and 3 h) of NaCl and sucrose. Weight loss was maximum and solute gain was low in 1:4 ratio which was selected for further studies. Preliminary experiments were conducted on OD of potatoes with 24 combination treatments of NaCl (1, 2 and 3%) and sucrose (7.5, 15, 30 and 45%) and two durations of dipping (2 and 3 h) in cv. Kufri Chipsona-3. Freshly cut fries were dipped in different solutions (sample: solution ratio 1:4) for 2 and 3 h, washed in water, extra moisture was blotted off, frozen for 24 h and fried for 1.5 minutes at 180°C. Moisture (%) in OD products before frying decreased with increase in solute concentration and duration of dipping. Organoleptic evaluation of fried frozen product recorded acceptable colour with more crispness in six treatment combinations with 7.5% sucrose and NaCl (1-3%) (Table 4). Salt and sugar taste was appropriate with 1% NaCl treatments but was a bit higher in treatments with 2 and 3% NaCl. The firm texture of the product was retained in these treatments even after 5 minutes of frying while French fries became soggy after 5 minutes. The oil content in the finished fried OD product was significantly low (2.35-4.74%) compared to frozen French fries (10.43%). Though the OD products were less crispy as compared to French fries, still significantly low oil content can be of much importance for older generation and calorie conscious people.

Table 4. Evaluation of osmotically dehydrated (OD) frozen fried potato products prepared from potatoes of cv. Kufri Chipsona-3.

Treatments	*Colour	Oil content (%)	Dry matter (%)	Reducing sugar (mg/100g FW)	Sucrose (mg/100g FW)
1% NaCl + 7.5% Sucrose /2h	3.2	3.2	40.2	132	1072
1% NaCl + 7.5% Sucrose /3h	4.0	3.8	42.2	138	1004
2% NaCl + 7.5% Sucrose /2h	3.2	2.7	40.3	143	1447
2% NaCl + 7.5% Sucrose /3h	3.2	2.3	46.3	154	1906
3% NaCl + 7.5% Sucrose /2h	3.7	4.7	57.3	195	1593
3% NaCl + 7.5% Sucrose /2h	3.7	2.7	54.6	281	2147
French fries	1.5	10.4	48.9	91	89

Colour up to 4.0 was acceptable

In another experiment to reduce oil content in food items while maintaining the sensory quality characters, the par fried frozen French fries of four varieties viz. Kufri Chipsona-1, Kufri Chipsona-3, Kufri Jyoti and Kufri Lauvkar were cooked in microwave oven for different durations on full power by omitting final frying. Results confirmed last year's results. Taste analysis showed that final fries (after 2.30 minutes cooking in microwave) were found acceptable in colour and taste with significantly low oil content (3.75-5.42%) compared to final fried frozen French fries (9.59-15.45%)(Table 5). Oven cooked fries were comparatively less crispy as compared to fried French fries. Efforts will be made to improve the texture of oven cooked fries while maintaining the taste.

Table 5. Evaluation of microwave cooked French fries in comparison to normal fried French fries

Variety	Fry colour1	Oil content (%)	Dry matter (%)	Reducing sugar[2]	Sucrose[2]	Phenols[2]	Free amino acids2	Ascorbic acid2	Firmness of fries3 (g force
Fried French fries									
Kufri Chipsona-1	1.5	13.1	53.9	214	113	158	955	12	1244
Kufri Chipsona-3	1.4	10.4	48.9	91	89	150	680	11	1294
Kufri Jyoti	4.5	15.4	56.8	403	283	205	992	14	1531
Kufri Lauvkar	4.2	9.6	51.1	273	364	203	807	17	1609
Mean	2.9	12.1	52.7	245	241	179	858	13.5	1419
Microwave cooked french fries									
Kufri Chipsona-1	3.7	3.7	40.5	244	82	193	809	10	986
Kufri Chipsona-3	3.5	4.8	40.4	156	84	141	620	7	913
Kufri Jyoti	3.0	4.0	38.2	207	163	162	727	15	1108
Kufri Lauvkar	3.2	5.1	49.1	277	375	211	925	10	1118
Mean	3.4	4.4	42.1	221	176	177	770	10.5	1031

[1]Colour up to 4.0 was acceptable ;[2] mg/100 g FW ; [3]Higher force indicates superior texture of fries

Fractionation of leaves and stems of potato

Fresh leaves and stems (1000g) of variety Kufri Pukhraj were chopped separately and juice was extracted. The juice obtained after pressing leaves and stems was subjected to heat at 80°C to obtain coagulum. The coagulum was analyzed for reducing sugars, sucrose, phenols and starch. The results indicated that stem residue (2158 mg/100g FW) contained more reducing sugar in comparison to leaf residue (1045 mg/100g FW), likewise, stem coagulum (3363 mg/100g FW) had more content of reducing sugars in comparison to leaf coagulum (951 mg/100g FW) (Fig.6). Reverse trend for reducing sugar content was observed for leaves and stem whey. More or less similar trend was observed for starch and sucrose content. Leaf residue (96 mg/100g FW), coagulum (117 mg/100g FW) and whey (23 mg/100g FW) contained more total phenols as compared to stem portion. Whey, which contains water soluble carbohydrates could be utilized for the production of yeast or micro-organism or can be used as a medium for tissue culture.

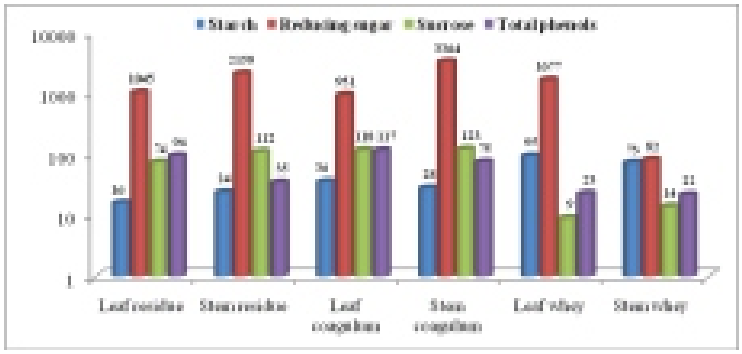


Fig.6. Nutrients in different fractions of leaves and stems of potato varietyKufri Pukhraj. {Starch : (g/100g FW) Reducing sugar, Sucrose and Total Phenols : (mg/100g FW)}

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

Executive Summary: CIPC spray in freshly harvested potatoes reduced sprouting and post-harvest losses in 5 cultivars up to 60 days after treatment, while the same treatment in 5 month cold stored potatoes was effective in only two cultivars (Kufri Chipsona-1 and Kufri Surya). Cutting of haulm 15 days before harvest reduced losses under heap storage and at 4 and 12°C. Reducing sugar concentration in stored potatoes remained low in Kufri Chipsona-1 up to 105 days of storage in heaps and chip colour was acceptable even in immature and uncured tubers. At harvest dry matter content was lower in tubers harvested immaturely. Starch content varied from 82.5 to 84 mg/100 mg dry weight, and it decreased with increase in storage duration at 4 and 12°C and was accompanied by higher accumulation of reducing sugars.

Foliar spray of growth retardants (paclobutrazol and ethrel) four and six weeks before harvest caused mild sprout suppression effect in progeny tubers up to 90 days of storage in heaps. A commercial formulation of 1,4-Dimethylnaphthalene (1,4 DMN) significantly reduced number of sprouts/tuber and length of the longest sprout in seed potatoes of two varieties stored in diffused light storage up to 240 days. Method for the estimation of 1,4-DMN from potato tubers was standardized by HPLC. A decrease in DMN residues was recorded with the age when the dormancy is terminated.

Extract of one plant species in three solvents showed good sprout suppression activity up to two weeks of storage at 18°C and 85% RH. Catalase activity increased during storage at 4 and 12°C in three varieties stored up to 180 days. Ascorbic acid content decreased during storage at 4 and 12°C.

Use of CIPC for reduction in post-harvest losses in potatoes

CIPC spray treatment in two concentrations (50 and 60 ml/tonne of Oorja) was evaluated to improve the shelf life of potato cultivars which can be helpful in export. Results suggest that freshly harvested CIPC treated potatoes of 5 varieties can be exported with reduced losses (<7.6%) and negligible rotting up to 60 days after harvest.

Whereas, CIPC treatment in 5 month cold stored potatoes, significantly reduced sprouting (Fig. 7) and losses in only two varieties (Kufri Chipsona-1 and Kufri Surya) (Fig. 8).Cold stored potatoes of these two varieties can thus be exported after CIPC treatment while Kufri Jyoti, Kufri Pukhraj and Kufri Bahar were found unsuitable for export. CIPC residues in potato peels was 2.91-4.97 mg/kg fresh weight 15 days after treatment and it decreased to 0.27-0.90 mg/kg fresh weight after 45 days. The levels were far below the permissible limits of 10 mg/kg fresh weight.

Fig. 7. CIPC treated and untreated potatoes of cv. Kufri Surya 45 days after removal from the cold storage (2-4°C).

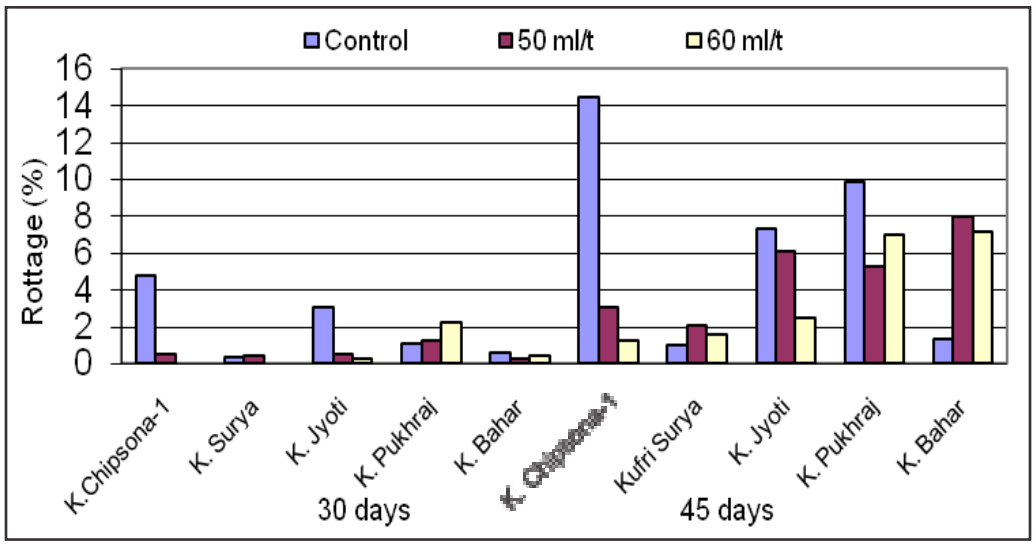
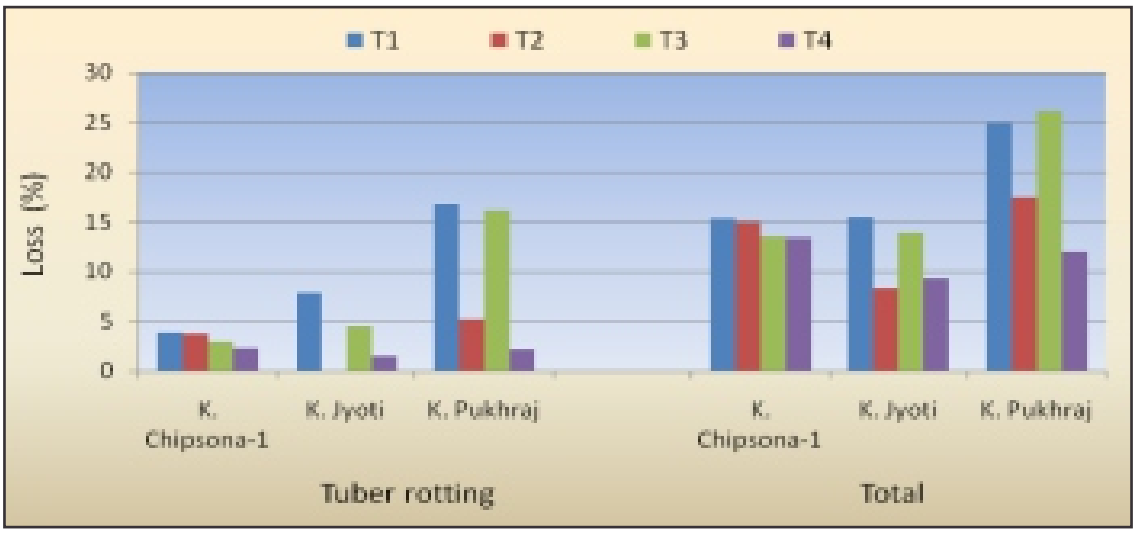


Fig. 8. Losses in CIPC treated and untreated (control) potatoes previously stored at 2-4°C for 5 months

Pre harvest biomarkers for improved storability and processing quality

Effect of tuber maturity and skin curing on storage parameters was evaluated under different storage conditions in three potato cultivars harvested at two maturity dates with/without a curing period of 15 days following haulm cutting. In heaps, haulm cutting prior to harvest significantly reduced losses compared to direct harvest in all cultivars. Losses in CIPC treated potatoes due to tuber rots and total losses up to 105 days of storage were minimum in treatments harvested at full maturity after 15 days of haulm cutting (Fig. 9). Immature and uncured potatoes after storage appeared shriveled and discolored. Reducing sugar (RS) concentration was high in immature tubers of Kufri Jyoti and Kufri Pukhraj during storage in heaps up to 105 days while in Kufri Chipsona-1, RS content remained low throughout storage and chip colour was acceptable in all treatments (Table 6).



T1- Immature + uncured, T2= Immature + cured, T3= Mature + uncured, T4= Mature + cured

Fig. 9. Effect of tuber maturity and skin curing on losses in potatoes up to 105 days in heaps

Table 6. Effect of tuber maturity and curing on reducing sugar content (mg/100 g fresh weight) and chip colour of potatoes stored in heaps (cv. Kufri Chipsona-1).

Treatment	Reducing sugar			*Chip colour score		
	0 day	105 days		0 day	105 days	
		CIPC	Control		CIPC	Control
Immature + uncured	101.0	35.3	159.9	2.3	1.8	2.0
Immature + cured	115.2	142.8	148.1	4.0	2.0	1.7
Mature + uncured	89.7	61.3	148.6	2.8	1.5	2.5
Mature + cured	126.8	24.0	126.1	3.7	2.0	2.0

*On a scale of 1-10, colour score up to 4.0 was acceptable

Weight loss during storage at 4 and 12°C was higher in tubers harvested directly (uncured), as compared to those harvested 15 days after haulm cutting (Table 7). At harvest dry matter content was lower in tubers harvested immaturely. Starch content varied from 82.5 to 84mg/100 mg dry weight and it decreased with increase in storage duration. The decrease in starch content was higher in tubers stored at 4°C than at 12°C.

Table 7. Effect of tuber maturity and curing on weight loss, dry matter and starch content in potatoes stored at 4 and 12°C (Values are mean of three cultivars).

Parameter	Treatment	0 Day	180 days of storage		300 days of storage	
			4°C	12°C	4°C	12°C
Weight loss (%)	Immature + uncured	-	13.5	12.4	16.5	21.8
	Immature + cured	-	10.4	11.0	16.0	18.3
	Mature + uncured	-	14.1	13.3	17.1	21.5
	Mature + cured	-	10.5	12.6	16.9	18.6
Dry matter (%)	Immature + uncured	17.7	18.6	19.1	17.2	19.3
	Immature + cured	17.4	17.8	18.7	17.9	18.4
	Mature + uncured	18.5	20.7	20.1	19.3	19.6
	Mature + cured	18.1	20.2	20.0	19.0	19.2
Starch (mg / 100mg dry weight)	Immature + uncured	83.7	68.9	85.0	76.9	79.0
	Immature + cured	82.5	69.0	80.2	72.9	82.0
	Mature + uncured	84.0	61.7	81.6	79.6	83.0
	Mature + cured	84.0	64.0	83.0	79.0	83.7

Use of growth retardants for prolonging the dormancy period

Two growth retardants were evaluated for delaying sprouting under heap storage in a short dormancy cultivar (Kufri Lauvkar). Foliar spray of Paclobutrazol and Ethrel 4 and 6 weeks before harvest retarded foliage growth (Fig. 10) and caused mild sprout suppression effect in progeny tubers up to 90 days of storage. There was no effect on tuber yield with spray of paclobutrazol while ethrel spray reduced the tuber yield.

Fig. 10. Potato crop after spray with ethrel (left) and unsprayed crop (right) (cv. Kufri Lauvkar)

Prolonging the dormancy of seed potatoes in the north-western hills

A commercial formulation of 1,4-Dimethylnaphthalene (1,4 DMN) named 1,4 Seed was used in four concentrations (5, 10, 20 and 50 ml/tonne) for treating seed potatoes of two varieties for prolonging the dormancy under the diffused light storage conditions without affecting the seed vigour. By 240 days, i.e. May 2011 coinciding with the planting in hills, all the treated and control tubers had 100 percent sprouting. The number of sprouts/tuber and length of the longest sprout was significantly reduced in treated potatoes in both the varieties (Fig. 11). The tubers were planted in the field and the seed vigour was estimated. The germination in the control tubers was late by 7-10 days compared to four treatments, but there were no differences in the growth and yield of the crop.

Fig. 11. Sprout growth in seed tubers of Kufri Jyoti and Kufri Giriraj at 240 days as affected by treatment with 1,4-dimethylnaphthalene

Standardization of HPLC procedure for the analysis of 1,4-DMN from potato tubers

Method was standardized for analysis of 1,4- DMN using a C-18 column and the mobile phase of acetonitrile and water. The extraction was done with acetonitrile and iso-propanol mixture and the traces were analysed. The peaks of 1,4-DMN were obtained at approximately 4 minutes with clear cut separation and identification. The quantifications were validated and the method was finalized as given in the attached chromatogram (Fig. 12). The trace analysis of DMN was done in the freshly harvested tubers. The content was highest in Kufri Girdhari (1.73 µg/kg) followed by Kufri Jyoti (1.44 µg/kg) and was the least in Kufri Giriraj (0.22 µg/kg). After two months of storage, a decrease in DMN residues (0.19 to 0.52 µg/kg) showed that with the age, the residues tend to decrease and the dormancy is terminated.

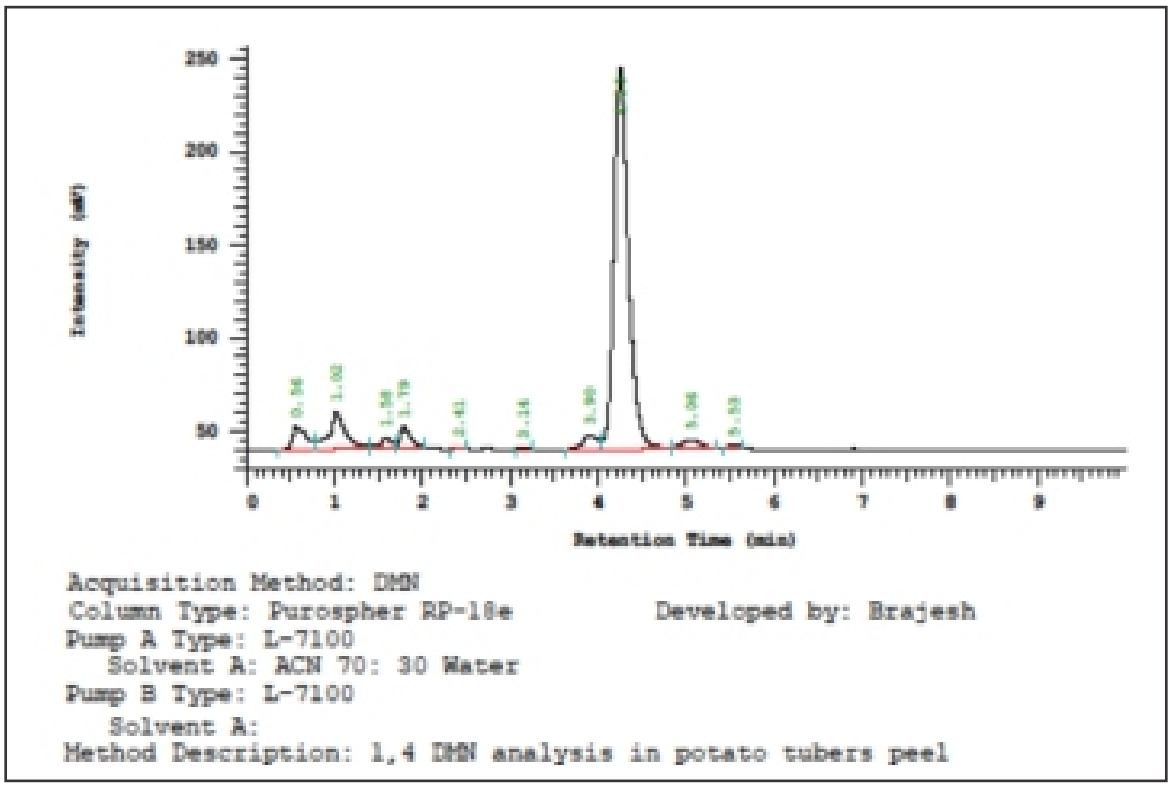


Fig. 12.Chromatogram showing peak of 1,4-DMN

Use of plant products as sprout suppressants

Extracts of 4 plant species made in 3 solvents (hexane, ethyl acetate and methanol) were evaluated for sprout suppression effect in potatoes. Extract of one plant part in all the solvents recorded good sprout suppression activity up to two weeks of storage at 18°C and 85% RH.

Catalase activity during prolonged storage

Lipid peroxidation in terms of catalase activity was measured in three cultivars stored at 4°C and 12°C up to 180 days. Catalase acts as a defense against hydrogen peroxide mediated damage during aging. Higher catalase activity (0.413 to 0.646 µmoles/min/g fresh weight) recorded at 180 days in all the three varieties stored at both

temperatures (Fig. 13) indicated higher level of lipid peroxidation and high rates of production of hydrogen peroxide in tissues on prolonged storage.

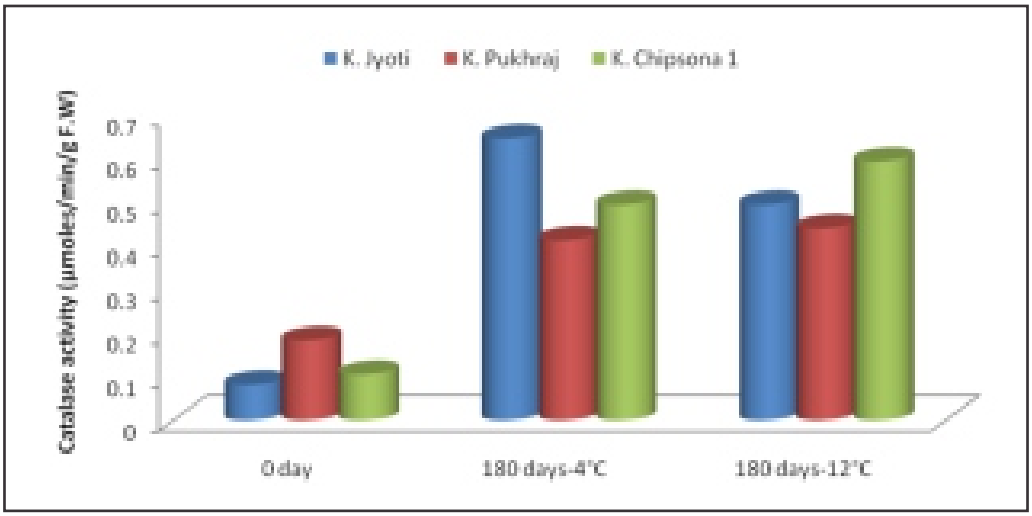


Fig. 13. Changes in catalase activity during storage at 4 and 12°C

Changes in ascorbic acid contents during storage at 4 and 12°C

Kufri Chipsona-1 recorded significantly higher contents (18.4 mg/100g fresh weight) as compared to Kufri Chipsona-3 (17.4 mg/100g fresh weight) and Kufri Pukhraj (14.8 mg/100g fresh weight) at 0 day of storage. Ascorbic acid contents decreased during storage at both the temperatures (Fig. 14) with a lesser decrease recorded at 4°C.

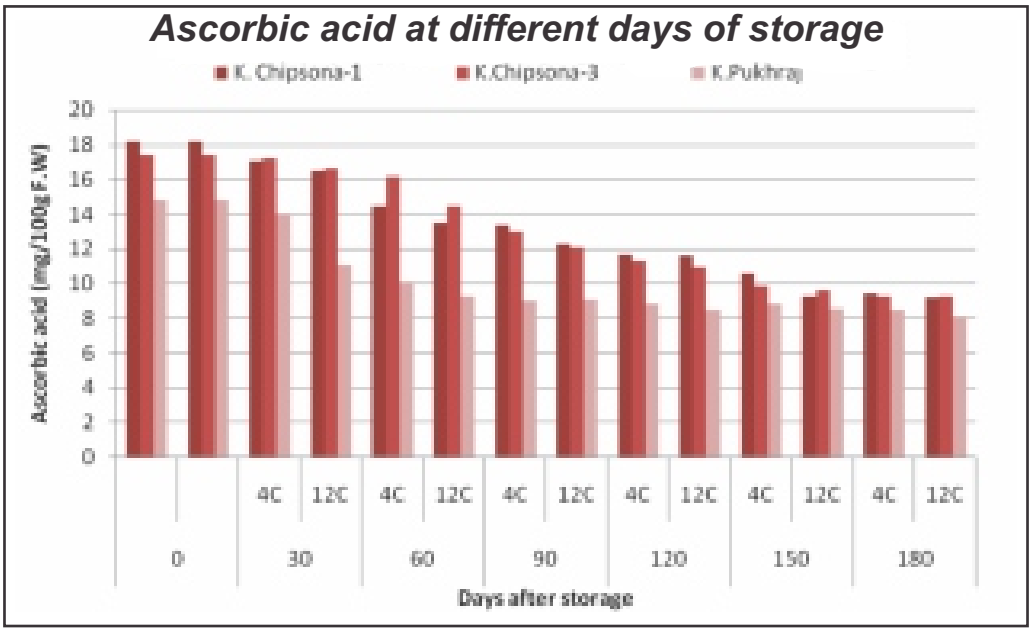


Fig. 14. Changes in ascorbic acid contents during storage at 4 and 12°C

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

Out of 1074 successful crosses for heat tolerance, 2,41,199 seeds were extracted. 1609 selections were made from the seedlings raised from these seeds in F_1C_1in the glass house and field. In the field selection at Modipuram, 242 clones were selected from F_1C_2-F_1C_5 stage for further evaluation. Heat tolerance in advanced hybrids was quantified by leaf bud tuberization test under controlled conditions. Four hours of low night temperature was sufficient for tuberization in potato however, tuber size and weight increased up to 12 hr night duration. Growth retardant, Paclobutrazole, 5 and 10 ppm spray 30 days after planting improved tuber yield and harvest index under heat stress conditions. Hybrid HT/05-935 was found to be resistant to hopper and mite burn during early planting. At Jalandhar, Kufri Surya out-yielded Kufri Pukhraj during early planting. For drought tolerance 879 hybrids were selected at F_1C_1 stage from 20530 seeds from seven crosses. 5 hybrids were selected from 2005 series, 32 were selected from 2006 and 2007 series, 70 from 2009 and 74 from 2010 series. Root pulling force can be used

Hybridization and Evaluation of clones for heat tolerance

Ninety three crosses were attempted at Kufri, out of which 54 were successful and yielded 28,075 seeds. During winter 53 successful crosses at Modipuram yielded 2,15,054 seeds. Seedlings were raised from 26145 seeds of 21 crosses and 6526 seedlings were transplanted to field. At harvest 1169 selections were made based on tuber characters like size, color, shape, synchrony, eye depth etc. At Shimla, 1410 seeds from 7 crosses were screened in a heated glass house and 440 selections were made. At Modipuram F_1C_1 to F_1C_3 were multiplied and evaluated during normal planting season and F_1C_4 to F_1C_6 were evaluated during early planting conditions under heat stress. The results are shown in table 8.

Table 8. Field evaluation of heat tolerant material at Modipuram

Stage	Clones evaluated	selected	Season	Kind of trial
F_1C_1	747	124	Main	Seedling crop
F_1C_2	303	100	main, early	Multiplication, row trial
F_1C_4	28	13	Early and late	Replicated trial
F_1C_5	18	5	Early and late	Replicated trial

Confirmation of heat tolerance in advanced hybrids under controlled conditions

Advanced hybrids were tested for their ability to tuberize at 24°C night temperature by leaf bud cutting technique with sessile tuber formation showing good tuberization stimulus. At 24°C night temperature, the sessile tuber formation was observed in HT/04-744, HT/06-97 and HT/06-88, whereas, amongst controls, only Kufri Surya (33%) and Kufri Lauvkar (33%) showed sessile tuber formation. At 22°C night temperature, the best performance was obtained in the hybrids HT/06-97 and HT/06-88 and Kufri Lauvkar. The tests confirmed that three hybrids viz., HT/04-744, HT/06-97 and HT/06-88, out of 5 tested had good heat tolerance (Fig.15)

Fig. 15. Tuberization on leaf bud cuttings at 24°C night temperatures in heat tolerant hybrids

Duration of night temperature and tuberization in potato cuttings

Night temperature is very important for tuberization in potato. In some areas of peninsular India, night temperature comes below 20°C only for a very short duration during early morning. Experiments were conducted to find out the importance of night temperature duration on tuberization in potato. Results have shown that survival of cuttings was good at 18°C. Tuber diameter and fresh weight increased when duration of night increased from 4 to 12 hrs, however, even 4 hrs of night was sufficient for tuberization in the tested varieties.

Paclobutrazole improves harvest index and tuber yield under heat stress

Pacloburtazole had a beneficial effect of tuber yield and harvest index in three varieties grown under heat stress during early planting. Data on fresh weight of different plant parts at harvest showed a significant decline in shoot height, shoot weight, increase in fresh tuber weight. Harvest index also improved but the effect was statistically non-significant. Tuber dry matter also improves significantly in all the treatments and maximum increase was observed in T3 (Table 9). Considering the response of the 5 and 10 ppm doses and timings of sprays, paclobuterazole can effectively ameliorate the ill effects of heat stress in potato.

Table 9. Effect of paclobutrazole on morphological traits and tuber yield (mean of three varieties) during heat stress condition of early planting at Modipuram

Treatment	Shoot height (cm/plant)	Biological yield (g/plant)	Tuber yield (g/plant)	Harvest Index (%)	Tuber Dry Matter (%)
T1 Control	41.4	102.4	80.7	78.7	17.1
T2 5ppm-S	39.2	129.6	106.7	81.9	20.3
T3 10ppm-S	37.2	157.1	130.8	83.1	22.4
T4 5ppm-R	32.0	153.6	128.2	83.4	22.1
T5 10ppm-R	32.3	93.8	73.0	78.0	21.6
LSD 5%	6.3	17.5	17.4	n.s.	0.8

S: single spray 28 days after planting

Kufri Surya out yields Kufri Pukhraj during early planting at Jalandhar

Kufri Pukhraj is the predominant variety grown during early planting in Jalandhar and surrounding areas. Performance of Kufri Surya, a heat tolerant variety was evaluated vis-a-vis Kufri Pukhraj. There was severe hopper burn in Kufri Pukhraj while K. Surya had negligible damage on this account. Kufri Surya out-yielded K. Pukhraj at all dates of planting and harvesting. Tuber yield was low in both the varieties at 6th and 12th September planting due of heavy rains just after planting. Tuber yield of Kufri Surya was twice as high as compared to Kufri Pukhraj at all harvests (Table 10). Proportion of small tubers was higher in K. Pukhraj and that of medium and large tuber was higher in K. Surya at all dates of harvesting.

Table 10. Total tuber yield in K. Surya and K. Pukhraj during early planting at Jalandhar (q/ha)

Date of Harvesting	Variety	Date of Planting		
		6 Sept	12 Sept	20 Sept
60 DAP	K. Surya	19.1	81.1	186.4
	K. Pukhraj	1.3	21.9	80.9
75 DAP	K. Surya	50.6	87.7	223.4
	K. Pukhraj	9.5	24.3	114.0
90 DAP	K. Surya	56.9	97.0	239.3
	K. Pukhraj	16.9	44.8	145.4
LSD (5%)	16.7			

Performance of advance stage genotypes at Ladol (Gujarat) under early planting season

Four heat tolerant hybrids along with two controls viz., Kufri Surya and Kufri Badshah were evaluated in replicated trial under early planting season at 90 DAP at Ladol in Gujarat. Advance hybrid HT/6-88 produced highest total tuber yield (42 t/ha) however, it remained statistically at par with Kufri Surya (41 t/ha) and Kufri Badshah (40 t/ha). Foliage maturity was late in all the hybrids compared to controls (Table 11).

Table 11. Performance of advance stage genotypes at Ladol (Gujarat) under early planting season

Genotypes	Germination%	Tuber yield (Marketable)t/ ha	Total Tuber yield t/ ha	D M%	Foliage senescence
HT/04-744	92.5	22.4	24.4	16.84	3.5
HT/04-755	100.0	28.1	33.1	19.32	2
HT/06-88	95.0	40.6	42.2	17.61	2
HT/06-97	100.0	29.4	30.7	16.09	3.5
Kufri Badshah	87.5	38.5	40.4	16.6	1
Kufri Surya	100.0	40.0	41.1	17.41	1
LSD 5%	5.54	3.2	3.5		

Growth parameters of heat tolerant genotypes

In this study growth and physiological parameters were recorded at prime growth stage (45 days) and salient findings are as follows:

Plant height varied from 39cm to 52cm. Plants were tallest in HT/6-10 (52.5cm) and shortest in hybrid HT/5-837 (39.7cm). Genotype HT/6-88, which performs well under heat stress had plant height 46.8 cm comparable to control K. Surya (47.3 cm).Stem number varied from 1.96 (HT/6-88) to 5.00(HT/5-177). Similarly, lowest leaf number/ plant was observed in HT/6-88 (24.6 cm) and hybrid HT/04-744 also had significantly lower leaf number (43.5) than genotype HT/5-177 (66.0), which had highest leaf number. Highest LAI (0.64) was observed in hybrid HT/6-840 and lowest in HT/6-22 (0.25) and MS/5-1543 (0.25). Hybrid HT/04-744 and HT/6-88 recorded LAI 0.51 and 0.41, respectively, which was comparable to genotype HT/6-840. Genotype HT/05-45 was able to maintain lowest canopy temperature (27.3°C), which was comparable to hybrid HT/04-744 (24.3 °C) and HT/6-88 (24.9 °C), respectively (Table 12).

Table 12. Mean growth and physiological parameters in heat tolerant hybrids

Genotypes	Plant height (cm)	Stem No./ plant	Leaf No./ plant	LAI	Canopy temperature (°C)
HT/04-744	41.2	3.40	43.5	0.51	24.3
HT/4-755	41.9	2.86	33.9	0.42	25.1
HT/4-935	50.5	2.33	28.4	0.45	23.9
HT/05-45	47.6	2.00	33.8	0.47	27.3
HT/5-177	44.7	5.00	66.0	0.49	26.6
HT/5-131	47.1	3.26	39.5	0.44	24.9

Genotypes	Plant height (cm)	Stem No./ plant	Leaf No./ plant	LAI	Canopy temperature (°C)
HT/05-133	42.0	3.00	35.8	0.36	25.4
HT/05-203	52.2	2.16	31.6	0.47	25.2
HT/5-837	39.7	2.20	31.6	0.63	24.4
HT/6-10	52.5	2.33	34.1	0.26	24.5
HT/6-22	48.9	2.73	37.8	0.25	23.2
HT/6-26	52.1	2.73	36.9	0.41	24.2
HT/6-88	46.8	1.96	24.6	0.41	24.9
HT/06-97	41.1	2.63	34.9	0.61	25.1
HT/6-840	44.8	2.53	36.6	0.64	24.3
MS/5-1543	44.2	2.63	40.6	0.25	24.7
MS/6-1947	48.5	2.53	34.8	0.28	23.7
K. Surya	47.3	3.50	40.7	0.62	25.7
CD (0.05)	6.5	0.96	12.7	0.34	2.5

Leaf hopper and mite burn resistant hybrid

Screening of heat tolerant hybrids against hopper and mite burn has resulted in the identification of hybrid HT/04-935 which had less burn percentage by both the pests than Kufri Surya at 60 and 70 days (Table 13).

Table 13. Mite and hopper burn damage in HT/05-935 and Kufri Surya at 60 and 70 days

Genotype/ variety	60 days		70 days	
	Hopperburn%	Miteburn%	Hopperburn%	Miteburn%
HT/05-935	3.0	1.3	6.7	15.0
K surya	3.3	3.3	18.3	31.7
K Bahar	Complete burn at 55 days	Complete burn at 55 days	Complete burn at 55 days	Complete burn at 55 days

Screening for drought tolerance

A total of 20530 seed from seven crosses were used for raising seedlings and successful crop was managed. On the basis of morphological characters like tuber shape, color, depth of eyes etc., 879 clones each with 3-5 tubers were selected in WS 2011 series.

Screening technique for drought tolerance

Root pulling force was tested in two drought tolerant and two drought susceptible varieties. Drought tolerant varieties had higher root pulling force that further increased under water stress. On the other hand root pulling force was lower in

drought susceptible varieties that further decreased under water stress (Fig 16). Kufri Arun showed highest root pulling resistance 20.7 kg/plant under stress and as compared to about 10.6 kg/plant in K.Anand and 12.3 kg/plant in K. Pukhraj. The results confirmed last year's findings.

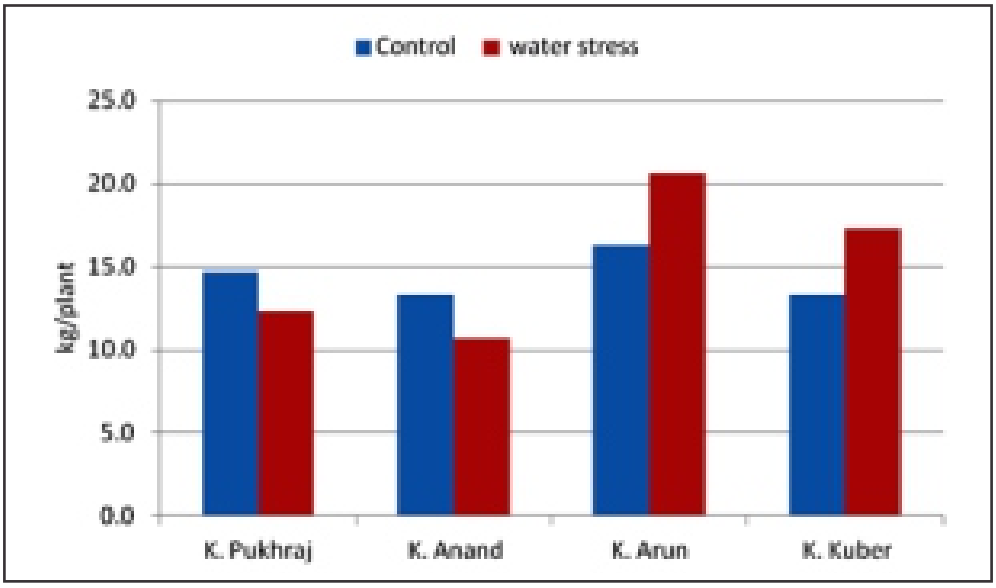


Fig. 16. Root pulling force at 60 DAP in potato cultivars differing in yield under water stress

Evaluation of potato hybrids for drought tolerance

Potato germplasm was screened for high water use efficiency and high water mining capacity based on isotope ratio of carbon and oxygen. Both these characters were combined through conventional breeding. Sixteen hybrids selected from 2005 series were exposed to water stress by withholding irrigation. Based on the results of trials conducted during last 4 years by physiologist and agronomist at Modipuram and Jalandhar six hybrids were selected that performed consistently better over the years. These hybrids are WS/05-146,108 152,103, 119 and 137 (Table 14).

WS/2006 and WS2007 Series: A total of 55 hybrids were evaluated in15 tuber/row in 4 replications under water stress and well watered control. Kufri Arun, K. Bahar, K. Kuber, K. Lauvkar and K. Pukhraj were used as check cultivars. Considering the tuber yield, particularly in medium and large tuber categories a total of 32 nos. were selected for further evaluation.

Genotypes of different series tabulated below were multiplied, evaluated and selected for further evaluation (Table 15).

Table 14.Summary of best five performers during last 4 crop seasons

Bank of WS/05 geno	2008-9	2009-10	2010-11	2010-11 (Agron)	2011-12	2011-12 (Agron)	2011-12 (Jalandhar)
1st	137	121-A	108	120	146	119	119
2nd	108	147	204	146	108	103	147
3rd	121-A	137	147	108	152	120	137
4th	103	108	146	165	103	137	108
5th	146	103	137	144	137	108	206

Table 15. Multiplication and evaluation of drought tolerant hybrids

Water stress series	No. of genotypes		Selected genotype No. / details	Tubers retained
	Planted	Selected		
WS/2009	115	70	Multiplication -3rd	65
WS/2010	--	74	Multiplication 2nd	8-10
CP Nos	100	3	Germplasm evaluation for C13 test	8-10
Mutants Set A	28	27	Multiplication2nd	8-10
Mutants Set B	24	24	Multiplication 1st	8-10

Variety specific minimum thresh-hold water requirement of potato

Twenty four varieties were evaluated at 15, 20, 25 and 30mm CPE irrigation. All potato cultivars produced significantly higher yield, when irrigations applied at 15 mm CPE (450 ha-mm total water applied) in comparison to 20, 25 and 30 mm CPE water level tried. But statistically, the potato yields produced at 15 mm CPE were found at par with the produce of 20 mm CPE water level (350 ha-mm total water applied) in case of many cultivars. However, the total tuber yields decreased with decrease in water levels from 15 to 30 mm CPE, the significant differences being observed when irrigations applied at 30 mm CPE water level. The potato cultivars viz., Kufri Khyati, Kufri Sadabahar, Kufri Anand and Kufri Pukhraj produced significantly higher yield as compared to other varieties. The water use efficiency (WUE) was also higher in case of K. Khyati (1.32q tubers), K. Sadabahar (1.15 q tubers), Kufri Anand (1.11 q tubers) and Kufri Pukhraj (1.10 qtubers), in comparison to others varieties tried. The water requirement of K. Khyati (0.76 mm/q tubers), K. Sadabahar (0.87 mm/q tubers), Kufri Anand (0.90 mm/ q tubers) and Kufri Pukhraj (0.91mm/q tubers) was less than other potato varieties (Table 16).

Table 16. Crop productivity and water use efficiency of different potato cultivars as influenced by irrigation levels.

Varieties	Potato yield (q/ha)				Mean (q/ha)	WUE (q tubers/ ha mm)	WR (ha-mm /q tuber)/
	15mm CPE	20mm CPE	25mm CPE	30mm CPE			
K. Bahar	349	332	305	276	316	0.94	1.07
K. Pukhraj	423	397	365	296	370	1.10	0.91
K. Sutlej	358	293	275	244	293	0.87	1.15
K. Anand	422	396	376	307	375	1.11	0.90
K. Khyati	493	474	437	385	447	1.32	0.76
K. Sadabahar	433	406	371	338	387	1.15	0.87
K. Surya	248	234	218	211	228	0.68	1.48
K. Chip-1	365	339	284	265	313	0.93	1.08
K. Chip-3	372	362	349	322	351	1.04	0.96
K. Ashoka	388	346	334	306	344	1.02	0.98

Varieties	Potato yield (q/ha)				Mean (q/ha)	WUE (q tubers/ ha mm)	WR (ha-mm /q tuber)/
	15mm CPE	20mm CPE	25mm CPE	30mm CPE			
K. Pushkar	408	391	346	293	360	1.07	0.94
K. Jawahar	391	357	337	325	353	1.05	0.96
K. Jyoti	329	316	277	271	298	0.88	1.13
K. Lauvkar	316	303	267	246	283	0.84	1.19
K. Kanchan	339	318	296	263	304	0.90	1.11
K. Giriraj	347	312	287	243	297	0.88	1.14
K. Sheetman	389	343	303	295	333	0.98	1.02
K. Jeevan	317	291	218	192	255	0.75	1.32
K. Kumar	323	299	273	227	281	0.83	1.20
K. Shakti	384	356	323	296	340	1.01	0.99
K. Red	331	298	298	260	297	0.88	1.14
K. Chamatkar	332	328	309	262	308	0.91	1.10
K. Kuber	346	336	332	311	331	0.98	1.02
K. Safed	396	343	341	303	346	1.02	0.98
Average	367	341	314	284	-	0.97	1.06
CD at 5%	Varieties (V) 26		Irrigation levels (I) 27			Interaction (VXI) NS	

Screening potato germplasm for WUE through carbon isotope analysis:

Out of 100 no. germplasm lines analyzed for delta 13 C values, three nos. namely **CP-3109, CP-3167** and **CP-3201** were found superior in water use efficiency with lower C13 values (Fig. 17). These lines will be used in crossing work to enhance genetic variability and 15 to 20 tubers of these lines were handed over to the breeder

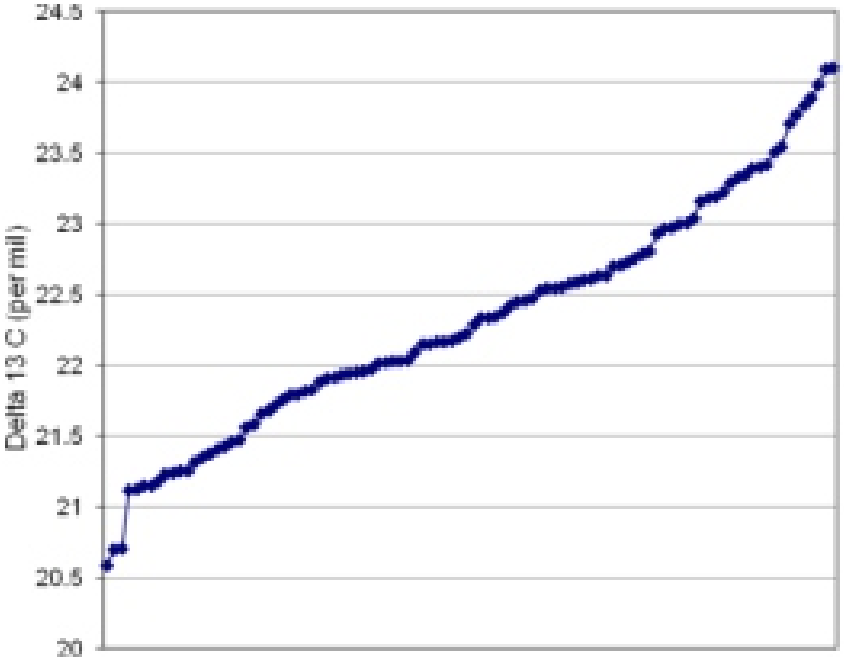


Fig.17. Delta 13 C values (surrogate for water use efficiency) in 100 potato germplasm lines

Evaluation of potato genotypes for drought tolerance (Physiological parameters)

Physiological parameters in 38 genotypes were measured in the field at 75 DAP and salient findings are as follows; Genotypes WS/07-108 (11.5°C), WS/07-145 (11.6°C) and WS/07-116 (11.7°C) were able to maintain lower mean canopy temperature during crop growth period and also under mild water stress, whereas WS/06-13 recorded highest canopy temperature (13.5°C) among all genotypes. Water stress significantly increased mean crop canopy temperature (12.6°C) over normal irrigation (12.3°C). Interactions of genotypes and irrigation management were also statistically significant. Hybrid WS/07-146 (50.0), WS/06-119 (49.8) and WS/06-201 (49.0) recorded comparable and higher chlorophyll content (SPAD values) like control K. Arun (52.5) having highest values and K. Pukhraj (49.0). Increase of water stress did not affect this parameter and interactions of genotypes and irrigation management were also not significant (Table 17).

Table 17. Mean canopy temperature (°C) and chlorophyll content (SPAD values)

Genotypes/ Varieties	Crop Canopy Temperature at 75 days (°C)		Chlorophyll Content at 75 days (SPAD Values)	
	Water stress	Normal irrigation	Water stress	Normal irrigation
WS/07-108	11.3	11.7	46.6	44.1
WS/07-116	11.3	12.2	43.8	39.2
WS/07-146	11.9	11.6	52.5	47.5
WS/06-117	12	12.1	45.5	45.6
WS/07-145	12	11.8	46.2	46
WS/07-159	12.1	12.2	46.6	44.9
WS/06-105	12.2	12.5	42.4	44.7
WS/07-113	12.2	12.1	46.8	46.1
WS/07-124	12.2	11.8	42.5	41.8
WS/07-138	12.2	12.8	47.8	47.5
WS/06-54	12.3	13.1	41.2	45.2
WS/07-208	12.3	12.2	44.4	42.2
WS/06-3	12.4	12.5	42.9	42.9
WS/06-201	12.4	11.6	48.6	49.4
WS/06-217	12.4	11.8	44.3	40.1
WS/06-82	12.5	12.1	41.1	41.8
WS/06-88	12.5	13.8	36.7	45.3
WS/07-209	12.5	12.5	44.3	43
WS/06-13	13.1	13.8	41.6	48.3
K. Arun	11.4	12.9	51.3	53.7
K. Bahar	12.7	12.8	41.4	44.4
K.Pukhraj	13	12	50	48.1

Genotypes/ Varieties	Crop Canopy Temperature at 75 days (°C)		Chlorophyll Content at 75 days (SPAD Values)	
	Water stress	Normal irrigation	Water stress	Normal irrigation
K. Lauvkar	13.2	12.4	42.8	44.6
K. Kuber	13.3	12.6	42.2	45.2
Statistics	CD 0.05		CD 0.05	
Irrigation (I)	0.17		NS	
Genotypes(G)	0.82		4.19	
I x G	1.16		NS	

Evaluation of dwarf transgenic lines for plant height and tuber yield

Eleven selected transgenic lines were multiplied in the net house at CPRS Jalandhar. Plant height and number of stems was measured at 45, 60, 75 and 90 days after planting. Average node length was measured at 60 DAP. Tuber number and weight was recorded at harvest. All the transgenic lines were shorter than the control plants in both the varieties. Tuber number per plant was similar in both transformed and untransformed plants. Average node length decreased in transgenic plants and was proportional to the reduction in plant height. Five out of seven transgenic lines of Kufri Surya yielded better than control with KS 1 yielding 314 g/plant compared to 152 g/plant for untransformed controls. Similarly, two transgenic lines out of four of K. Himalini yielded better than untransformed controls with KH13 yielding 274 g/plant compared to 191 g/plant for untransformed control (Table 18).

Table 18. Evaluation of transgenic plants in the net house

Transgenic line	Plant height at 75 DAP	Tuber yield g/plant	Tuber no/pl	Average Internode length
K Surya	89.7	152.4	3.45	5.98
KS 1	16.65	314.05	4.7	1.11
KS 13	28.65	274.95	4.15	1.91
KS 8	13.85	188.85	3.8	0.92
KS 6	6.4	172.2	5.2	0.43
KS 11	14.35	162.2	3	0.96
KS 2	7.75	160.9	3.4	0.52
KS 5	5.85	149.95	4.65	0.39
KS 3	8.1	105.5	2.6	0.54
K.Himalini	93.25	191.65	3.75	5.49
KH 79	61.4	211.1	5.3	3.61
KH 90	76.5	185	3.5	4.50
KH 65	47.5	118.5	5.7	2.79

Division of Seed Technology

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

Potato is vegetatively propagated crop. Seed potatoes the most essential input in potato cultivation account for about 40 - 50% of total cost of cultivation. Therefore, seed stocks should be free from all seed-borne diseases. To maintain the higher productivity, it is essential to have a technically sound seed production system through which high degree of health standard of the seed crop is maintained. In this context seed technology division in the institute has been set up with the mandate "To produce disease-free basic seed of notified varieties developed by the institute". Therefore a programme entitled "Production of breeder seed through conventional and high tech - system" was started under revolving fund scheme. At present nucleus and breeder seed is being produced at five different regional stations located in different regions of the country. The division has also started several seed research programmes on emerging problems in conventional and high-tech seed production system to improve the quality and quantity of nucleus and breeder seed in the country.

I. Conventional Seed Production System:

i) Tuber indexing: Total 20,220 tubers of various potato cultivars were indexed for seven potato viruses at Modipuram (7,772), Jalandhar (2,636), Gwalior (7,328), Patna (964) and Kufri (1,520). Health status diagnosed during tuber indexing at above centers was 96.5, 98.2, 97.0, 90.0 and 100 % respectively.

ii) Stage-I: Total 144.51 q seed tubers were produced in stage-I from an area of 2.37 hactare both in hills and plains. The clonal development was under taken on 2.22 hectare in plains and 0.15 hactare in hills and a production of 122.96 and 21.55q was obtained, respectively (table1). The mean production achieved at Modipuram, Jalandhar, Gwalior, Patna and Kufri was 66.38, 29.18, 54.21, 88.0 and 143.67 quintal per hectare, respectively. Health status recorded in field at above centers was 97.13, 95.80, 96.60, 97.83 and 98.90 per cent respectively.

iii) Stage-II: Total 1113.16q seed tubers were produced in this stage from an area of 8.15 hactare both in hills and plains. The clonal multiplication was undertaken on 7.80 hactare area, from where 1068.11q production was achieved at all stations of plains, whereas in hills only 0.35 hactare area was planted and a production of 45.05q was obtained (table.1). The productivity at Modipuram, Jalandhar, Gwalior, Patna and Kufri was recorded 141.27, 104.07, 140.34, 136.94 and 128.71 quintal per hectare, respectively.

iv) Stage-III: In this stage total 4438.29q seed tubers were produced from an area of 26.0 ha with a yield of 170.7q/ ha (in hills and plains). In this stage seed tubers were multiplied on 25.20 hactare area at all the stations in plains with a total production of 4296.34q, whereas, in the hills the production obtained was 141.95q from 0.80 hactare (table1). The yield at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 173.29, 198.58, 152.29, 183.96 and 177.44 quintal per hectare, respectively.

v) Stage-IV: Total 14173.81q breeder seed was produced from an area of 82.02 hactare both in hills and plains. In the plains, 13,722.01q breeder seed was produced from 77.68 hactare area, these figures also include the area (17.96ha) as well as production (3898.75q) under RFS – II. In the hills (Kufri), 451.80q breeder seed was produced from an area of 4.34 hectare (table1).

Table 1. Station wise, stage wise area planted and production obtained during 2011-12

S. No	Variety	Stage-I		Stage-II		Stage-III		Stage-IV		Total	
		Area (ha)	Production (q)	Area (ha	Production (q)	Area (ha	Production (q)	Area (ha	Production (q)	Area (ha	Production (q)
Modipuram											
1	K Bahar	0.28	2.90	1.90	316.75	6.30	1044.50	9.20	2249.00	17.68	3613.150
2	K. Pukhraj	0.06	7.25	0.60	71.65	1.20	259.50	1.50	479.00	3.36	817.40
3	K. Anand	0.03	2.90	0.20	31.80	0.55	119.00	1.00	247.00	1.78	400.70
4	K. Surya	0.05	5.45	0.40	36.05	1.00	181.00	-	-	1.45	222.50
5	K. Chipsona-1	0.04	4.60	0.15	20.35	0.50	80.00	1.90	444.00	2.59	548.95
6	K. Chipsona-3	0.04	3.75	0.25	27.55	0.30	33.70	1.00	242.00	1.59	307.00
7	K Badshah	0.02	1.55	0.20	26.15	0.50	105.00	1.20	291.00	1.92	423.70
8	K. Himsona	-	-	0.10	9.80	0.25	35.70	-	-	0.35	45.50
9	K. Sadabahar	0.09	8.00	0.55	81.00	1.00	165.70	1.95	359.00	3.59	613.70
10	K. Frysona	0.03	2.35	0.10	15.65	0.45	100.50	3.00	544.50	3.58	663.00
11	K. Sutlej	-	-	0.10	11.15	0.25	28.40	1.00	166.50	1.35	206.05
12	K. Chipsona-4	0.06	4.40	0.05	6.20	1.00	151.70	-	-	1.11	162.30
13	K. Khyati	0.06	7.30	0.30	38.10	-	-	-	-	0.36	45.40
	Total	0.76	50.45	4.90	692.20	13.30	2304.70	21.75	5022.00	40.71	8069.35
Jalandhar											
1	K. Jyoti	0.30	4.17	0.65	29.20	2.50	470.00	9.90	1395.35	13.35	1898.72
2	K. Pushkar	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
3	K. Pukhraj	0.02	1.92	0.10	49.50	0.01	44.50	4.50	842.50	4.63	938.42
4	K. Badshah	0.01	0.87	0.05	12.00	0.01	18.69	1.00	177.00	1.07	208.56
5	K.Chandramukhi	0.02	0.34	0.10	0.66	0.10	26.50	0.90	177.00	1.12	204.50
6	K. Chipsona-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	K. Chipsona-3	0.01	1.17	0.00	0.00	0.00	0.00	2.00	334.00	2.01	335.17
8	K. Surya	0.02	1.37	0.00	0.00	0.40	40.00	1.20	316.69	1.62	358.06
9	K. Khyati	0.01	1.83	0.05	7.50	0.00	0.00	0.00	0.00	0.062	9.33
	Total	0.40	11.67	0.95	98.86	3.02	599.69	19.50	3242.54	3.87	3952.76
Gwalior											
1	K. Sindhuri	0.14	6.67	0.29	50.43	1.20	191.0	8.36	1367.25	9.99	1615.35
2	K. Jyoti	0.27	15.39	0.31	47.75	1.60	0187.50	7.89	986.20	10.07	1236.84

3	K. Chipsona-1	0.11	6.71	0.36	44.74	1.25	249.50	2.75	464.40	4.47	765.35
4	K.Chandramukhi	0.11	6.00	0.12	12.63	0.69	107.00	1.54	231.40	2.46	357.03
5	K. Chipsona-2	-	-	-	-	0.25	32.50	0.00	0.00	0.25	32.50
6	K. Lauvkar	0.23	10.69	0.43	63.88	1.63	258.50	4.39	540.10	6.68	873.17
7	K. Arun	-	-	-	-	0.16	39.50	-	-	0.16	39.50
8	K. Chipsona-3	0.10	6.58	0.14	12.12	-	-	2.37	245.75	2.61	264.45
9	K. Surya	-	-	-	-	0.85	96.50	0.80	146.00	1.65	242.50
	Total	0.96	52.04	1.65	231.55	7.63	1162.00	28.10	3981.10	38.34	5426.69
Patna											
1	K. Jyoti	0.04	3.10	0.10	13.00	0.30	71.65	2.35	460.25	2.79	548.00
2	K. Arun	0.03	3.00	0.12	17.00	0.40	56.80	1.15	185.33	1.70	262.13
3	K. Surya	-	-	-	-	-	-	1.05	186.20	1.05	186.20
4	K. Pukhraj	0.03	2.70	0.08	5.50	0.55	101.50	3.78	644.59	4.44	764.29
	Total	0.10	8.80	0.30	45.50	1.25	229.95	8.33	1476.37	9.98	1760.62
	G. Total Plains (A)	2.22	122.96	7.80	1068.11	25.20	4296.34	77.68	13722.01	112.90	19209.42
Kufri											
1	K. Jyoti	0.10	12.00	0.20	23.00	0.35	60.50	3.21	374.50	3.86	470.00
2	K. Himalini	0.018	4.20	0.04	9.70	0.15	31.50	0.40	29.00	0.61	74.40
3	K. Kanchan	0.006	1.10	0.04	2.00	0.05	9.00	0.25	18.20	0.35	30.30
4	K. Shailja	0.002	0.50	0.016	3.20	0.03	5.75	0.20	9.00	0.25	18.45
5	K. Giriraj	0.002	0.25	0.01	2.00	0.04	7.50	0.05	2.00	0.10	11.75
6	K. Girdhari	0.02	3.10	0.04	4.75	0.15	26.20	0.15	12.00	0.36	46.05
7	K. Himsona	0.002	0.40	0.004	0.40	0.03	1.50	0.08	7.10	0.12	9.40
	G. Total Hills (B)	0.15	21.55	0.35	45.05	0.80	141.95	4.34	451.80	5.64	660.35
	Grand Total (A+B)	2.37	144.51	8.15	1113.16	26.00	4438.29	82.02	14173.81	118.54	19869.77

Highest yield of breeder seed @ 230.9q/ ha was recorded at Modipuram campus followed by Patna (177.24) and Jalandhar (166.29) stations.

II. Hi-Tech Seed production Technology:

I) Maintenance and multiplication of virus free buffer stocks:

Disease free buffer stock tubers of twenty five varieties were planted under controlled conditions in the poly house. During its growth period samples were collected and tested against 19 viruses viz. PVX, PVS, PVY, PVY-n, PVA, PVM, PLRV, ABV, TMV, TSWV, APMoV, TNV, PVT, APLV, PALCV, PAMV, TBRV and TSV by ELISA and all the varieties were found free from all the viruses tested. The microplants of all the varieties were also tested through ELISA against 18 viruses viz. PVX, PVS, PVY, PVA, PVM, PLRV, PALCV, CMV, TSV, SqMV, PAMV,TSWV, APMoV, PVT, TNV, APLV, TBRV and PYDV by ELISA and all the samples were found free from all viruses.

ii) Production of microplants, microtubers and minitubers:

Total 47030 *in vitro* plantlets of 17 potato cultivars and 47581 microtubers of 14 cultivars were produced at CPRI, Shimla. About 46,030 in vitro plantlets were supplied to differentregional stations for further multiplication. A total of 62,700aeroponic minitubers were produced at CPRIC, Modipuram (Fig.1). A total of 3,25,000 (83.05q) minitubers were produced from 95,367 microplants (2,52,396; 72.9q) and 23,358 microtubers (72604;10.15q). A total of 3,30,282 (11.9q) tubers were produced in net house from aeroponic miniutubers (1,20,451) and recycling of <3 g minitubers (2,09,831 ;11.90q) at different regional stations (table 2).

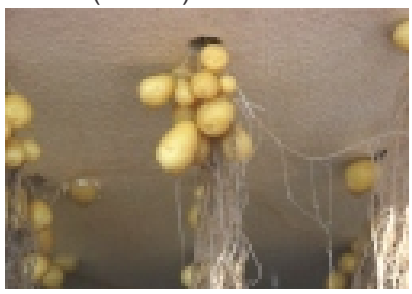


Fig. 1, Aeroponic minituber

Table 2.Station-wise microplants, microtubers and minitubers (<3 g) planted and production obtained during 2011-12.

Station	Planting material	Planted (Nos.) (Nos.)	Establishment	Mini/tuber produced (Nos.+q)
Modipuram	Microplants	69606	65270	141575+72.60 q
	Microtubers	11086	7959	21775+8.75 q
	Minitubers (<3 g)	43056	41308	130820
	Aeropinc tubers	30000	30000	120451
Jalandhar	Microplants	13532	10731	53897
	Microtubers	4083	4083	32622
	Minitubers (<3 g)	1110	1110	56211
Kufri	Microplants	10700	10176	34852
	Minitubers (<3 g)	2695	2552	7707
Gwalior	Microplants	4270	739	3898
	Microtubers	12320	4656	15890
	Minitubers (<3 g)	2560	2560	12485
Patna	Microplants	10000	2623	0.30 q
	Microtubers	11300	6130	1.40 q
	Minitubers (<3 g)	18600	16835	11.90 q
Shillong	Microplants	13074	5828	18174
	Microtubers	825	530	2317
	Minitubers (<3 g)	840	600	2608
Total Microplants		**121182**	**95367**	**252396+72.9 q**
Total Microtubers		**39614**	**23358**	**72604+10.15 q**
Total Minitubers (<3 g)	**68861**	**64965**	**209831+11.90 q**	
Aeropinc minitubers	**30000**	**30000**	**120451**	

iii) Generation-1: A total production of 1646.28 was achieved in generation-1 from an area of 9.46 hactare both in hills and plains. In this generation 9.26 hactare area was planted at all the stations in the plains and a total production of 1621.68q was achieved, whereas, in the hills the production obtained was 24.60 quintal from 0.20 hactare (table 3). The productivity at Modipuram, Jalandhar, Gwalior, Patna, and Kufri was 174.86, 176.86, 132.98, 205.00 and 123.00 quintal per hectare, respectively.

iv) Generation- 2: Total 9,718.61q breeder seed was produced in generation-2 from an area of 40.14 hactare both in hills and plains. In this generation 39.02 hactare area was planted at all the stations in the plains from where 9,573.51q seed was produced, whereas, in the hills the production obtained was 145.10q from 1.12ha area (table 3) this also includes 0.50ha area and 103.0q production under at CPRS, Kufri. The yields at Modipuram, Jalandhar, Gwalior, Patna, and Kufri were recorded @ 260.36, 199.38, 166.06, 178.60 and 129.55 quintal per hectare, respectively.

III) Production of nucleus and breeder seed during 2011-12

Total 31,234.66q nucleus and breeder seed was achieved in both conventional and hi-tech seed production system from an area of 168.14 hectare both in hills and plains. The quantity includes 7,342.18q nucleus seed produced on 45.98 ha area and 23,892.42q breeder seed produced from 122.16 hactare area both in hills and plains. In plains a total production of 23,295.52q was achieved in 116.7 hectare area and in hills 596.90q was achieved from 5.46 hectare area .

IV) Supply of breeder seed during 2010-11

Total 22,995.88q breeder seed was supplied to various agencies during 2010-11from plains and hills which includes both pre and post cold storage supply (table4).

Table 3. Station wise, generation wise area planted and production obtained during 2011-12

S.No	Variety	Generation-I		Generation -II		Total	
		Area (ha)	Production (q)	Area (ha)	Production (q)	Area (ha)	Production (q)
Modipuram							
1	K. Bahar	2.7	440	17.3	4773	20	5213
2	K. Chipsona-3	1.25	184	4.25	991	5.5	1175
3	K. Surya	0.415	84.45	3.85	810.1	4.265	894.55
4	K. Sutlej	0.02	6.7	0.01	1.5	0.03	8.2
5	K. Anand	0.01	2	0.25	54	0.26	56
6	K. Chipsona-4	0.06	17	0.03	10	0.09	27
7	K. Himsona	0.04	9.7	3.6	886	3.64	895.7
	K. Pukhraj	1.22	226	0.8	301.8	2.02	527.8
9	K. Himalini	0.03	10.7	-	-	0.03	10.7
10	K. Khyati	1	180.5	0.9	262.5	1.9	443
11	K. Sadabahar	0.12	27.5	0.55	122	0.67	149.5
13	K.Frysona	0.11	32	-	-	0.11	32
	Total	**6.98**	**1220.55**	**31.54**	**8211.90**	**38.52**	**9432.45**
Jalandhar							
1	K. Pukhraj	0.15	62.5	0.8	166.37	0.95	228.87
2	K. Chandramukhi	0.1	23.5	0.3	65.05	0.4	88.55
3	K. Badshah	0.3	51.5	0.5	96.64	0.8	148.14
4	K. Sutlej	-	-	0.3	49.1	0.3	49.1
5	K. Himsona	0.2	4	0.05	10.4	0.25	14.4
6	K. Jyoti	0.05	13.5	0.2	32.77	0.25	46.27
7	K. Chipsona-3	0.05	9.5	0.05	9.22	0.1	18.72
8	K. Pushkar	0.2	10.5	0.1	24.51	0.3	35.01
9	K. Khyati	0.15	33.5	0.1	24.45	0.25	57.95
10	K. Chipsona-1	*	2.5	-	-	*	2.5
11	K. Surya	0.08	15.38	-	-	0.08	15.38
	Total	**1.28**	**226.38**	**2.4**	**478.51**	**3.68**	**704.89**
Gwalior							
1	K. Lauvkar	0.2	28	0.3	48	0.5	76
2	K. Sindhuri	0.07	7	0.22	32	0.29	39
3	K. Chandramukhi	0.02	2	0.05	6	0.07	8
4	K. Chipsona-1	0.01	0.7	0.01	3	0.02	3.7
5	K. Chipsona-3	0.01	2.35	1.31	220	1.32	222.35
6	K.Jawahar	0.01	0.8	0.01	1.5	0.02	2.3
7	K. Surya	0.1	15	0.03	10	0.13	25
	Total	**0.42**	**55.85**	**1.93**	**320.5**	**2.35**	**376.35**
Patna							
1	K. Pukhraj	0.20	48.50	0.55	93.95	0.75	142.45
2	K. Kanchan	0.08	9.00	1.15	197.93	1.23	206.93
3	K. Ashoka	0.10	18.00	0.60	122.27	0.70	140.27
4	K. Surya	0.00	0.00	0.05	9.35	0.05	9.35
5	K. Jyoti	0.12	25.00	0.50	97.00	0.62	122.00
6	K. Chipsona-3	0.02	4.90	0.25	32.45	0.27	37.35
7	K.Pushkar	0.02	3.50	-	-	0.02	3.50
8	K. Sindhuri	0.02	5.00	-	-	0.02	5.00
9	K. Khyati	0.02	5.00	0.05	9.65	0.07	14.65
	Total	0.58	118.9	3.15	562.6	3.73	681.5
G. Total plains (A)		**9.26**	**1621.68**	**39.02**	**9573.51**	**48.28**	**11195.19**
Kufri							
1	K. Jyoti	0.02	4.25	0.08	13	0.1	17.25
2	K. Himalini	0.06	8.15	0.5	73	0.56	81.15
3	K. Giriraj	0.03	2.2	0.2	7	0.23	9.20
5	K. Kanchan	0.01	0.5	0.05	3.8	0.06	4.30
6	K. Shailja	0.05	6	-	-	0.05	6.00
7	K. Girdhari	0.03	3.5	0.27	46.4	0.3	49.90
8	K.Himsona	-	-	0.02	1.9	0.02	1.90
G. Total hills (B)		**0.20**	**24.60**	**1.12**	**145.10**	**1.32**	**169.70**
Grand total (A+B)		**9.46**	**1646.28**	**40.14**	**9718.61**	**49.60**	**11364.89**

Table 4. Agency wise total breeder seed supplied during 2010-11 (quintals)

State/ Agency	Kufri Bahar	Kufri Jyoti	Kufri Pukhraj	Kufri Chip.3	Kufri Chip.1	Kufri Badshah	Kufri Sindhuri	Kufri Surya	KCM	Kufri Anand	Kufri Himsona	Kufri Kanchan	Kufri Lauvkar	Kufri chip.2	Kufri Sadabhar	Kufri Arun	Kufri Sutlej	Kufri Himalini	Kufri Ashoka	Kufri Girdhari	Kufri Pushkar	Kufri Shailja	Kufri Giriraj	Kufri Khyati	Kufri Frysona	Total
UP	4668.5	-	400	613	479	382.5	368.5	280	80	422	18.5	291	-	-	-	-	54	-	-	-	-	-	-	-	-	8057
Punjab	30	120	325	60	-	100	20	94	120	-	-	-	50	-	40	80	12	-	5	-	3.6	-	-	-	-	1059.6
Haryana	-	-	70	-	-	56	-	65	-	63	56	-	-	-	-	-	13	-	-	-	6.3	-	-	-	-	329.3
H.P	-	1080	-	-	-	-	-	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	1158
M.P	-	156.5	-	135.5	160	-	60	-	72.5	-	37.5	-	190	92	-	-	-	-	-	-	-	-	-	-	-	904
W.B	-	507	130	5	-	-	-	-	85	-	-	-	-	10	-	10	-	-	22	-	-	-	-	-	-	769
J&K	-	301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	7	-	-	320
Bihar	-	5.4	439.5	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	476.9
Jharkhand	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5
Chattisgarh	-	-	230	90	-	-	-	-	-	-	-		-	-	-	-	-	-	18.5	-	-	-	-	-	-	338.5
Arunachal Pradesh	-	15	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	2	-	-	-	-	-	27
Nagaland	-	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	27
Sikkim	-	20	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	20	-	-	-	40
Uttaranchal	-	20	-	-	-	-	-	-	-	-	20	10	-	-	-	-	-	40	-	25	-	-	15	-	-	130
Meghalaya	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
Manipur	-	40	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	13	-	-	-	65
Gujarat	-	-	-	-	-	32.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.3
NSC	175	356	150	50	-	100	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1031
SFCI	50	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	84
NHRDF	-	-	30	-	-	-	-	100	-	-	-	25	-	-	-	-	-	-	-	-	-	-	-	-	-	155
FOC/ICAR	17.4	73.52	119.18	58.51	11.06	3.27	-	196.09	1.38	17.55	19.9	0.4	8.05	0.5	15	0.5	0.01	4.9	2.49	4.9	7.29	2.9	2	0.2	-	567
University	-	5.35	65.5	0.55	0.1	7.1	-	0.1	0.1	-	-	-	-	-	-	-	0.1	-	-	-	0.1	-	-	-	-	79
PVt./Farmers	1080.5	1056.11	942.44	273.65	406.7	214.48	407.83	269.88	253.62	147	425.2	43.4	81	178	132	101.53	5	11.95	0.01	13.3	26	0.7	1.95	-	-	6072.25
Auction/Market	699.5	5.23	170.54	106.53	18.41	36.08	-	30.8	0.49	39.55	29	2.95	-	7	64.1	1.25	14.3	-	1.05	-	0.05	-	-	3.2	2.5	1232.53
Total:	**6720.9**	**3860.11**	**3073.66**	**1420.74**	**1075.27**	**931.73**	**856.33**	**1035.87**	**883.09**	**689.1**	**606.1**	**394.75**	**329.05**	**287.5**	**251.1**	**193.28**	**98.41**	**70.85**	**53.05**	**45.2**	**43.34**	**36.6**	**33.95**	**3.4**	**2.5**	**22995.88**

* Area negligible

V) Revenue generated in Revolving Fund Scheme (RFS):

During the financial year 2010-11, an amount of Rs. 4,10,52,585 was generated from the sale of breeder seed of potato and the recurring expenditure was Rs. 2,99,26511 under RFS as per the record of audited balance sheet.

VI) Production and supply of quality seed:

A total production of 1758.07q was achieved in 14.30 hactare area at CPRS, Ooty and Shillong out of which 1159.87q has been supplied. At CPRS, Shillong a production of 594.87q quality seed has been obtained in an area of 4.96 hactare out of which 348.07q has been supplied. At CPRS, Ooty, a production of 1163.2q quality seed has been obtained from an area of 9.34 hactare out which 811.80q seed has been supplied. The productivity of quality seed at Shillong and Ooty was 119.3 and 124.54q/ ha respectively. The revenue generated was approximately Rs. 5.27 lakh and Rs. 16.70 lakh, respectively.

VII) Production of rotational crop:

About 92.69 hactare area was planted at all the regional centers with rotational crops comprises of wheat, moong, bajra, dhaincha, gram, lentil, mustard, bean and tea through which a revenue of Rs. 33.46 lakh was generated for the institute.

VIII) Health status of nucleus seed crop

Modipuram: The health status of all the cultivars was higher (92-100%) in tuber indexing. The percentage of healthy clones was found 89.82 to 100% when samples from stage-I were tested. During tuber indexing as well as stage – I testing, maximum incidence was recorded due to PVM (1.7 and 1.67) followed by PVX (1.2 & 0.54) and PVS (0.62 & 0.48). Among the cultivars, Kufri Chipsona-1 (8.0%) had maximum virus incidence followed by Chipsona-3 (6.70%) during tuber indexing, whereas in Kufri Surya (10.2%) during stage-I testing.

Jalandhar: The health status ranged between 97.9 to 100% during tuber indexing. The health standards of all the varieties were decreased from tuber indexing to stage-I (88.6 -100%), Kufri Chandramukhi (13.3%) and Kufri Surya (5.8%) was maximum infected with PVY.

Gwalior: The health status of all the cultivars ranged between 96.5 to 97.8% during tuber indexing, while percentage of healthy clones was found 96.1 to 98.0% in stage-I crop. In tuber indexing maximum infection was found due to PVS (1.47%) and PVY (1.15%), whereas in stage-I, maximum incidence was recorded due to PVS (2.3%) followed by PVX (1.0%) and PVY (0.8%).

Patna: The health status ranged between 91.82 to 95.03% in tuber indexing, while in stage-I crop 95.44 to 99.37% clones were found healthy.

Kufri/Fagu: During tuber indexing all clones were found free from all the viruses. However, in stage – I crop virus incidence was detected in cultivars Kufri Girdhari and Kufri Jyoti.

1. Integrated approach for maximization of breeder/ quality seed potato production in India

1.1. Comparison of crop raised with tissue culture v/s conventional seed tubers

At Modipuram campus, the growth parameters were recorded at par in conventional and tissue culture crops. All the cultivars grown as stage –3 and 4 crop performed better in comparison to generation 1 and 2 crops but statistically these were at par. Among the cultivars Kufri Pukhraj gave highest total tubers yield followed by Kufri Bahar and Kufri Sadabahar. As far as production of number of tubers is concerned, significantly higher numbers of seed tubers were recorded in generation 1 and 2 crops over stage 3 and 4 crops. Tissue culture grown crops were found much healthier than conventional seed crops. Generation -1 crop was found 100% healthy and only 8.3% plants were found infected in Generation – 2 crop when tested through ELISA for six potato viruses. While in conventional crops, 2.8% and 16.7% infection was found in stage–3

and stage- 4 crops, respectively.

At CPRS, Kufri crop raised with tissue culture and conventional seed tubers did not had any significant effect on plant height, number of shoots, compound leaves per plant, percent ground cover at 75 DAP, haulms weight per plant (120 DAP), number of tubers and tubers yield per ha. However, at 105 DAP, per cent ground cover varied significantly within stages as well as among varieties (table 5). Lower haulms weight in Stage III and IV of K. Jyoti at 120 DAP indicates early maturity of the crop raised from conventional seed. However, with other two varieties the differences among different stages were not that apparent. It indicates that the production potentiality of potato crop raised from two different seed sources is same within the variety and differences, if any, may be due to variation in genotype. However, at CPRS, Jalandhar more number of stems in G1 and G2 crop was recorded as compared to Stage III and IV crop.

Table. 5. Plant height and yield in potato crop raised from two different seed sources.

Variety	Plant Height (cm) 75 DAP					No. of tubers (lakh/ ha)					Yield (q/ ha)				
	G1	III	G2	IV	Mean	G1	III	G2	IV	Mean	G1	III	G2	IV	Mean
K. Jyoti	57.9	36.6	52.4	50.9	49.5	4.1	5.2	4.0	5.8	4.8	323.8	305.4	350.0	402.8	345.5
K. Himalini	70.3	73.3	76.5	77.5	74.4	5.8	4.3	5.1	4.9	5.0	496.5	459.5	476.4	482.7	478.8
K. Girdhari	78.0	76.1	67.3	72.4	73.5	5.2	5.0	4.3	4.1	4.7	346.9	335.0	305.9	313.3	325.3
Mean	68.7	62.0	65.4	66.9	-	5.0	4.9	4.5	4.9	-	389.1	366.6	377.4	399.6	-
Factor	(V)	(S)		VxS		(V)	(V)		VxS		(V)	(V)		(V)	
CD 0.05	8.0	N.S.		N.S.		N.S.	N.S.		0.8		37.7	N.S		N.S	

It is apparent that incidence of both the soil borne diseases viz. common scab and black scurf was slightly more in the seed crop grown through conventional system (Stage - III and IV) in comparison to the crops raised through hi-tech. system i.e. G-1 and G-2. Among the varieties, incidence of common scab was found to be minimum (12.0%) in Kufri Himalini than other two varieties, whereas, incidence of black scurf was minimum in Kufri Jyoti (4.0%) and maximum (7.2%) in Kufri Girdhari.

At CPRS, Gwalior in Genartion 1 and 2 total number of seed tubers were higher than their counterpart Stage III and IV in all the varieties. Howerver, in Kufri Sindhuri and Kufri Chandramukhi seed yield was higher in Genartion 1 than its counter part stage III (Fig.2). But among Gen-2 and stage IV, it was at par in K. Sindhuri. Number of rejected diseased plants through ELISA test were highest in stage-III (3.2%) and stage IV (4.4%) than their counterparts G-1(1.0) and G-2 (1.9).

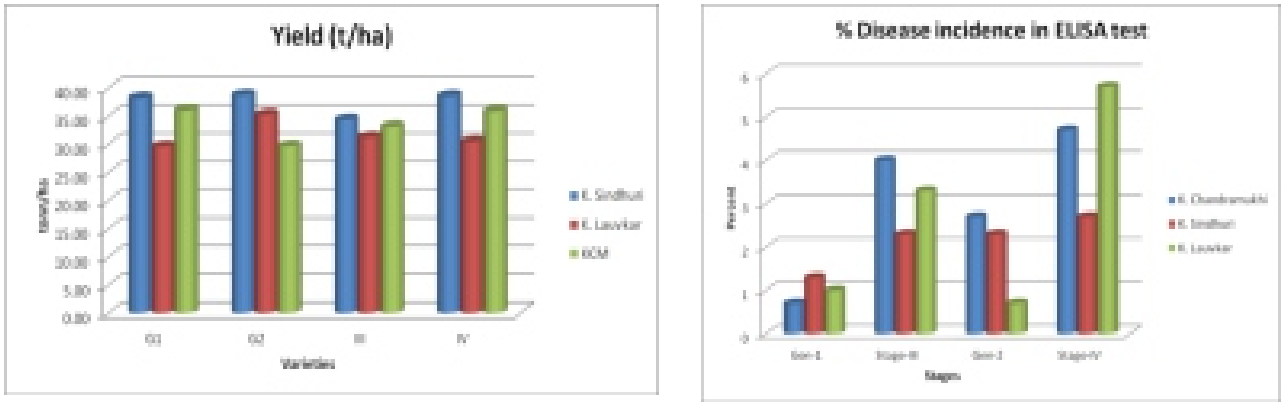


Fig. 2. Comparative performance in hightech and conventional system

1.2. Exploring possibilities for early planting of seed potato crop

At Jalandhar the early crop was planted on 21st September, while main crop on 10th October in 2011. Damage by thrips leafhoppers and mites was a major problem in early planted crop. Damage in different varieties varied from 9.64 - 23.64% in early planted ware crop of potato, while only 1.75 to 18.16% damaged was observed in main ware potato crop. Similarly, the insect damage ranged between 7.0 and 18.16% in the early seed crop as compared to 0.01 to 1.25% in main seed crop. Total yield obtained in early crop in various potato cultivars was significantly low and ranged between 6.06 and 31.69 t/ha as compared to 26.48 to 48.87 t/ha in crops planted on normal dates (Fig. 5).

At Gwalior, normal planted crop took 8 days for emergence while early planted crop took 13 days. Tuber production by number as well as by weight was higher in normal planted crops. Incidence of early blight was recorded only in early planted crops (up to 0.5%). Stem necrosis incidence was higher (12.8 to 34.1%) in early planted crops as compared to normal planted crops (5.6 to 8.7%).

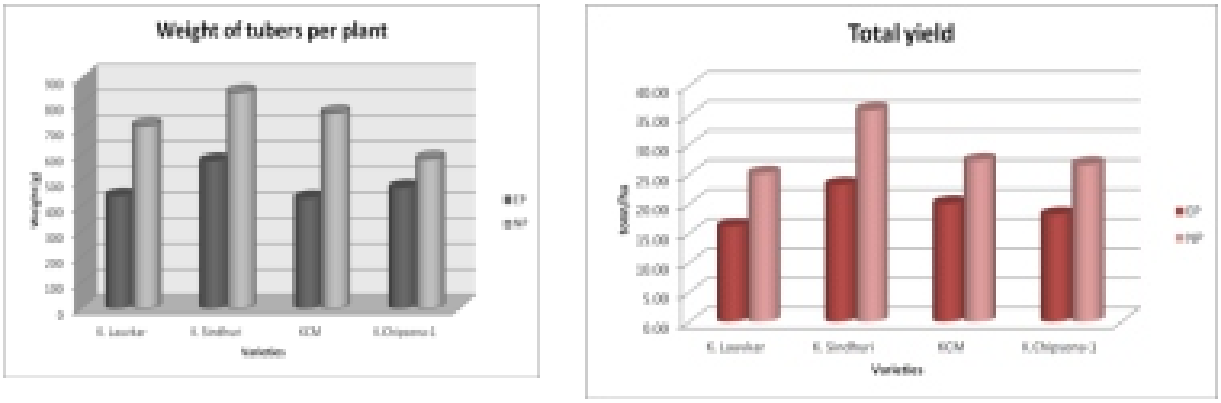


Fig. 5. Effect of early planting on weight & yield

1.3. Monitoring of aphid population build up in seed crop during crop season

There was no appearance of aphids in seed crop during crop period in all the varieties at Kufri. At Jalandhar, population of Aphis gossypii and whiteflies increased till 4th week of November which declined later in December. Population of M. *persicae* in unsprayed crop attained critical limit of 20/100 compound leaves in the last week of December.

1.4. Virus profiling in different potato growing regions

For this purpose samples were collected from Hassan and Chikmangloor districts of Karnataka and analysed through ELISA for six viruses. The results revealed that 64.9% plants were found infected at least by one virus in Hassan district while 91.9% plants were found infected in Chikmangloor district when tested. In Hassan district maximum infection was found due to PVX (49.1%) followed by PVY (26.3%), PVS (17.5%), PVM (5.3%) and PLRV (5.3%). In Chikmangloor district PVY was dominant with an infection level of 75.7% followed by PVS (24.3%), PVX (18.9%) and PVM (2.7%). Visual symptoms of mosaic were shown higher in Hassan district (8.25%) compared with Chikmangloor district where mosaic symptoms were appeared only on 5.33% plants.

Virus profiling survey revealed that 22.7% samples were healthy in the surrounding areas of Fagu and Kufri. Among the infected samples, maximum infection was found due to PVX (48.5%) followed by PVS (40.4%) while minimum infection was due to PVA (0.5%). In Una area, all the seven samples were found infected at least by one virus. Similar to Fagu and Kufri area, maximum infection was found due to PVX (85.7%) followed by PVS (57.1%), but all samples were found negative for PVM, collected from Una area.

Survey of district Jalandhar, Hoshiarpur, Kapurthala and Amritsar revealed that mild mosaic was most predominant in all localities and its incidence ranged between 0 and 86.6% in different fields. It was prevalent in 45 out of 47 field surveyed. Severe mosaic was the next most prevalent and its incidence ranged between 0 and 76.0%. The disease was present in 35 out of 47 fields (table 6). Apical leaf curl virus incidenc ranged between 0 and 70% and it was observed in 27 out of 47 fields. Plants exhibiting bright yellow spots caused by Aucuba mosaic virus were also noticed (0.01% incidence) in a few fields.

Table. 6. Average incidence of different viruses in farmers' field in Punjab

Village	District	Mild Mosaics (%)	Severe Mosaics (%)	PLRV (%)	PALCV (%)	Other Viruses (%)
Dhand Rohera	Hoshiarpur	86.6	46.6	15.0	60.0	2.3
Shyamchwarasi Road side-1	Hoshiarpur	56.0	22.3	6.0	21.6	3.3
Shyamchwarasi Road side-2	Hoshiarpur	76.6	76.0	2.3	70.0	9.3
Thankot	Amritsar	36.6	17.0	7.6	3.0	1.3
Kartarpur/Sareha	Jalandhar	70.0	17.0	10.3	17.0	4.0

Survey of Gwalior district revealed that the incidencery new disease ranged from 10 to 70% in Kufri Surya was observed in Agronomy trials and a little incidence was also observed in stage- IV crop. Symptoms were bright yellowing from the lower corners of leaflets The disease disappeared after some time. At later stage clear veinal necrosis symptoms were observed in variety Kufri Lauvkar stage . Only PVA was detected from all the 3 samples. PLRV was detected in one sample from Rabbani School, Suserakothi in Gwalior district. Out of 52 samples, PVX was detected in 6 samples, PVS in 8, PVA in 8, PVM in one and PLRV in one sample.

1.5. Management of soil and tuber-borne diseases in seed crop

A sharp decrease in incidence of russet scab and black scurf was observed at Jalandhar when seed crop was grown in plots subjected to Potato-green manure-wheat crop-Potato rotation together with the use of seed treated with 3% boric acid. Potato cultivars Kufri Jyoti grown in such plots revealed a low incidence (5.6%) of russet scab and 8.0% black scurf whereas, incidence of russet scab was 17.8% and black scurf 14.3% in plots where the same variety was grown without the wheat crop in the same rotation. Similar trend was observed with potato cultivars Kufri Badshah and Kufri Chipsona- 3. The experiment conducted at Shimla revealed that boric acid (3%), monceron (0.3%), captan (0.3%), mancozeb (0.4%) and carbendazim (0.3%) were found equally good and can be used for the management of black scurf disease in the hills.

1.6. Effect of minituber treatment with biopesticides on plant vigour and post harvest storage behaviour of different potato varieties

Results revealed that plant height and number of leaves/ plant in Kufri Badshah and Kufri Chipsona-3 was increased by *Trichoderma. viride* (1.5%) as compared to untreated control. *T. viride* (1.5%) also resulted in highest fresh weight of sprouts in Kufri Chipsona-3 and Kufri Badshah while slightly higher dose (2%) proved better for Kufri Bahar and Kufri Kanchan. The sprout length was higher in Kufri Chipsona-3 and Kufri Badshah treated with *T. viride* (1.5%). Tubers harvested from T. viride (1.5-2.0%) treated minitubers produced significantly higher dry weight. After five months of storage tubers treated with *T. viride* (1.5%) resulted less shrinkage and driage. It is concluded from the present findings that biopesticide priming of minitubers promoted vegetative growth of the plant and resulted better post harvest storage in terms of vigor of sprouts, and weight loss of tubers in comparison to untreated control as well as to that of chemical fungicides.

2. Seed potato production through aeroponic system at Modipuram

2.1. Performance of different potato cultivars in aeroponic system

Among the varieties Kufri Bahar took minimum days (39 days) for first harvest whereas, Kufri Frysona took 63 days. Kufri Sadabahar recorded maximum number (54.3) as well as yield (202g) of tubers/plant. Kufri Khyati recorded minimum number whereas, Kufri Himalini the minimum weight of tubers/plant. Yield of tubers/plant was recorded 83.07 g while mean tuber weight ranged from 2.31 to 3.72g.

2.2. Effect of spacing and harvesting interval on minituber production in aeroponic system

Maximum number and yield of tubers per plant as

Fig. 6. Aeroponic system & seed products

well as mean tuber weight were obtained at 20 × 20 cm spacing and minimum at 10 × 10 cm plant spacing(Fig.6). Effect of harvesting interval revealed that maximum number (17.6) of tubers/plant was obtained from minimum harvesting interval (3 days) and thereafter the number of tubers/plant were almost same for 7, 10

and 14 days interval. However, maximum yield of tubers per plant (128.04 g) was obtained from no picking. Mean tuber weight increased with the increase in harvesting interval.

2.3. Field performance of aeroponically produced mini tubers

Results revealed that germination (%), plant height, number of stems and leaves per plant were not affected significantly due to change in planting pattern. Number (71) as well yield (2.06 kg) of tubers /m^2 was recorded significantly higher when three rows were planted on a raised bed compared with two rows, while tubers yield/ plant (146.7g) was achieved significantly higher in the beds where only two rows were raised. Although number of tubers/ plant were also higher at two rows/ bed, but the difference was non-significant. Number as well as yield of tubers/ m^2 decreased significantly with increase in in-row distance. Highest yield of 2.06 kg/m^2 was recorded at 10cm in-row distance which decreased to 1.55 kg/m^2 at 20cm. In case of three rows treatments yield of tubers increased from 2.04 kg/m^2 to 2.30 kg/m^2 with increase in in-row distance from 10cm. to 15cm. and then decreased to 1.83 kg/m^2 at 20cm in-row distance.

3. Augmenting micropropagation potential of potato cultivars

3.1. Grouping of the potato cultivars based on in vitro response.

As per the results obtained from the study, varieties Kufri Ashoka, Kufri Badshah, Kufri Girdhari, Kufri Himalini, Kufri Megha, Kufri Sindhuri and Kufri Surya were classified as fast growing (>8cm), Kufri Arun, Kufri Chandramukhi, Kufri Khyati and Kufri Pukhraj were in the medium growing (6-8 cm) group, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3, Kufri Chipsona-4, Kufri Gaurav, Kufri Frysona, Kufri Himsona, Kufri Jawahar, Kufri Kanchan, Kufri Lauvkar, Kufri Pushkar and Kufri Shailja were slow growing (4-6 cm) whereas, Kufri Sadabahar and Kufri Jyoti were in the non-responsive/recalcitrant group (<4 cm).

3.2. Influence of growth hormones on in vitro performance of different potato cultivars

The experimental results revealed that after five cycles of sub-culturing the medium prepared with and without growth regulator had significant effect on microplant height, number of leaves, number of nodes and root length. However, there was no significant effect due to medium prepared with and without growth regulator on inter-nodal length, number of roots, fresh and dry weight. Cultures grown on the medium without growth regulator produced more microplant height, number of leaves and number of nodes (Fig. 7).

Fig. 7. Growth harmone effect on microplants

3.3. Influence of rooting hormones on in vivo performance of potato microplants

At Shimla, significant differences due to cultivar, treatment and their interaction were observed on all the characters studied in upper portion of microplantlets (Fig.8). In general, upper portion of microplantlets treated with IBA 125 ppm resulted better establishment, number of roots as well as root length and was found to be at par with standard control (rootex). Whereas, lower portion of microplantlets treated with IAA 125 or IBA 250 or NAA 125 ppm resulted maximum establishment and root length which was also found to be at par with standard control (rootex). At CPRS, Jalandhar in K. Khyati it was inferred that IAA at 500 ppm or IBA at 250 yielded significantly higher tuber numbers and weights per plant as compared to microplants with intact roots, while NAA at 250 ppm yielded significantly lower tuber weight per plant. No significant differences were observed for survival rates as compared to control.

Fig. 8. Rooting harmone effect on in vitro microplants

3.4. Study on effect of biopesticides on in vivo establishment, vigour of microplants and their yield potential

At Shimla, experiment with Kufri Girdhari in net house revealed that treatments were significant for the establishment percentage after 35 and 70 days of planting, number of tuber per plant and line as well as weight of minituber per line. Out of eleven treatments, *T. viride* @ 2% resulted highest survival of 93.3% as compared to 60% in control. In another experiment with moicroplants of Kufri Jyoti in poly house gradual wilting/root rotting increased in control and only 15.6% plants survived after 60 days of planting in comparison to 66.7% in *P. fluorescence* (2%). Higher plant height and weight of minitubers was recorded in *T. viride* (1%)treated plants which was at par to *P. fluorescence* (2%). The number of minituber and weight of minituber was significantly highest in *P. fluorescence* (2%) in comparison to control (Fig. 9). In general, efficacy of P. fluorescence (2%) for most of the parameters was better than *T. viride* (1%).

Fig. 9. effect of P. fluorescense on K.Jyoti

At Jalandhar, effect of six microbes on establishment of microplants and yield revealed that application of Azoxystrobulin 0.25 for 10 minute dip was the best treatment with 100% survival, maximum number of tubers per plant (15.8) and yield (232.4q).

3.5. Study the photoautotrophic micropropagation in plants

Presence of agar in solid sugar free nutrient medium caused fungal and bacterial contamination while liquid medium was prone to algal growth which strongly restricted the growth of microplants. Significantly vigorous growth was achieved when photo autotrophic micropropagation was carried out in presence of peat moss medium. The plants grown in photoautotrophic chamber showed significantly higher growth rates as compared to photoautotropically grown microplants in test tubes and magenta boxes.

3.6. Standardizing priming and pelleting techniques for improved storage and germination potential of microtubers

The results indicated that the microtuber weight loss was significantly reduced over control in all the polymer coated treatments from 30 days of storage onwards. The lowest weight loss was recorded in Chitosan 1% treatment which was almost 50% less than that of control. Sprout thickness was improved with Chitosan treatment with maximum value being in 1.0 per cent concentration (8.95mm). Chitin had shown negative effect on improving the thickness of sprouts in comparison with control. Sprout length did not differ significantly with the application of polymers.

However, the increased concentration of Chitosan showed a reduction in sprout length. In field performance of these treated microtubers, Chitosan performed better in terms of stand establishment, tuber number as well as yield.

At Shimla, effect of biopesticide priming on microtubers sprouting behaviour at ambient temperature revealed that there was no adverse effect of high dose of *Trichoderma viride* (3%), *Pseudomonas fluorescence* (3%) and mancozeb

(0.4%) on sprouts growth, shoot and root development of microtubers. The vigour and health was much better in bioagent treated microtuber than mancozeb as well as control after seven days of the treatment (Fig.10). The sprouts were detached and re-sprouting behaviors in microtubers were recorded after 12 days of detachment. The average resprouts length comprised of root and shoot was 7.6 cm in Kufri Bahar and 10.7 in Kufri Frysona in comparison to negligible growth in control.

3.7. Study on the effect of hardening duration on in vivo micro-plant establishment, plant growth and mini-tuber production

Increasing durations of hardening did not influence the establishment of micro-plants however, plant height, number of shoots and haulms weight affected positively. Increasing duration of hardening from 1 to 3 weeks was useful in improving the number and yield of mini-tubers per unit area, however, it did not affect the grade of mini-tubers significantly.

Fig. 10. effect of Biopesticites on microtuber germination

Division of Social Sciences

Impact of potato production technologies developed by the institute

Impact of micro-irrigation technology on the farmers' socio-economics

Micro-irrigation technology has been widely discussed as an important tool for breaking stagnating yields and ensuring second green revolution. Various benefits of this technology were also advocated by the industry as well as other sections of the society directly or indirectly related to potato crop. Madhya Pradesh (MP) and Gujarat being the important adopters of this technology were selected as the states comprising study area. Indore district of MP and Anand-Khera (single pocket as most potato crop are lies on the borders of these two districts) and Banaskantha of Gujarat were selected districts.

Table 1. Potato area and per cent yield enhancement due to micro-irrigation.

State(s)	Particulars	Drip irrigation	Sprinkler irrigation	Total micro irrigation
Gujarat	Potato area (%)	13.12	14.79	27.91
	Yield enhancement over furrow irrigation (%)	33.41	20.17	26.39
MP	Potato area (%)	18.16	4.92	23.08
	Yield enhancement over furrow irrigation (%)	23.40	6.67	19.83

High expenses on the adoption of micro irrigation technology is the first thought on the mind of a farmer. However, average annualised cost of cultivation of potato farmers having micro-irrigation technology was estimated after taking care of government subsidy, down payment and bank loan etc. It was found that the cost of potato cultivation under sprinkler and drip irrigation systems, respectively, was 12 and 20% higher than the cultivation under furrow irrigation in Gujarat state. However, the benefit cost ratio of potato cultivation under furrow, sprinkler and drip irrigation systems was 1.37, 1.52 and 1.97, respectively. The gap in this ratio was affected by higher yield and per unit prices of the produce under micro-irrigation compared to the furrow irrigation. The per hectare yield of potato on drip and sprinkler irrigated farms was 33 and 20% higher compared to the furrow irrigation system in the state of Gujarat. The gap in yield and profitability was lower in MP compared to Gujarat.

Availability of canal water (6% non adopter respondents), costly micro-irrigation installation (30% non adopter respondents) and adjustment leading to convenience in the old set-up (64% non adopter respondents) were the principal constraints in the way to adoption of micro irrigation technology in the study area. The sprinkler adopters elicited better yield (22% adopters), cheaper than drip irrigation (13% adopters), compulsion under contract farming (12% adopters), water saving (19% adopters) and continuous pursuance by marketing companies

(34% adopters) as the reasons for adoption of this technology. Similarly, the adopters of drip irrigation cited government subsidy (28% adopters), water saving (18% adopters), higher crop yields (27% adopters), better quality of potato tubers (21% adopters) and fertilizer saving (6% adopters) as main reasons for adopting this technology.

Analysis of adoption pattern and technology gap in important potato growing areas

There is no dearth of improved agricultural technologies in India, still, the gap exists between recorded yield at experimental plots and yield at farmers' fields for many crops. CPRI developed many high yielding improved potato varieties and modern technologies. These varieties and technologies were demonstrated at farmers' fields during the year 2011-12 at various locations in different parts of the country. Under this project altogether 56 on-farm technology demonstrations were laid out, of which 10 were in UP, 16 in Bihar, 15 in Shimla and 15 demonstrations were laid out in Meghalaya. The recommended varieties and technologies of CPRI were demonstrated and compared with farmer's practices of potato cultivation.

Demonstration of improved varieties and technologies at farmer's field

In Himachal Pradesh, three improved varieties of potato i.e. Kufri Girdhari, Kufri Himalini and Kufri Shelja were given to the 15 farmers in three villages of Shimla district namely Talai, Bekhalti and Shoghi during 2011-12. These varieties were raised using recommended package of practices of potato developed by CPRI under the observation of CPRI scientists. Farmers planted Kufri Jyoti as a control plot using their own practices. Data revealed that incidence of early blight was observed in control plot of Kufri Jyoti to the extent of 20-25% while none of the three varieties of demonstration plot showed any symptom of early blight. The incidence of late blight was observed in control plot of Kufri Jyoti to the extent of 15% while none of the three varieties of demonstration plots showed any symptom of late blight. In case of white grub infestation, it was found in Kufri Girdhari, Kufri Himalini and Kufri Shailja to the extent of 20-25% while in Kufri Jyoti it was 30-35% infestation of white grub. Thus new varities of CPRI performed better and showed less symptoms of diseases and pests. Yield level of Kufri Himalini (21.5 t/ha) and Kufri Shailja (17.5 t/ha) were found to be higher than Kufri Jyoti (17.0 t/ha). Kufri Himalini recorded 26.47% higher yield than K. Jyoti. Thus, it can be concluded that there was significant increase in yield of potato by using high yielding varieties and recommended package of practices.

Demonstration plots in Shimla

Healthy crop of potato at farmers field in Meerut (UP)

In Uttar Pradesh, 10 field demonstrations were conducted in three districts namely Meerut, Panchsheel Nagar and Muzaffarnagar. Five farmers planted Kufri Frysona and another five planted Kufri Khyati with Kufri Bahar as check. Three demonstrations were conducted on late blight management with planting of late blight resistant variety Kufri Frysona. In Kufri Frysona, 14.97% yield was increased over the control plot. Three demonstrations on cutworm management were also conducted and recommended practices were applied i.e. 2 sprays of Chloropyriphos (drenching on ridges) @ 0.20 % at 20 and 50 DAP. Farmers did not apply any chemical in their control plot. So they got 2.5 % tuber damage at harvest. No cut worm damage was observed in sprayed crop under the recommended practices. Under three demonstrations conducted for cutworm management overall 9.62% yield increased under recommended practices over the control. A total of four field demonstrations were conducted on balanced fertilizer dose. Recommended doses of fertilizers 180:80:100 NPK kg/ha for Kufri Khyati and 270:80:150 NPK kg/ha for processing cultivar Kufri Frysona was applied as basal and as top dressing. It was observed that farmers of this region are using unbalanced dose of fertilizers through DAP, MOP and NPK (12:32:16) as basal and urea as top dressing. Highest tuber yield (341.18 q/ha) was obtained from Kufri Khyati followed by Kufri Frysona (300.08 q/ha). The lowest tuber yield (276.92q/ha) was recorded under farmers practices in variety Kufri Bahar.

In Bihar, 16 varietal demonstrations were laid out in Bhojpur district. 7 farmers planted K. Ashoka and 9 planted K. Frysona in their plot against the check C-40. The incidence of late blight in K. Ashoka and K. Frysona was 0.35 and 0.42% respectively, while farmer's variety C-40 recorded 1.9% incidence. It was observed that almost all the farmers of this area are using very high dose of fertilizer i.e 250:180:120 Kg NPK/ha against the recommended dose of 150:80:100 kg NPK/ha. The yield of K. Ashoka (23.8 t/ha) and K. Frysona (22.3t /ha) was 24.6% and 16.7% higher than yield of control variety C-40 (19.1 t/ha).

In East Khasi hill district of Meghalaya, a total of 16 demmstrations were laid out on balanced fertilizer dose, white grub management and late blight management. Improved package of practices were applied on these plots and results were compared with farmer's practice. There was 84.28% increase in yield of K. Jyoti with recommended dose of fertilizers over farmer's practice. Similarly, K. Giriraj (13 t/ha) recorded 18.66% higher yield with recommended management of white grub as compared to no management (10.96 t/ha) at farmer's field. In case of management of late with chemicals, K. Jyoti (16.4t/ha) gave 96.52% higher yield than control plot (8.38 t/ha).

In addition to above mentioned activities, a survey of potato growers in three districts of HP namely Shimla, Mandi and Kangra was also conducted under this project in which more than 90 farmers

were interviewed regarding adoption pattern of potato technologies and constraints in potato cultivation and marketing. Tabulation and analysis of data is going on.

Impact of Extension Training

Two model training courses were conducted during the period under report. The first one on "Production for processing potato and post harvest technologies" was organized from 20-27 Sep, 2011 at CPRI Shimla to improve the knowledge and skill of extension officers working in state departments of agriculture/horticulture. The training course was attended by 20 participants from 12 states. A variety of methods of training were used to provide rich learning experience to the trainees. These included lecture-cum discussion, practical sessions, field visits and video film shows. To assess the impact of training; pre and post training evaluation were conducted and the outcome was found to be quite impressive. It was found that after the training the overall knowledge of the participants was improved by 23%. Maximum gain in knowledge was in social sciences like Economics and Statistics (31%) closely followed by Crop Physiology and PHT (29%) and Crop Improvement (Plant breeding and bio technology) by 28%.

The second training "Healthy seed potato production-conventional vs hi tech" was organised from 14-21 October, 2011 at CPRI Shimla. The objectives of the training were to enrich the extension functionaries in seed production technologies. This training course was attended by 13 participants from 6 states. The same methodology of imparting the training was adopted and the trainees were well versed with latest techniques being adopted in seed potato cultivation. Overall gain in knowledge in this training was 21% with a massive gain in Crop Improvement (Plant breeding and bio technology) i.e. 48% followed by Processing and Storage (26%) and Crop Protection by 25%.

Transfer of Technology

Farmers training programmes at CPRI, Shimla Division of Social Sciences organized a number of training programmes for framers of different parts of the country. All the aspects of potato cultivation from planting to harvesting, storage and marketing were thoroughly covered during these trainings. The participants were exposed to a series of lectures on varietal selection for their respective areas, time and method of planting, disease and pest management, water management, harvesting, processing storage and marketing of potato in India. In these lectures multimedia presentations were used by the lectures with extensive use of photographs and other informative tools like live samples, making learning more interactive and informative. Besides this, field visits were also organized for farmers to CPRS, Kufri/Fagu where seed production was going on under the supervision of CPRI experts there by further widening the knowledge of participants by practically seeing and experiencing the operations being undertaken in the field to raise seed potato. The details of the trainings conducted during the period is given in the table below :

S. No.	Title of Training Course	Date & Duration	No.of Farmers/ Officers	Sponsoring Agency
1.	Production of processing potatoes and post harvest technologies	20-27 Sept. (8 days)	20	Directorate of Extension, GOI, New Delhi
2.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	11-13 Oct. (3 days)	24	जिला परियोजना प्रबंधाक (ULIPH) टिहरी गढवाल, उत्तराखंड
3.	MTC on Healthy seed potato production– Conventional vs High Tech.	14-21 Oct. (8 days)	13	Directorate of Extension, GOI, New Delhi.
4.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	24-26 Nov. (3 days)	20	परियोजना निदेशालय आत्मा, मधेपुरा, बिहार
5.	आलू बीज उत्पादन एवं विपणन प्रबंधान	29 Nov.-3 December (5 days)	20	राज्य कृषि प्रबन्धन संस्थान, सीमा, रहमानखेडा, लखनउ, उत्तर प्रदेश
6.	Healthy seed potato production – Conventional vs High Tech.	20-22 Dec. (3 days)	15	M/s Pepsico India Holdings Pvt. Ltd Gurgaon
7.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	2-3 March (2 days)	18	उत्तराखंड हिमालय आजिविका सुधाार परियोजना, चम्बा, टिहरी गढवाल,
8.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	20-22 Mar (3 days)	25	निदेशक, केन्द्रिय आलू अनुसंधान संस्थान, शिमला
9.	उन्नत तकनीक द्वारा बीज आलू उत्पादन	26 March (1 day)	32	निदेशक, केन्द्रिय आलू अनुसंधान संस्थान, शिमला
10	उन्नत तकनीक द्वारा बीज आलू उत्पादन	27 March (1 day)	40	निदेशक, केन्द्रिय आलू अनुसंधान संस्थान, शिमला

Farmers training programme at different CPRI Stations

A number of on campus and on farm trainings were held at CPRI stations situated across the country during the period under report. Brief description of these trainings and beneficiaries are as follows :

CPRIC, Modipuram

- Training on Advance technology for potato production for hill area of Uttranchal during 14-15 Oct. 2011 for 20 farmers
- Training on Use of sprinkler irrigation system in potato production on 17th Oct, 2011 for 25 farmer
- Training programme on Micro-Propagation technique in potato seed production during 19- 22 Oct, 2011 for 6 officers
- Training on Aloo beej Utpadan ke unnat takneek during 14-15 Dec, 2011 for 120 farmers

CPRS Jalandhar

- Potato seed production on 19th November, 2011 for 120 farmers
- Seed certification training programme on 12th December, 2011 for 29 farmers
- Post harvest management of ware and seed potatoes on 9th March, 2012 for 70 farmer
- Seed certification personnel of Punjab, seed certification authority on 23th March, 2012.

CPRS Patna

- 18 trainings on improved Scientific Cultivation of Potato for 695 farmers
- 3 trainings on TPS for 81 farmers

CPRS Muthorai Ootacamund

- One Training on Potato seed production during 29-09-2011

CPRS Shillong

- Post harvest management in Potato on 8th August 2011 for 50 farmers
- TPS technology for Potato production on 3rd September 2011 for 50 farmers
- Improved potato production technology 18-19 November, 2011 for 75 farmers
- Harvesting, post-harvest care and storing potato 7-8 December, 2011 for 80 farmers
- Improved potato production technology on 15th Feb, 2012 for 50 farmers
- Improved potato production technology 29th Feb, 2012 for 50 farmers
- Improved potato production technology 14th

Varietal Demonstrations in Hooghly district of West Bengal

Varietal demonstration at farmer's field is an effective method for showing farmers the superiority of new varieties over the existing ones. Two new varieties of potato namely Kufri Himalini

and Kufri Shailja were tested at farmer's field in Khanan village of district Hooghly (West Bengal). 50 Kg of Breeder seed of both K. Himalini and K. Shailja variety were provided by CPRI to the farmers to see the adaptability of these two hilly varieties. It was observed that both the varieties did not show any symptoms of diseases or pest except 1-2% cutworm infestation. There was late germination in K. Himalini and no. of tubers per plant was also less (8-9 tubers) as compared to K. Shailja (10-11tubers). As a result the yield level of K. shailja was found higher i.e. 222 qt/ha than K. Himalini (188 qt/ha). It was also observed that yield of these varieties were at par with other institute varieties like K. Jyoti, K. Anand, K. Surya, K. Bahar and K-22. Kufri Khyati produced higher yield i.e. 240 qt/ha than these two hilly varieties K. Himalini and K. Shailja.

Participation in Live phone in programme and radio talk on Doordarshan & AIR

The Institute was involved in potato technology dissemination throughout the year by means of its programme on AIR, Shimla and Doordardshan Kendra, Shimla. The expert scientists of different subjects took part in Live Phone-in-Programmes and chat shows. The detail of the topics covered with date and name of expert is given in Table 2.

S.No.	Date	Topic	Name of Expert
1.	11 April 2011	Seed preparation and planting of potato in higher hills of HP	Dr. Vinod Kumar Dr. Ashwani Kumar
2	11 May 2011	Earthing up and potato disease management in mid hills of HP	Dr Manoj Kumar Dr Sanjeev Kumar
3.	08 June, 2011	Harvesting and post harvest operations in mid hills of HP	Dr KK Pandey Dr Brajesh Singh
4.	12 July, 2011	Inter-culture practices in potato	Dr SS Lal
5.	August, 2011	Fungal, Soil borne disease and insect pest in potato in higher hills of HP	Dr Sanjeev Kumar Dr VK Chandla
6.	September, 2011	Harvesting and Storage of potato in higher hills of H	Dr Vinod Kumar Dr Brajesh Singh
7.	31 October, 2011	Field preparation and planting of potato in lower hills of HP	Dr SS Lal Dr Ashwani Kumar
8.	09 Nov., 2011	Fertilizer application in potato in lower hills of HP	Dr VK Dua
9.	21 Dec., 2011	Disease and pest management in potato in lower hills of HP	Dr Sanjeev Kumar Dr VK Chandla
10.	January, 2012	Planting of potato in mid hills of Shimla and other districts of HP	Dr SS Lal Dr PM Govindakrishnan
11.	February, 2012	Potato disease and pest management in mid hills of HP	Dr SK Chakrabarti Dr Sanjeev Sharma
12	March, 2012	Potato varieties for lower hills of HP	Dr NK Pandey Dr Vinay Bhardwaj

Activities of Agriculture technology information centre (ATIC)

Sale and distribution of CPRI technical and extension bulletins :

A total of 3797 technical bulletins were sold through ATIC along with a number of free Extension bulletins, CPRI brochures, Potato Crop Colander and several leaf-lets related to model potato technologies were distributed to the Scientists, Extension Workers and Farmers who visited CPRI during the period. Specially developed CDs of PPM (Potato Pest Manager)- 45 Nos. and CAASPS (Computer Aided Advisory System for Potato Crop Scheduling) – 33 Nos. were also sold through ATIC. Altogether this generated a revenue of Rs.1,21,410.00 for the Institute i.e. an increase of more than 100% over the last year's sale.

Dissemination of knowledge to visitors :

A museum has been set in where the technologies developed by CPRI has been displayed by means of display panels, live samples and models etc. The methodology and advantages of these technologies were explained by the ATIC staff to the visitors. The stake-holders who visited CPRI were benefited by strengthening their knowledge about potato cultivation. A total of 1306 stake holders visited the Institute during the said period. It included 452 B.Sc./M.Sc. students of various Universities of different states, 657 farmers from different states of the country and 197 scientists/ extension workers/state level agriculture & horticulture officers.

Film Shows : The visitors were made aware of the activities being undertaken in the institute by means of a documentary film "CPRI in tune with time" of 21 minutes duration. The farming community and others associated with potato cultivation in hills have been shown a 20 minutes documentary "Seed potato production in hills" specially meant for hilly regions of country. Since storage and post harvest handling is one of the major issues in potato one more documentary was added this year "Improved practices for potato storage". These documentaries proved highly beneficial to all the potato growers and people associated with potato cultivation. These documentaries are available in Hindi and English, as per requirement of the visitors. These documentaries helped the visitors to get acquainted with modern technologies in potato.

Participation in agricultural fairs and exhibition:

CPRI participated in many exhibitions, kisan melas, field days, kisan goshtis and industrial fairs organized in different parts of the country through ATIC. Modern potato technologies were show cased through institute stalls in these exhibitions and fairs. Thousands of farmers/entrepreneurs /extension workers etc. visited CPRI stall and got benefited. The visitors were distributed crop calendars, leaflets and extension bulletins free of cost. The list of the agricultural exhibitions and fairs held during the period is given in the table under:

S.No.	Name of fair/exhibition	Years	Location
1.	National Mushroom Mela	2011	DMR, Solan, HP
2.	Kisan Mela	2011	Kathnol, Distt. Shimla
3.	Horti-Expo	2011	Dehradun, UK
4.	India International Trade Fair	2011	Pragati Maidan, New Delhi
5.	All India Mango Show	2011	CISH, Lucknow, UP
6.	NAIP Exhibition	2010	CIPHET, Ludhiana
7.	Ludhiana & National Sugar Fest	2012	IISR, Lucknow, UP
8.	Pusa Kisan Mela	2012	IARI, New Delhi.
9.	Kisan Mela	2012	UP Agril. Dept., Meerut
10.	Akhil Bhartiya Kisan Mela & Krishi Udyog Exhibition	2011	SVBP, Univ. of Agril. & Tech., Meerut
11.	Agril. Exhibition	2012	CSWCR&TI Regional Station, Teetikkal, Ooty.
12.	Farmers Day	2011	CPRS, Ootacamund

Activities undertaken under Mini Mission: Under the project "Training entrepreneurs skills to the farmers in potato based farming system of HP" the responsibility of transfers of technology was under taken and altogether 9 on farm and on campus training were conducted during the period. The farmers in the state were sticking to there traditional cultivation practices and were facing number of problems and were bearing loses year after year. The purpose of these training was mainly to make the farmers aware to latest technology developed by CPRI and there by making their cultivation profitable. Also through these trainings marginal/ small farmers and farm women were trained towards value addition in potato for a better living. These training were conducted in different parts of Himachal Pradesh so as to maximize the impact of technologies developed by the institute. These training were conducted under the title **Advance techniques of potato and other vegetables cultivation** the details are as under:

Sr.No.	Particular	Dated	Venue
1	On campus training	19-20 April, 2011	CPRI Shimla
2	On farm training	3-4 May, 2011	KVK Kangra
3	On farm training	13-14 June, 2011	Nauhradhar, Sirmour
4	On campus training	7-8 Sep, 2011	CPRI Shimla
5	On farm training	11-12 Nov, 2011	KVK Una
6	On farm training	28-29 Dec, 2011	Gohar, Mandi
7	On farm training	16-17 Jan, 2012	Ghaini, Shimla
8	On farm training	17-18 Feb, 2012	Shoghi, Shimla
9	On campus training	27-28 Feb, 2012	CPRI Shimla

on campus training

on farm demonstration

Externally Funded Projects

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

In the seed component of the project, dipstick based detection kits developed for detection of PVX, PVS, PVM and PVY viruses. Dipstick assay was found more sensitive than DAS-ELISA. Twenty dipstick strips each for PVA and PVX were prepared and sent to regional stations and AICRP centers for validation.

In the processing component, work on water requirement of variety Kufri Frysona under micro-irrigation systems was initiated during 2011-12, where the cultivar recorded highest French fry (27.6 tonnes ha^{-1}) and total tuber yield (49.4 t ha^{-1}) at 75% CPE level in drip irrigation; while, in case of sprinkler irrigation cv. Kufri Frysona had highest French fry (14.2 t ha^{-1}) and total tuber yield (22.6 t ha^{-1}) at 125% CPE level. Five quintal seed per farmer of Kufri Frysona was supplied at five locations in Gujarat. Productivity with normal planting under micro- irrigation ranged between 45- 52 t/ha. Raw material at harvesting maintained excellent French fry color and other quality parameters required by M/s McCain Foods India Pvt. Ltd. The two crops of baby potatoes of cv. K. Himsona are quite feasible in one potato season as this variety yielded baby grade tubers i.e. 10.9-13.0 & 9.1- 11.1 t ha^{-1} during October- December and December- January, respectively.

In the Speciality component, availability of antioxidant rich potatoes (K. Surya) was assessed through on-farm survey to facilitate a business plan on speciality potatoes in NCR. Estimation of glyco-alkaloids was done in the animal feed samples developed at CIPHET, Ludhiana. It was observed that sample 'High protein extruded feed with potato waste' contained higher concentrations of both the alkaloids, whereas, samples 'Extruded feed with potato waste' and 'Pelleted feed with potato waste' contained low concentrations of solanine and chaconine. In waste utilization component, high protein extruded potato animal feed was prepared. Along with potato waste, deoiled soybean and mustard cake was used. Extracted fibre with different levels (5, 10 and 15 %) was incorporated in chicken nuggets. Chicken nuggets samples with 5 % fibre were observed to be acceptable overall. A sensory characteristic of chicken nuggets incorporated with potato peel fibre has been done. In the Social Sciences component survey was conducted in three Districts of Gujarat viz, Sabarkantha, Banaskhantha & Mehsana for assessment of economic feasibility and potential of growing French fries grade potatoes in Gujarat.

Project 2. Integrated development of horticulture in NEH region funded by Technology Mission on Horticulture (Mini Mission I)

Component I: Production of nucleus/ basic seed and planting material

Total 37,021 micro-plants of K. Giriraj (5112), K. Jyoti (6252), K. Himsona (11514), K. Himalini (4452), K Megha (2317), K. Girdhari (6843) and K. Kanchan (531) were produced through micro-propagation during the report. Besides, 248.86 kg of minitubers (K.Himalini-90.83, K. Girdhari-34.44, K. Giriraj-82.15, K.Himsona-28.81 and K.Megha-12.63) were produced in net-house. Produced 1010.00 kg and 518.65 kg of quality seed in the G1 and G2, respectively. A total of 1777.63 kg of quality seed of 6 most promising varieties, K. Girdhari (153.06), K. Giriraj (294.69), K. Himalini (860.18), K. Himsona (187.51), K. Megha (262.63) and K. Jyoti (19.56) was produced for NEH region.

Component II: Standardization of Production and Protection Technology

Comparison of micro-tubers and micro-plants as a source of quality potato seed.

Results of comparative analysis between micro-plants and micro tubers of K. Girdhari and K. Mega revealed that micro plants of K. Girdhari performed better than micro tubers while reverse was true for K.Megha (Table 1).

Table. 1. Comparison of microplant and microtubers for tuber yield attributes.

Treatments		Germination/ survival (%)	Total tubers/plot	Total yield (Kg)/plot	% <3g tubers	
					Weight basis	Number Basis
Kufri Girdhari	Micro-plants	73.67	192	1.76	12.17	45.10
	Micro-tubers	79.00	163	0.74	27.27	72.09
Kufri Megha	Micro-plants	70.67	380	1.26	38.83	76.44
	Micro-tubers	75.33	187	1.87	13.22	47.77

Integrated nutrient management in true potato seed production yield in potato.

Results of effect of integrated nutrient management practices on true potat seed production revealed that plots which received 100% recommended dose of fertilizers gave highest tuber yield (3.5 kg/plot) whereas maximum number of tubers were recorded with application of 100% through FYM.

Studies of the Bio efficacy of bio agents against late blight of potato under natural epiphytotic condition

Efficacy of four bio agents' *viz. Chaetomium globosum WPI*, *Chaetomium globosum WPII*, *Trichoderma harzianum* WP and *Bacillus subtilis* (B5) WP was tested as an alternative control measures against late blight of potato on susceptible cultivar K. Jyoti under natural epiphytotic conditions. Three sprays of bio-agent was found to be effective in controlling late blight incidence with *Trichoderma harzianum* WP being most inhibitory to disease spread (AUDPC ~1359.17) followed by *Chaetomium globosum* WP II (AUDPC (~1388.33). The maximum yield was obtained with three sprays of *Chaetomium globosum* WP II although it was at par with three and two sprays of *Trichoderma harzianum* WP and *Chaetomium globosum* WP I.

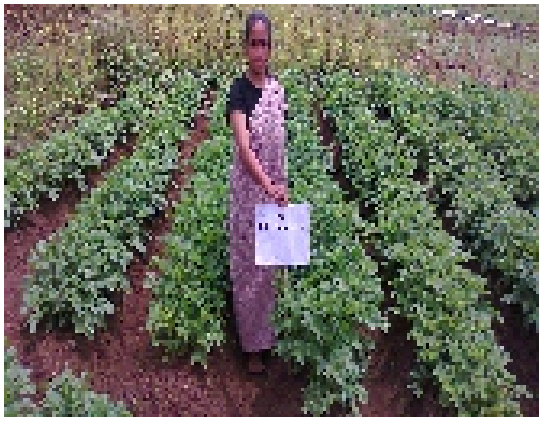
Effect bio control agents against late blight of potato (2010-11)

Bio control agents	Treatments	AUDPC	total Yield (t/ha)
Chaetomium globosum WP I	Three spray	1493.33	119.47
	Two spray	1452.50	18.47
	One spray	1563.33	17.64
Chaetomium globosum WP II	Three spray	1388.33	20.50
	Two spray	1417.50	18.78
	One spray	1528.33	18.09
Trichoderma harzianum WP	Three spray	1359.17	18.98
	Two spray	1400.00	18.74
	One spray	1458.33	17.87
Bacillus subtilis (B5)	Three spray	1505.00	17.47
	Two spray	1534.17	17.11
	One spray	1545.83	16.52
Control	No spray	1604.17	15.79
C.D. 5%		46.98	2.10
C.V.		1.88	6.89

Component III: Technology assessment & refinement and imparting training

On-farm demonstration conducted in different villages at East Khasi Hills and West Khasi hills , Shillong with High yielding Potato varieties

Forty (40) on- farm demonstrations on Kufri Giriraj were conducted in the farmers' field in East and West Khasi hills district of Meghalaya. An average yield of 17.4t/ha was recorded as against of 6.9 t/ha in local variety which resulted in 152% increase in yield over local variety. The farmers expressed their desire to adopt the improved variety.



Full grown potato crop in demonstration plot at Mawjrong

Besides, 10 demonstrations on TPS(92-89-27) technology were also laid out at farmers fields. The average yield of 2.19t/ha was obtained. In addition to demonstrations, trainings (5) were also conducted on various aspects of potato technology in which 270 farmers participated.

On farm training on TPS technology for potato production

Project 3. ICAR network project on climate change on assessment of impacts of climate change on potato production in the major potato growing zones of India and its agronomic adaptation opportunities

Thematic maps of the stress degree hours in the winter potato growing regions were prepared. Under the baseline scenario, most of the Indo-Gangetic plains region experienced 1000 to 5000 degree hours of stress due to combination of both maximum and minimum temperatures (Fig. 1). However, under climate change scenario (A1F1) the temperature stress increased and pockets with stress of 5000 to 9000 degree hours intruded into this region. Similarly, the area with severe stress (9000 to 13000 degree hours) increased appreciably and occupied large parts of Maharashtra, Jharkhand, Odisha and Gujarat under the climate change scenario from almost negligible (except for a narrow belt in northern Karnataka and Andhra Pradesh) under the baseline scenario. Similarly pockets with extreme stress (>13000 degree hours) were also prominently visible under climate change scenario as compared to that under the baseline scenario.

The thematic maps of the ratio of stress due to minimum temperature to the total stress show that both under baseline and climate change scenario, the stress due to minimum temperature was 40 to 50% in most of the winter potato growing regions of India (Fig. 2). However, pockets with higher stress (50-60%) occurred scattered under both the scenarios, but pockets with extreme stress due to night temperature (>60%) were also quite prominent under climate change scenario contrary to that under baseline scenario.

As regards the change in temperature stress per se due to climate change (Fig. 3), the pockets with positive effect or no change were visible scattered here and there in the northern states, though quite small. There was also quite a

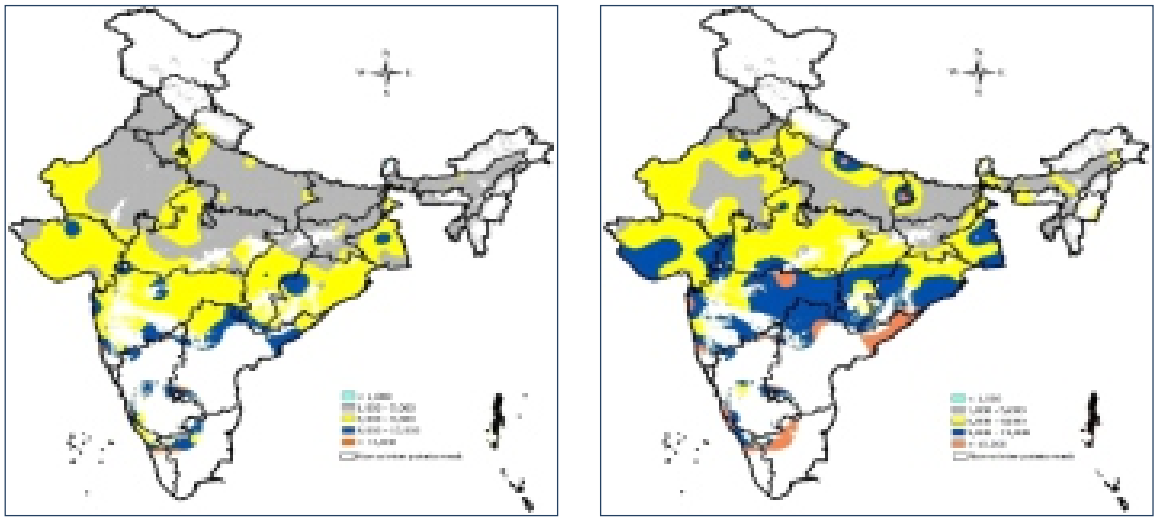


Fig. 1. Maps showing the total stress degree hours under baseline (left) and climate change (right) scenario

significant area where the increase in temperature stress (<1000) is likely to be quite less while the most of the northern states are likely to experience moderate to high increase in temperature stress due to climate change.

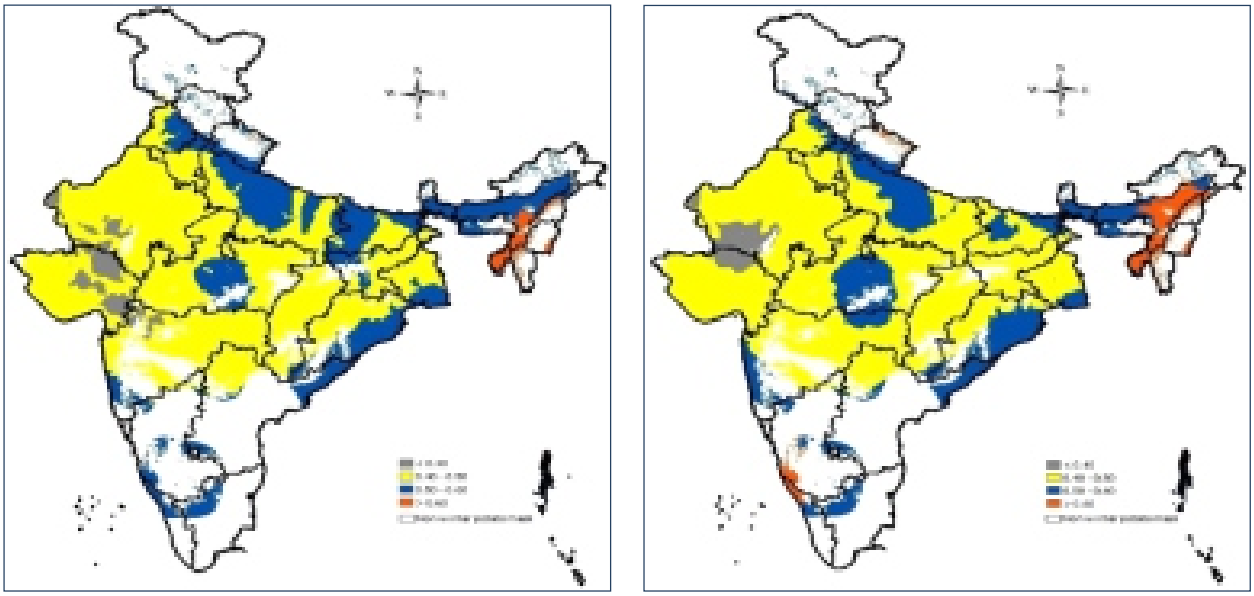


Fig. 2. Maps showing the minimum temperature stress degree hours under baseline (left) and climate change (right) scenario

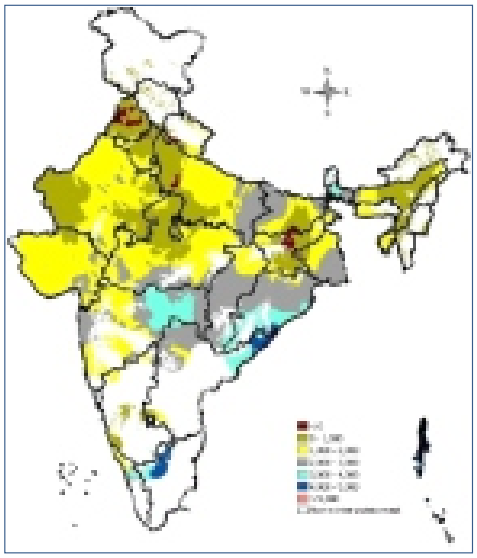


Fig. 3. Map showing the change in stress degree hours due to climate change

Project 4: DST sponsored project on Towards understanding vermicompost technology: Analysis, experimentation and standardization of practices

Intensive field survey was carried out in Meerut, Ghaziabad, Bagpat, Muzaffar Nagar and Bulandshahar districts and depth wise earthworms were collected. About five hundred specimens of earthworms were collected during rainy, summer and winter seasons for vermicomposting. In general sub surface specimen did not survive in dung and dung+biomass media. When reared in soil alone and soil+dung media, the survival lasted hardly for two months or so. During this period, the multiplication was very slow. Among the surface collected specimen, all were very effective in vermicomposting. But except one, all were identified as *Eisenia fetida*. The unidentified new species was sent to Zoological Survey, Calcutta for identification. The details of this new species is presented in Fig. 4.

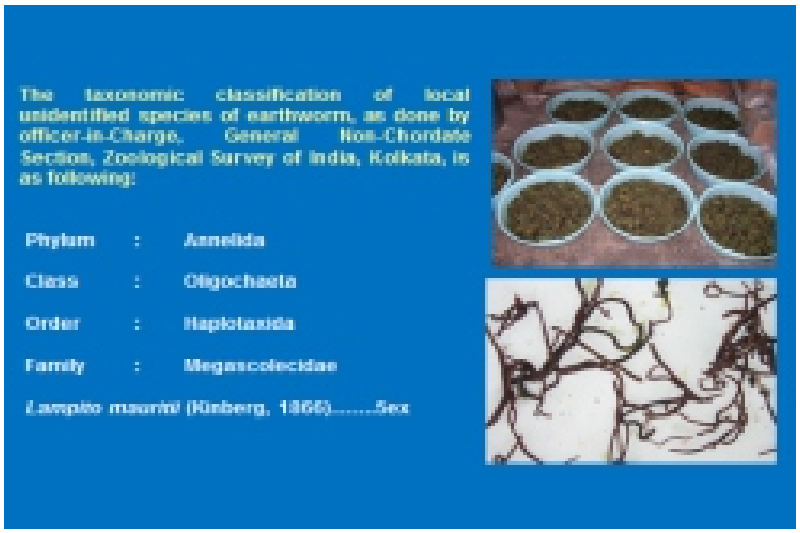


Fig. 4.Taxonomic classification of new species

The new identified species were as effective as *Eisenia fetida* for vermicomposting. In subsequent years, *Lampito moritii* was used for commercial production of vermicompost. In addition, vermiwash was also prepared for foliar spray. The vermiwash, when sprayed on potato after mixing with water in 1:1 ratio, prolonged the greenness and increased tuber production.

Project 5 Farmer participatory action research programme (FPARP) 2nd phase funded by Ministry of Water Resources, Govt. of India, New Delhi

Rain water harvesting farm ponds in Shimla and Solan districts of Himachal Pradesh

45 rain water harvesting farm ponds measuring 6 m (L) x 2.5 m (B) x 2 m (D) lined with HDPE sheet of 250 micron meter thickness were constructed at different locations in project area for rain water/spring water harvesting for recycling of stored water as supplemental irrigation for Rabi crops. Low cost dug out farm pond of 20-25 m^3 capacity lined with 250 micron meter black HDPE sheet costing around Rs 10000-15000 could act as a source for supplement irrigation water for mitigating water stress to the field crops.

Use of poly mulch/organic mulch in vegetable crops

Polythene mulches were used in tomato, capsicum, bean, cucumber and peas for crop earliness, increasing yield, improving crop quality, reducing fertilizer nutrients leaching, soil evaporation and weed population, apart from managing insect pests population and diseases.

Most of the plastic mulching materials, made up of high and low density poly-ethylene ranging from 15-50 µm in thickness were used to demonstrate the various type of mulches under different crops for in-situ soil moisture conservation and moderation of the soil-hydro-thermal properties for achieving higher crop productivity under rainfed farming system. By adopting this technology yields of above vegetable crops increased up to 25% over bare conditions.

Micro-irrigation through mini-sprinkler at Modipuram

25 farmers were selected from different villages at Hapur and Ghaziabad districts of Uttar Pradesh for demonstration on economizing irrigation water input through mini-sprinkler. Irrigation was scheduled on the basis of daily evapo-transpiration rate as measured through sunken-pen evaporameter and was applied at alternative days under micro-irrigation system and 50 mm of irrigation water at 7-10 days interval under furrow irrigation methods. Plant growth parameters viz. number of leaves, plant height, shining and greening of leaves were higher under micro-irrigation in comparison to the furrow irrigation methods. In micro-irrigation methods, on an average 7-8 tubers were obtained at 50-55 days crop whereas under furrow irrigation methods it were 4-5 in number. It shows superiority of micro-irrigation over furrow irrigation method beside 30-40 % saving in applied irrigation water. Preliminary observation on frost damage revealed that there is less damage to the plants under micro-irrigated plots in comparison to the furrow irrigated plots. The crop yield was 15-20 % higher under micro-irrigation in comparison to furrow irrigation.

Project 6: Refinement of technology for potato crop management through botanicals and their effect on soil pest dynamics, crop growth and soil health under MM-1 of ICAR

Light traps were installed at the selected locations and proper monitoring from the first week of the March till harvesting of the potato was done. A total 2638 *Agrotis* sp.(Adult of cutworm) and 7634 beetles were collected from the light traps. Faunal composition of scarabaeids associated with potato crop in Shimla and Solan districts of Himachal Pradesh was investigated. Ten species of scarabaeids beetles belonging to five genera representing two sub families Melolonthinae and Rutelinae were recorded. Four new species viz. *Apogonia* spp.*, Mimela pectorolis, H. sikkimensis and A. varicular* were recorded.

Refined extract of *A. indica, M. azadarach* and *S. mukorossi* prepared in solvent and cattle urine were observed to be good repellent against the populations of the Agrotis and white grub beetle. Solvent refined extracts at 2.5 and 5% and cattle urine extracts at 5 and 10% gave maximum mortality of 3rd instar cutworm and white grubs. The refined cattle urine extracts at higher dose gave maximum mortality of the target pests under control conditions.

Two awareness programmes were organised at Kandaghat and Fagu to impart knowledge to the farmers on the importance of the botanical pesticides for potato pest management. 30 farmers participated in this camp. Pamphlets on the bio-intensive management of the potato pests were also distributed in these programmes.

Project 7: National project on organic farming funded by Ministry of Agriculture, Govt. of India, New Delhi

Vermi-hachery cum vermi-compost unit was installed at CPRI, Shimla. Vermicompost (8.0t) was prepared during 2011-12, which was used in organic potato production on the farm. Culture of vermiwash and earthwarms was prepared and distributed to the different users for their research and development activities. Production of organic potato under potato based farming system is in progress.

Project 8 : All India Coordinated Research Project on rabi - summer groundnut initial varietal trial stage-1

Eleven entries of groundnut were evaluated. The

highest pod yield (6.34 t/ha) was recorded in INS-I-2010-12 followed by INS-I-2010-13 (6.30 t/ha). The important diseases and pests recorded during crop season were tikka (Cercospora) disease, leaf hopper, spodoptera and termite. These were controlled through appropriate plant protection measures. The cost benefit ratio also favors introduction of groundnut in western Uttar Pradesh.

Project 9: Refinement of rapid multiplication technique for recalcitrant potato cultivar suitable for Himachal Pradesh.

Experimentation for development of low cost technology for potato micropropagation revealaed that the cultures grown on MS medium prepared with type-2 water recorded highest mean shoot length, maximum mean number of nodes and fresh as well as dry mass but most of the water types yielded at par results with respect to the studied characters. Among different carbon sources commercial sugar (sulphur less), commercial sugar, sugar cubes and sucrose produced at par results in most of the morphological characters studied. Cultures grown on the medium solidified with gelrite resulted better morphological characters however, medium solidified with bacteriological grade agar also produced at par and next best results on different morphological characters. These results have clearly demonstrated that cheaper and easily available culture media ingredients like tap water + commercial sugar + gelrite/ agar (bacteriological) can be used as low cost alternative for successful micropropagation of potato without compromising on quality of plants.

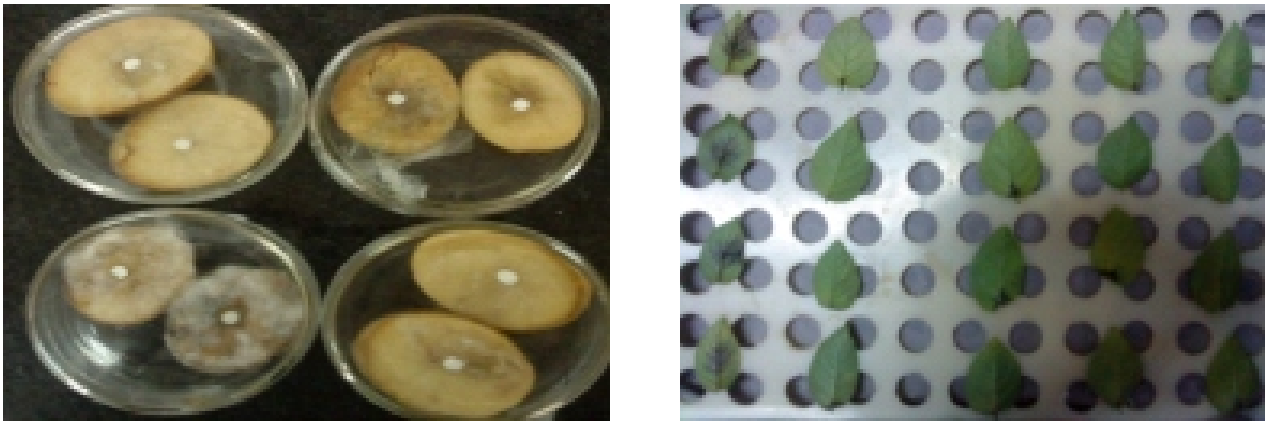
Project 10: Production of planting material of potato through high-tech system of seed production for the hills of Himachal Pradesh

Under the project various types nucleus planting material of potato was produced at Shimla and further multiplied at regional station of CPRI and different centers of universities viz., Kufri, Kandaghat, Una and Dhaulakuan. A total of 14,240 microplants, 10,831 minitubers (G0) and 19,128 tubers (G1) were produced. These planting materials were kept for further multiplication in subsequent generations to establish a viable seed chain in Himachal Pradesh.

Project 11: Phytophthora, Fusarium and Ralstonia diseases of horticultural and field crops (ICAR outreach project)

Phytophthora infestans isolates were collected from different geographical regions of the country and characterized for phenotypic and genotypic markers. The population was composed of most complex races and frequency of occurrence of 11 genes was 100% in most of the locations. With regard to metalaxyl sensitivity, about 80% isolates of Tamil Nadu and Meghalaya exhibited tolerance to 400 ppm while in rest of the geographical locations, isolates exhibited tolerance to 200-300 ppm. Temperate highlands were dominated by A2 mating type while sub-tropical plains by A1 mating type. In plateau (Karnataka), the population of A2 mating type is on the rise. Mt DNA haplotype analysis of the isolates revealed that majority of isolates collected from hills and plains belonged to Ia Mt type which 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. Diversity analysis of *P. infestans* isolates based on SSR markers revealed that though variability exist in the population but no correlation could be established between origin of isolates or phenotypic traits. Promising isolates of *Pseudomonas aeruginosa* possessing biosurfactant and biocontrol properties against *P. infestans* have been identified. The biosurfactant metabolite has been characterized and identified as rhamnolipids. The metabolite showed excellent control of P. infestans.

Putative transformants of Kufri Khyati and Kufri



Effect of 48 hrs. old culture filtrate on development of P. infestans on detached leaf & tuber slices

Pukhraj developed by siRNA and amiRNA approach were analyzed by Reverse transcriptase polymerase reaction (RT-PCR) and results revealed that12 and 7 lines were positive for nptII gene (amplicon size of 750 bp) for both Kufri Pukhraj and Kufri Khyati, respectively. In case of amiRNA transgenic plants (amiRNA2 construct transformed Kufri Khyati) 13 lines showed the amplification for the nptII gene (750 bp) out of 113 transformed lines. All positive lines were multiplied under *in-vitro* condition for further screening against *P. infestans* resistance under glass house conditions. Molecular markers linked to late blight resistance genes R1 and R3a were used to screen a total of 163 genotypes including 44 commercial cultivars. R1 gene was confirmed to be present in 23 genotypes where 61 possessed R3a gene. Based on these results parental lines were selected and hybridization attempted to combine R1 and R3a genes in single host background. Seeds were extracted from six successful crosses and these are being tested for confirmation of gene pyramiding using molecular assisted selection. Molecular linkage map of *S. chacoense* was prepared containing 208 markers. The data so generated could resolve 12 linkage groups.

Project 12: Engineering late blight resistance in susceptible Indian potato cultivars (ICAR/ABSP II collaboration)

The ~3 kbp long cDNA of the RB gene was amplified from the RB-transgenic Katahdin line SP951 by RT-PCR using the primer set cDNAF3: ATGGCTGAAGCTTTCATTCAAG and cDNAR1: GCAATCACAATGGCAGGAAC. The amplified product was purified and cloned in pPRIME vector (TA cloning vector). The transformants (132 nos.) were screened for the insert by restriction digestion as well PCR amplification with MAMA primers. Restriction fragment analysis of the plasmids revealed only two clones having 3 kb insert size, out of which only one was positive in MAMA PCR. Few clones having smaller insert size (700 bp) were also obtained, and their sequencing analysis showed similarity with N terminal or C terminal ends of the RB gene. Such transcripts may have arisen due to alternate splicing. The sequence of RBcDNAclone3 (3kb) (negative for MAMA) was homologlous to RB gene with high degree of variations. The sequence of the other clone, i.e. RBcDNAC17 (positive for MAMA) was similar to RB gene with few base substitutions. The assembled cDNA sequence was aligned with the corresponding genomic sequence of the RB gene and a 679 bp long intron was identified. Multiple sequence alignment (CLUSTAL W) of the RB cDNA was performed using genomic sequences of the RB gene available in NCBI (RGA2_gi|32693280 and RBgenepCLD04541) and resequenced in our laboratory (RGA2Contig_Assembled). The cDNA sequence had one C to T at 33, and five T to C substitution at 62, 335, 1167, 2402, and 2792, and two A to G at 449 and 1132 nucleotides. Further, the three nucleotide substitution in the cloned RB gene has been confirmed, and found correct. The 3 kb cloned fragment from cDNA of SP951 showed nucleotide substitution. These substitutions resulted in alteration of amino acid in the translated peptide. There are total nine amino acid substitutions, L21P, V112A, Q150R, I378V,

E420K, L556P, K662M, L801P, and L931P. Beside this there are two silent mutations causing no change in the amino acid.

Project 13: Development of transgenic potato with resistance to major viruses (ICAR network project on transgenics in crops)

Promising transgenic lines of last year's were further evaluated in the glass house through grafting for resistance. Transgenic plants showed varied resistance against PALCV as compared to untransformed control plants. One line of GTLC2 (GTLC2-127), and three of the KPLC2 (KPLC2-37, KPLC2-44, KPLC2-53) transgenic lines showed complete resistance. Symptom expression was noted and viral load in each plant was quantified by real time RT-PCR analysis of the CP gene using TaqMan assay. Copy number was estimated for resistant lines in terms of cycle threshold Ct with respect to a house control gene Elongation factor 1-alpha. Copy number varied from 8 (GTLC2 127) to 3(GTLC2 90) per tetraploid genome of potato.

Project 14: Training Entrpreneurial Skills to Farmers in Potato Based Farming System of Himachal Pradesh (MM-I)

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

One On-campus training was also conducted at CPRI, Shimla for farmers of nearby areas of Shimla district. A total of 20 farmers participated in this training and they were trained in potato seed production, management of late blight, water management & organic farming of potato, marketing and storage of potato. The data regarding improvement in knowledge and skills before and after this training was collected and analyzed. The results revealed that there was an improvement of 28% in the knowledge and skills of farmers after training.

Project 15: Development and evaluation of potato germplasm and varieties with improved tolerance to abiotic stress and viruses (ICAR-CIP collaboration)

Evaluation of early generation

A total of 38450 true seeds of 75 CIP x CPRI families produced at Kufri were sown in the nursery beds at Modipuram for seedling raising. At harvest, 509 promising clones of 66 families were selected from the 10804 seedlings transplanted in the field. In F_1C_1 generations, 197 promising clones were selected from 653 clones for further evaluation. In F_1C_2 generations, 55 promising clones were selected from 252 clones on the basis of tuber characters and relative tuber dry matter content.

Evaluation of F_1C_3 clones at Modipuram

Thirteen CIP clones were evaluated in the F_1C_3 generation and 9 promising clones were selected. Among the selected clones highly significant total tuber yield was obtained in MCIP/9-6 (39 t/ha) followed by MCIP/9-9, MCIP/9-1 (38 t/ha), MCIP/9-12, MCIP/9-8 (37 t/ha), MCIP/9-11 (36 t/ha), than the best control Kufri Sadabahar (31 t/ha) at 80 days crop duration.

Evaluation of CIP clones at Modipuram

Twelve CIP advance clones were evaluated at and 4 clones namely CP4052 (44 t/ha), CP4176 (43 t/ha), CP4196 (42 t/ha) and CP4181 (40 t/ha) produced significantly high total tuber yield than Kufri Bahar (33 t/ha) at 80 days crop duration.

Multiplication of CIP advance clones under net house conditions

Four promising CIP clones namely CP4154, CP4184, CP4197 and CP4206 were multiplied through *in-vitro* plants under net house conditions.

Evaluation of CIP advance clones for drought tolerance at Modipuram

Among the eight CIP advance clones and three indigenous potato varieties/CPRI clone evaluated at 90 DAP for drought tolerance at Modipuram, CIP clones CP 4184, CP 4175, CP 4168 and advanced hybrid, MS/6-1947 appears promising. Among CIP clones CP4175 (397006.18) was consistently found promising based upon its overall yield performances and drought tolerance as this clone maintained higher drought tolerance index (DTI).

Project 16: Central sector scheme for protection of plant varieties and farmer's rights

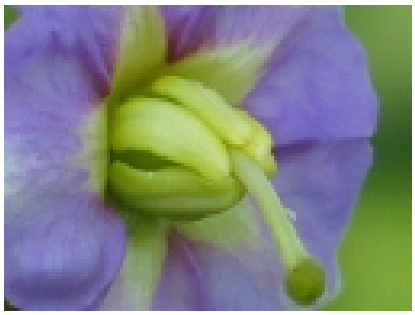
Varieties/numbers under maintenance breeding

Reference collection of 167 varieties/numbers was maintained; 138 *in vitro* at Shimla and 106 in fields at Kufri and Modipuram. These include 46 CPRI released varieties, 3 state varieties, 5 Indian number released elsewhere, 20 exotic varieties in cultivation in India, 64 indigenous varieties/numbers and 29 UPOV example varieties. Mini-tubers of 16 cultures were produced from in vitro plantlets and added to field maintenance at Kufri.

DUS characterization

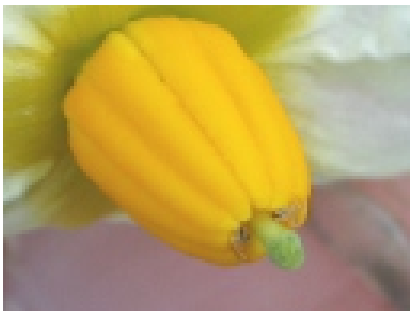
Fifty-nine varieties/samples (other than CPRI) were characterized for floral characters at Kufri as per DUS descriptors. The variation observed in reference collection for various morphological and floral characters. Computer databases regarding availability of various reference varieties at different conservation sites were updated.

Flower: anther colour



Greenish yellow

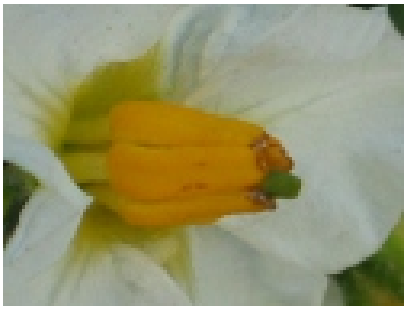
yellow



Orange

Flower: stylar length (in comparison to stamen column)

Shorter



Equal

Longer

Registration of extant potato varieties:

Application for registration of 16 extant varieties of potato was submitted to the PPV&FR authority, New Delhi.

Project 17: Intellectual property management and transfer/commercialization of agricultural technology scheme

(Up-scaling of existing components i.e. Intellectual Property Right (IPR) under ICAR Hqrs)

The information was compiled for the following technologies developed by CPRI-

- One potato variety has been released viz., Kufri Garima.
- Application for registration of 16 extant potato varieties viz., Kufri Anand, Kufri Arun, Kufri Chipsona-I, Kufri Chipsona-II, Kufri-Chipsona-III, Kufri Girdhari, Kufri Giriraj, Kufri Himalini, Kufri Himsona, Kufri Kanchan, Kufri Khyati, Kufri Pukhraj, Kufri Pushkar, Kufri Sadabahar, Kufri Shailja & Kufri Surya was submitted to PPV&FRA authority, New Delhi.
- Two elite germplasm lines have been registered with NBPGR, New Delhi viz., E-1-3 (INGR 11050) & P-7 (INGR 11051).
- An improved heap storage technology has been submitted to ZTMC, IARI, New Delhi for exploring their commercialization.
- License agreement between NRDC and Unique Biotech Ltd for Bio-fertilizer-cum-biofungicide/ biobactericide 'B-5' composition has been done.

One industry interface meetings “Stake Holders Meet on Potato R&D” was organised at CPRS, Jalandhar on 20th November, 2011.

Library and documentation services

In accordance of one of the CPRI mandate ***"To act as national repository of scientific information relevant to potato"*** CPRI Library and Documentation Services unit was established in 1956 with a modest collection of 256 documents. Presently this library stacked more than 60 thousands documents and has attained the position of most sought-after library on potato R & D in India. Since its inception, this library has acted as repository and clearinghouse of potato literature and information. It continually provided scientific and technical information supports and services towards attainment of research mission of the institute. Efforts were made for strengthening and developing the information resources and services through undertaking various activities given here below:

Resource Development

At the headquarter (Shimla), a total of 575 documents were purchased, procured and added to library resources. The total collection at Shimla stand at 36339 documents comprised of 14589 books, 14368 back volume of journals, 2531 serials, 2146 annual reports, 582 theses, 251 standards, 51 maps/atlases, 1663 reprints and 158 CD's. The libraries at six regional stations and one campus at Modipuram are having their own library collection of 26914 books; journals back volumes and other documents i.e. AR/Reprints and Bulletins etc. (Table-1).

Table-1: Library Collection of CPRIC & CPRS

	Regional Stations	Books	Back vols. of Journals	Other Documents (AR/Rpr/Bull)	Total	Current Journals subscribed (Indian)
1	CPRIC, Modipuram	4302	5576	1532	11410	23
2	PRS, Jalandhar	3061	1401	1187	5649	19
3	CPRS, Patna	1949	1280	-	3229	15
4	CPRS, Gwalior	891	4	58	953	1
5	CPRS, Ooty	1577	1876	538	3991	11
6	CPRS, Shillong	1388	–	150	1538	3
7	CPRS, Kufri	144	–	-	144	-
	TOTAL	13312	10137	465	26914	73

Periodicals and Serials Management

Thirty four serials title i.e. advances, annual reviews, reference annuals, yearbooks and statistical data publications etc. were purchased. A total of 190 current journals comprising of 37 foreign and 153 Indian have been subscribed at Shimla. Out of which 26 foreign and 136 Indian journals were subscribed on payment basis and rest on exchange or gratis. In all 1121 issues of such journals were received, marked and kept in library for use. Besides, 73 titles of different journals were subscribed at CPRS libraries. 487 entries of library documents were made in Library Automation Software and 298 books were classified, catalogued, labeled, pasted and transcribed for use. The library has the complete series of CABCD and ISA databases for retrospective and current scientific literature search and use of scientists.

Computerized & Net Based Services

The institute scientists were facilitated with full text access to 5 online databases, 37 institutes subscribed foreign journals and more than 3000+ journals through ICAR's e-resources consortia (Consortia for E-Resources in Agriculture). The library resources e.g. library catalogue (OPAC), foreign journals, CD Net searching, and Current Journals Received Last Week were regularly updated and maintained on library web page. Now scientists are making use of mostly library resources online from their desktop. Many relevant web sites were visited and information and data were downloaded therefrom for scientists' use.

Readers and Reference Service

A total of 1075 documents were circulated (borrowed and returned) for home studies and 6950 readers consulted 9529 documents within the library. Besides, 38 outside scientists and research scholars of various research organizations consulted the library resources. 15 new members were enrolled and 18 old members withdrew their library membership due to their transfer or retirement. At present 148 readers are active members of library including RAs/SRAs. Library received 7589 reference queries from the users of the library and responded to them satisfactorily. Besides, 1229 job requests were received for 2,57,315 copies of photocopying and printing work of different scientific and administrative documents.

Documentation and Information Services

1121 issues of journals (823 issues of national and 298 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. 2,78,932.00 which include the amount charged on account of rendering CDROM searching & photocopying services (Rs. 5,487.00), IGNOU computer practical (Rs. 17400.00) and library discount (Rs.256045.00) in addition to normal 10% GOC discount saved on purchase of library books and journals through CPRI Book store. A total of Rs. 38,21,998.00 was spent (under Plan Rs. 29,99,043.00; Non-Plan Rs. 6,93,883.00 and Rs 1,29,072.00 under XIth Plan IPR Scheme) on library resources and developments like purchase of books (Rs. 19,38,758.00), and subscription of journals (Rs. 15,41,384.00) at HQ library Shimla and Rs 3, 41,856.00 on CPRS libraries.

CDS/ISIS Practical Training

As per MOU between CPRI and IGNOU, New Delhi, 17days computer, IT, and database creation and operation practical session was organized during 26th Aug – 11th Sept 2011 for 6 MLIS and 21 BLIS students of IGNOU Study Center, Shimla.

Infrastructure Development

One high end HP Server, 2 Desktop computers, one printer and one digital Xeroxing machine has been procured and installed to facilitate digital content storage, searching and copying of scientific documents.

Institute Research Council Meetings

Two meetings of the Institute Research Council (IRC) were held during 2011. The first IRC Meeting was held at CPRI, Shimla on 29th April, 2011. It was attended by 37 scientists from the Headquarters and Stations. The basic objective of this meeting was mid-term review of the achievements of 2010-11 of different research programmes. The 2nd IRC Meeting was held at CPRI, Shimla on 19th & 20th August, 2011. It was attended by 55 scientists from the Headquarters and the Stations. The basic objective of this meeting was to review the action taken on the recommendations of IRC Meetings of 2010 and discuss/finalize work plan for 2011-12 of research programmes of different divisions. Proceedings of these meetings were prepared. Some of the major recommendations of these IRC meetings are given below:

1. Six hybrids namely SM/92-338, LBY-15, LBY-17, MS/5-1543, P/03-2 and P/04-5 will be included in the AICRP on Potato trials.
2. The imported germplasm should not be used for any purpose before post entry quarantine and the records of the same should be maintained by the divisions of Crop Improvement and Plant Protection.
3. Recent promising late blight and processing cultures should be planted in the crossing block at Kufri for use in hybridization by the plant breeders of various programmes.
4. K-22, a widely grown early hybrid/clone should be evaluated for one more year at Kalyani, Patna and Modipuram locations. Trial should be conducted for 65 days crop duration only. Besides, yield and culinary attributes other traits like dry matter, nutrient content and maturity should also be recorded.
5. Developed somatic hybrids as well as improved andigena clones shall be planted in Kufri for use in crossing for enhancing the genetic base in all breeding programmes.
6. A concept paper on *kharif* potato will be developed and based upon that studies will be initiated on *kharif* potato at Hassan in Karnataka. Screening of cultivars for plateau region should be taken up at Hassan. All scientists from CPRS, Ooty will be involved in these studies.
7. The chlorophyll-nitrogen relationship experiment being conducted at Shimla shall be taken up at Patna and Gwalior.
8. Only need based machines should be developed according to the demand in the different regions. Work on design and development of potato harvesting and collection systems of a potato (combine harvester) and on design, development and testing of high capacity seed treatment system shall continue.
9. Work on design and development of aeroponic prototype for mini potato tuber production shall continue.
10. Aggressiveness and host specificity of *Phytophthora infestans* isolates collected from potato and tomato should be studied along with their molecular characterization.
11. Validation of molecular marker for late blight, PVY and cyst nematode should be done in advanced hybrid lines.
12. Work on identification of resistance to PVX, PLRV and other viruses in LB-15 and LB-17 hybrids should be expedited.
13. Profiling of hrpB gene for *Ralstonia solanacearum* isolates should be done. Chlorine related compounds, other than bleaching powder, should be explored for

management of bacterial diseases. Common schedule for management of black scurf and common scab should be developed.

14. In the experiment to find out population threshold of aphids for virus transmission, tissue cultured plants free from virus should be used. Viruliferous nature of aphids should be confirmed before releasing them on plants and virus accumulation on plants should be tested by ELISA.

15. Potato genotypes immune to cyst nematodes should be identified from the world catalogue of germplasm. Yearly experiments should be designed in such a way so that trap crops be evaluated throughout the year.

16. Other fumigants in addition to carbafuron, in combination with soil solarisation and soil amendment with neem cake should be explored for management of PCN.

17. Variations in population structure of *Ralstonia solanacearum* have been observed which need to be reconfirmed by molecular techniques.

18. Since the improved heap storage technology has been successfully demonstrated, there is a need for water based formulation of CIPC for its user friendly application.

19. Sprout suppression activities of volatile compounds may be assessed on a large scale using walk-in-chambers available at CPRIC, Modipuram.

20. Data on aphid build up starting from its first appearance and subsequently at weekly intervals during crop season should be collected systematically along with meteorological data at all the seed producing stations. While exploring possibilities for early planting of seed crop data on whitefly, thrips and mite population should be recorded twice a week along with weather data.

21. Performance of aeroponically produced minitubers should be carried out under poly/net house as well as under fields' conditions simultaneously in raised beds. Agronomic practices for raising seed crop through aeroponically produced mini tubers should also be standardized.

22. Reasons for difference in growth of *in vitro* plants in insulated and non-insulated culture rooms should be explored with the help of CPB&PHT division.

23. Under the project activity “Quick survey on potato outlook” Maharashtra and Karnataka states should also be covered in order to assess situation of *kharif* potato in the country.

24. More training programmes should be conducted for the farmers/extension officials and others interested in potato production technology. Separate budget provision for organizing trainings, Kisan Melas and awareness camps should be made in 12th Plan.

Publications

A-Research papers published in referred journals

1. Arora, R. K. 2012. Management of soil and tuber borne diseases of potato in an environment friendly way. (K.C. Mehta and Manoranjan Mitra Award – 2011). *Indian Phytopathology* **65:** 2-6.

2. Ashwani Kumar Sharma 2012. E.P.Venkatasalam and R.K.Singh. Micro-tuber production behaviour of some commercially important potato *(Solanum tuberosum)* cultivars. *Indian J. Agric. Sci* . **81**: 1008–13.

3. Ashwani, K. Sharma and Venkatasalam. E. P. 2012. Impact of replacing the chloroplast agglutination test with enzyme-linked immunosorbent assay (ELISA) on the health status and productivity of seed potatoes, *Archives of Phytopathology and Plant Protection,* DOI:10.1080/03235408. 2011.559039

4. Bhardwaj, V., P. Manivel, J. Gopal. 2011. Screening potato *(Solanum spp)* for cold-induced sweetening. *Indian J. Agric. Sci.* **81:** 20-24.

5. Ezekiel R, Singh, B. Mehta, A. Kumar, D. and Dutta, R. 2011. Changes in processing quality of potatoes at different holding temperatures. *Indian J. Hort.* **68:** 408-412.

6. Gopal, J. and Garg, I.D. 2011. An efficient protocol of chemo-cum-thermotherapy for elimination of potato *(Solanum tuberosum)* viruses by meristem tip culture. *Indian J Agric. Sci.* **81:** 544-549.

7. Govindakrishnan, P.M. Shashi Rawat, Pandey, S.K. Singh, J.P. Lal, S.S and VK Dua. 2011. Computer aided advisory system for potato crop scheduling (CAASPS) – A decision support tool for potato planting strategies. *International Journal of Agricultural and Statistical Sciences* **7:** 571-577.

8. Gulati, Sunil and Manjit Singh. 2011. Energy requirement and management in a potato production system. *Potato Journal* **38:** 61-66.

9. Gupta VK; BP Singh, SK Kaushik and SK Luthra. 2011. Performance of late blight resistant advanced potato hybrids in north-eastern hill region. Vegetos. **24:**168-171.

10. Gurjar M.S. and Shekhawat K.S. 2011. Effect of organic manure against wilt of muskmelon caused by Fusarium oxysporum *Schlecht. Annals of Horticulture* **4:** 106-107.

11. Gurjar, M.S. Rashmi Aggarwal and Prashar M. 2012. Evaluation of wheat germplasm against three wheat rust pathogens in vivo. *Annals of Plant Protection Sciences.* **20:**164-168.

12. Gurjar, M.S. Shekhawat K.S. and Bag T.K. 2011. Effect of carbon and nitrogen sources on the growth and sporulation of Fusarium oxysporum Schlecht causing wilt of muskmelon. *Annals of Plant Protection Sciences.* **19:** 254-255.

13. Jaipaul, Sharma Sanjeev and Sharma AK. 2011. Effect of organic fertilizers on growth, yield and quality of potato under rainfed conditions of central Himalayan region of Uttarakhand. *Potato J.* **38:** 176-181.

14. Jaipaul, Sharma Sanjeev, Dixit AK and Sharma AK. 2011. Growth and yield of capsicum (Capsicum annum) and garden pea (Pisum sativum) as influenced by organic manures and biofertilizers. *Indian J. Agric. Sci.* **81:** 637-642.

15. Jatav, M.K, Kumar, M. Trehan, S.P. Dua, V.K. Lal, S.S 2011. Influence of micro-organisms

inoculation for nutrient economy in potato-radish crop sequence in north western Himalayas. *International Journal of Agricultural and Statistical Sciences* **7:** 309-316.

16. Jatav, M.K, Sharma, RP.. Manoj Kumar, Trehan, S.P. Dua, V.K and Lal, S.S. 2011. Integrated use of FYM and inorganic sources of nutrients in potato-radish crop sequence. *Vegetable Science* **38:** 44-48.

17. Jatav, MK, VP Chimote, KP Chandran, VK Dua, Manoj Kumar and BP Singh. 2011. Role of nutrient composition, organelle genome and breeding attributes on dry matter in potato. *IJASS* .**7:** 445-455.

18. Joseph, T.A, Singh B.P, Kaushik S.K, Bhardwaj V, Pandey S.K, Singh P.H, Singh S.V, Gopal J, Bhat MN and Gupta VK. 2011. Kufri Girdhari- A medium maturing, late blight resistant potato variety for cultivation in Indian hills. *Potato J.* **38**: 26-31.

19. Joseph, T.A., Singh, B.P. Kaushik, S.K Bhardwaj, V. Pandey, S.K. Singh, P.H. Singh, S.V. Gopal, J. Bhat M.N. and Gupta. V.K. 2011. Kufri Girdhari- A medium maturing, late blight resistant potato variety for cultivation in Indian hills. *Potato Journal.* **38:** 26-31.

20. Kumar Devendra, Singh, B.P. Rawal, S. Minhas, J.S and Pandey, S.K. 2011 Rehabilitation of frosted potato crop through plant growth regulators. *Potato J.* **38:** 18-25

21. Kumar Dhruv, Vinay Singh and Singh. B.P. 2011. Growth and yield of potato plants developed from in vitro plantlets in nethouse. *Potato J.* **38:** 143- 148

22. Kumar Dhruv, Vinay Singh, Singh, B.P. Harvir Singh, K.P. Singh and Kaushik, S.K. 2011. Yield of potato crop raised through aeroponic minitubers and in vitro plants in nethouse (Abstract). In: Abstracts, National Conference on Horti Business - Linking Farmers With Market, May 28-31, 2011, Dehradun, Uttarakhand, India.*pp*: **22.**

23. Kumar, M, Jatav, M.K Dua, VK.. Shashi Rawat and S.S Lal. 2011. Precise nutrient recommendations using targeted yield equation based on spatially mapped available nutrients. *International Journal of Agricultural and Statistical Sciences* **7:** 605-612.

24. Kumar, Parveen, Pandey, S.K. Singh, S.V. Singh, B.P. Kapur Singh, Dinesh Kumar, S Rawal and Sukhwinder Singh. 2011. Effect of growth duration, N application and row spacing on productivity, profitability and processing quality of potato. *Potato Journal.* **38 :**137-142.

25. Kumar, R., G.S. Kang, S.K. Pandey and J. Gopal. 2011. Genetic base and relatedness of Indian early maturing potato (Solanum tuberosum) selections. *J. Agricultural Science, Cambridge.* **149:** 217-225.

26. Manorama K, A Balasubramanian and G Ravichandran. 2010. Weed flora of potato (Solanum tuberosum) and their management in the Nilgiris. *Indian Journal of Weed Science.* **42:** 63-66.

27. Mehta Ashiv, Brajesh Singh and R Ezekiel. 2011. Effect of CIPC treatment on keeping and processing attributes during short term storage. *Indian J. Plant Physiol.* **16:** 85-92.

28. Mehta Ashiv, Charaya, P. and Singh B.P. 2011. French fry quality of potato varieties: Effect of tuber maturity and skin curing. *Potato Journal.* **38:** 130-136.

29. Minhas, J. S., Rawat, S. P. M. Govindakrishnan and Kumar, D. 2011. Possibilities of enhancing potato production in non-traditional areas. *Potato J.* **38:** 14-17.

30. Pankaj Baiswar, T.K. Bag, Satish Chandra and S.V. Ngachan. 2011. Identification of powdery mildew pathogen on Milletia pinnata using light and scanning electron microscopy in India. *Environment and Ecology.* **29:** 1099-1100.

31. Rai, R. Diengdoh, L.C. Srivastava, A.K. and Bag, T.K. 2012. Efficiency of different nodal

segments for potato micro-propagation. *Environment and Ecology.* **30:** page no.

32. Rana Rajesh, K. 2011. The Indian potato processing industry-global comparisons and business prospects. *Outlook on Agriculture.* **40:** 237-243.

33. Rana Rajesh. K. 2011. Status of Punjab State in Indian Potato Processing Industry. *Indian Journal of Agricultural Marketing.* **25**: 1-17.

34. Rana, Rajesh K., Neeraj Sharma, Kadian, M.S. Girish B.H, Arya, S. Campilan, D. Pandey, S.K. Carlo Carli, N.H. Patel and Singh B.P. 2011. Perception of Gujarat farmers on heat-tolerant potato varieties. *Potato J.* **38:** 121-129.

35. Ravichandran, G. Muthuraj, R. Somasekhar, N. and Umamaheswari, R. 2011. Effect of single and split application on potato cyst nematodes and tuber yield in potato. *Indian J Nematol.* **41:**page no.

36. Ravichandran, G. Natarajan, N. Manorama, K. and Vanangamudi, K. 2011. Effect of organic spray on storage behavior of seed potatoes. *Indian J. Hort.* **68:** 399-407.

37. Ravichandran, G. Natarjan, N. Manorama K.and K.Vanagamudi.2011.Effect of organic spray on storage behavior of seed potatoes. Indian *J. Hort.* **68:** 399-407.

38. Ray SS, Namarata Jain, Arora RK, Chavan S and Panigrahy Sushma. 2011. Utility of hyperspectral data for potato late blight disease detection. *Indian Journal Remote Sensing.* 161-169.

39. Sagar V, Sharma S, Jeevalatha A, Chakrabarti S.K. and Singh B.P. 2011. First report of Fusarium sambucinum causing dry rot of potato in India. *New Disease Reports* **24:** 5 (doi:10,5197/j.2044-0588.2011.024.005).

40. Sakar. D., Jagesh K. Tiwari, Sushruti Sharma, Poonam, Sanjeev Sharma, J. Gopal, B.P. Singh, S.K. Luthra, S.K. Pandey and D. Pattanayak. 2011. Production and characterization of somatic hybrids between *Solanum tuberosum L.* and *S. pinnatisectum* Dun. *Plant Cell, Tissue and Organ Culture.* **107:** 427-440.

41. Sarkar, D. Tiwari Jagesh, K. Sharma Sushruti, Poonam, Sharma Sanjeev, Gopal J, Singh B.P, Luthra S.K, Pandey S.K and Pattanayak D. 2011. Production and characterization of somatic hybrids between *Solanum tuberosum L.* and *S. pinnatisectum* Dun. *Plant Cell Tissue Organ Cult* (DOI **10.**1007/s11240-011-9993-8).

42. Sharma Nirupma, Thakur V.S, Sharma Sanjeev, Mohan, J. and Khurana S.M.P. 2011. Development of Marsonnina blotch (Marssonina coronaria) in different genotypes of apple. *Indian Phytopathol.* **64**: 358-362.

43. Sharma Sanjeev, Sharma AK, Jaipaul and Bhatt MP. 2011. Genotypic differences in growth, yield and quality attributes of capsicum (Capsicum annuum) under black polyethylene mulch. *Indian J Agric Sci.* **81:** 413-416.

44. Sharma, N. Parveen Kumar. M.S. Kadian, S.K. Pandey, S.V. Singh and S.K. Luthra. 2011. Performance of potato *(Solanum tuberosum)* clones under water stress. *Indian Journal of Agricultural Sciences* **81:**825–829.

45. Sharma, S. Sarkar, D. Pandey, S.K, Chandel, P. Tiwari Jagesh, K. 2011. Stoloniferous shoot protoplast, an efficient cell system in potato for somatic cell genetic manipulations. *Scientia Hort.* **128:** 84–91.

46. Shilpa Sharma, Venkatasalam, E.P. Rishu Patial, Jyoti Latawa and Sarjeet Singh. 2011. Influence of gelling agents and nodes on the growth of potato microplant. *Potato Journal.* **38 :**41-46.

47. Singh, D, Devendra Kumar, R. Pandey, Kamlesh Malik and Vipin Kumar. 2011. Physiological evaluation of different crop genotypes for the intensification of cotton-wheat system through inclusion of potato in

northwestern plains. *Indian. J. Pl. Physiol*. **16 :** 167-173

48. Singh, Name, Sood, M.C. Trehan, S.P. Lal, S.S. and Singh. S.P. 2012. Influence of irrigation and mulch on growth, yield and economics of potato. *Annals of Horticulture.* **5 :** 26-29.

49. Singh, S.K. and Lal, S.S. 2011. Integrated nutrient management in potato based cropping systems in south Bihar alluvial plains. *Potato Journal* **38:** 162-169.

50. Singh, S.P, Kushwah, V.S. and Lal, S.S. 2011. Integrated nutrient management in black gram-potato-wheat sequence. *Potato Journal* **38:**170-175.

51. Singh, Sood M.C. and Singh. S.P. 2012. Water need and nutrient movement in potato based cropping systems under drip, sprinkler and furrow methods of irrigation. *Annals of Horticulture.* **5:** 83-87.

52. Singh, Sukhwinder, Parveen Kumar, Manjit Singh, Dhruv Kumar, Singh B.P. and Pandey, S.K. 2011. Development and testing of a wide row ridger, inter row cultivator and digger for nucleus seed potato production. *Potato Journal.* **38:**155-161.

53. Srivastava, A.K. and Jaiswal, H.K. 2012. Combining ability status among parents and hybrids in a line x tester analysis involving indigenous aromatic rice genotypes (Oryza sativa L.). *Environment and Ecology,* **30:** 143—147.

54. Srivastava, A.K. Jaiswal, H.K. Agrawal R.K. and Singh R.P. 2012. Genetic architecture of yield and yield components in indigenous aromatic rice *(Oryza sativa L.). Vegetos,* **25.**

55. Srivastava, A.K. Jaiswal, H.K. and Agrawal, R.K. 2012. Genetics of grain quality traits in indigenous aromatic rice *(Oryza sativa L.). Crop Research.* **44.**

56. Venkatasalam, E.P., Jyoti Latawa. Shilpa Sharma, Sumita Sharma, Ashwani Kumar Sharma, Sneh Sharma, Rishu Patial and Sarjeet Singh 2011. In vitro and in vivo performance of potato cultivars for different seed production systems. *Potato Journal.* **38:** 149-154.

57. Vinay Singh, Kumar Dhruv, Sukhwinder Singh, Harvir Singh, K.P. Singh and S.K. Kaushik. 2011. Performance of aeroponically produced mini tubers as influenced by different grades (Abstract). In: Abstracts, National Conference on Horti Business - Linking Farmer With Market, May 28-31, 2011, Dehradun, Uttarakhand, *India.pp:* **169.**

58. Xun Xu, Shengkai Pan, Shifeng Cheng, Bo Zhang, Desheng Mu, Peixiang Ni, Gengyun Zhang, Shuang Yang, Ruiqiang Li, Jun Wang; Gisella Orjeda, Frank Guzman, Michael Torres, Roberto Lozano, Olga Ponce, Diana Martinez, German De la Cruz; S. K. Chakrabarti, Virupaksh U. Patil, Konstantin G. Skryabin, Boris B. Kuznetsov, Nikolai V. Ravin, Tatjana V. Kolganova, Alexey V. Beletsky, Andrei V. Mardanov; Alex Di Genova; Daniel M. Bolser, David M. A. Martin, Guangcun Li, Yu Yang, Hanhui Kuang, Qun Hu, Xingyao Xiong, Gerard J. Bishop, Boris Sagredo, Nilo Mejía, Wlodzimierz Zagorski, Robert Gromadka, Jan Gawor, Pawel Szczesny, Sanwen Huang, Zhonghua Zhang, Chunbo Liang, Jun He, Ying Li, Jianfei Xu, Youjun Zhang, Binyan Xie, Yongchen Du, Dongyu Qu, Merideth Bonierbale, Marc Ghislain, Maria del Rosario Herrera, Giovanni Giuliano, Marco Pietrella, Gaetano Perrotta, Paolo Facella, Kimberly O'Brien, Sergio E. Feingold, Leandro E. Barreiro, Gabriela A. Massa, Luis Diambra, Brett Whitty, Brieanne Vaillancourt, Haining Lin, Alicia Massa, Michael Geoffroy, Steven Lundback, Dean DellaPenna, C. Robin Buell, Sanjeev Kumar Sharma, David Marshall, Robbie Waugh, Glenn J. Bryan, Marialaura Destefanis, Istvan Nagy, Dan Milbourne, Susan Thomson, Mark Fiers, Jeanne Jacobs, Kåre L. Nielsen, Mads Sønderkær, Marina Iovene, Giovana Torres, Jiming Jiang, Richard E. Veilleux,

Christian W. B. Bachem, Jan de Boer, Theo Borm, Bjorn Kloosterman, Herman van Eck, Erwin Datema, Bas te Lintel Hekkert, Aska Groverse, Roeland C. H. J. van Ham, & Richard G. F. Visser. 2011. Genome sequence and analysis of the tuber crop potato. *Nature.* **475:** 189-195.

B. Popular/Newsletter Articles

1. Bhatnagar, A. Singh, S.P. Somani, A.K. and.Singh, B.P. Potato cultivation scenario in Chambal region of Madhya Pradesh.

2. Bhatnagar, A., A.K. Somani and B.P.Singh, 2012. Aaloo aadharit krishi takneek (Hindi). Kheti January, 2012, pp 26-27.

3. Joseph, T.A. Umamaheswari R and Manorama K. 2011. Nematode resistant potato variety. Dinathanthi, news paper on 5.5.2011, p16.

4. Kaushik, S.K. and Singh, B.P. 2011. Bharat me Allo ka etihas, vikas avm anusandhan. Bhoobharti, **6:**19-20

5. Khan, M.A. and Sanjay Rawal. 2011. Aalu mein nirai gurai evam kharpartwar niyantran, Bhoo-Bharti **7:** 30.

6. Lal Mehi and Singh B.P. 2011. Allo ki picheta jhulsa bimari av uski roktham. Bhoobharti, **6:**15.

7. Mehi Lal. 2011. Allo Fasal me laganne wale vishanu av unki roktham.Bhoobharti, **6:** 7-8.

8. Sanjay Rawal and MA Khan. 2011. Maidani chhetron mein aalu adharit fasal chakra, Bhoo-Bharti .**7:** 21-22.

9. Singh BP, Rana Rajesh K and Manoj Kumar. 2011. Technology infusion through contact farming: success story of potato. Indian Horticulture. **56:** 49-52.

10. SK Luthra, VK Gupta and Sanjay Rawal. 2011. MS/6-1947 An early bulking and drought tolerant advance stage hybrid. CPRI News Letter July, 2011

11. Tiwari, J.K., D. Sarkar, Poonam, S. Sharma and J. Gopal. 2011. Solanum tuberosum (+) S. pinnatisectum somatic hybrids: a new source of horizontal resistance to potato late blight in India. Sol newsletter. **29:** 4-5.

12. Venkatasalam, E. .P Jyoti Latawa, Chakrabarti, S.K. K.K. Pandey, Richa Sood, Vandana Thakur, Ashwani Kumar Sharma and B P Singh. "Modified medium for micropropagation of recalcitrant potato cultivar Kufri Jyoti (Solanum tuberosum L.)" CPRI Newsletter, July-September, 2011. pp 2-3.

13. एस. के. लुथरा, कमलेश मलिक, वी. के. गुप्ता एवं बी. पी. सिंह (2012) आलू की अगेती फसल – प्रजातियां एवं फसल प्रबन्धन, किसान भारती, मार्च, 2012

14. शम्भू कुमार, ऐ. के. श्रीवास्तव, ई. ईरादासप्पा एवं टी. के. बाग (2011). पूर्वोत्तर राज्यों में पौध कंद से आलू की व्यवसायिक खेती. पूर्वोत्तर भारती, राजभाषा पत्रिका, भारतीय कृषि अनुसंधान परिषद्, पूर्वोत्तर पर्वतिय कृषि अनुसंधान परिषद, बारापानी (मेघालय)

Technical/Extension Bulletins

1. Chowdappa P, Mohan Kumar SP, Sharma Sanjeev and Singh BP. 2011. Integrated management of early and late blight of potato and tomato. ORP on Leaf spot diseases series 17. IIHR, Bangalore and CPRI, Shimla, 9pp

2. Cultural management of crops in potato based cropping system in India (Revised Extension bulletin No.39).

3. Dua, VK, JP Singh, Manoj Kumar, PM Govindakrishnan, SS Lal and BP Singh. 2012. Cultural management of crops in potato based cropping systems in India. CPRI Extension Bulletin No. 39 (Revised). Central Potato Research Institute, Shimla, Himachal Pradesh, India, 69 pp.

4. Gunvatta yukt beej aloo utpadan ki taknik (Extension bulletin No. 43 in Hindi).

5. Indian Potato Varieties & their salient features (Revised technical bulletin No.78).

6. Kam Lagat me Aallo ka Utpadan (Revised technical bulletin (Hindi) No.92).

7. Mehta, Ashiv, R. Ezekiel, Brajesh Singh, JS Minhas and BP Singh. 2011. Modified heap and pit storage for table and processing potatoes. (English) Tech. Bull. No. 82 (Revised), Central Potato Research Institute, Shimla.

8. Modified heap storage for table & processing potatoes (Revised technical bulletin No.82).

9. Pandey, N.K, Singh, D.K, Pandey, K.K., Sharma Sanjeev and Singh, B.P. 2012. Agro-techniques for production of quality potato seed CPRI Extension Bulletin No. 43. Central Potato Research Institute, Shimla, Himachal Pradesh, India. (Extension bulletin No.43-Hindi & English)

10. Seed Potato Production technology (Technical bulletin)

11. Singh, B. P., K. K. Pandey and E. P. Venkatasalam. 2011. Consolidated Report of Phase-II (2006-2009), Centrally Sponsored Scheme for Integrated Development of Horticulture in Himachal Pradesh.

12. Singh, SK, S Kumar and TK Sinha. 2012. Bihar mein aloo ki vaigyanik kheti (In Hindi).

13. Singh, SK, S Kumar and TK Sinha. 2012. Satya beej (TPS) se aloo ki kheti (In Hindi).

14. Vinod Kumar, SK Luthra, Jai Gopal and BP Singh. 2011. Indian Potato Varieties and Their Salient Features. CPRI Technical Bulletin No. 78(Revised). Central Potato Research Institute, Shimla, Himachal Pradesh, India, 56pp.

1. Gurjar, M.S. Bag, T.K.. Srivastava, A.K Yadav, S.K. Singh, K.S. and Singh. B.P. Bio efficacy of bio agents against late blight of potato under natural epiphytotic condition. (Abst.). 3rd Global Conference, Plant Pathology for Food Security, January, 10-13, 2012, MPUAT, Udaipur, Rajasthan pp. 115-116.

2. Gurjar, M.S. Sagar Banerjee, Anupam, M. Prashar and Rashmi Aggarwal. Identification and validation of rust resistance genes in wheat through molecular markers. 64th Annual meeting, Indian Phytopathology Society, National symposium on Biology of Infection, Immunity and Disease Control on Pathogen –Plant Interaction,2nd to 4th December, 2011 at University of Hyderabad, Hyderabad (A. P.) pp. 88.

3. Kaushik, S.K, Sharma, R. Bhardwaj, V. Sharma, S. and Singh, B.P. 2012. Stacking of late blight resistance genes in potato using MAS. Paper presented in International Conference on Plant Biotechnology for Food Security: New Frontiers held at NASC, New Delhi w.e.f. 21-24 February, 2012.

4. Kaushik, S.K. Sharma, R. Bhardwaj, V. Sharma, S.and Singh, B.P. 2012. Stacking of late blight resistance genes in potato using MAS. Proceedings of International Conference on Plant Biotechnology for Food Security: New Frontiers, 21-24, February 2012, National Agricultural Science Centre (NASC), Pusa, New Delhi.

5. Khan, M.A, Upadhayay, N.C. Singh, O.P. and Singh, B.P. 2011. Long term effect of nutrients management on productivity and nitrogen uptake by crops in Rice-Potato-Wheat system in upper Indo –Gangetic plains. In 75th Annual Convention of the Indian Soc. Soil Sci. and National Seminar on Development in Soil Sciences held at UAS, Dharwad during November 16-19, 2011.

6. Khan, M.A. Singh, B.P. Bhatt, M.N. Kaushik, S.K. and Raunaq. 2012.

Evaluation of botanical extracts to control late blight of potato, IUPAC Sponsored 2nd International Conference on APCHNE: Role of Chemistry for Sustainable Agriculture held at IARI, New Delhi during 15-18 February, 2012 pp 212.

7. Manorama, K. Somasekhar, N. Joseph, T.A. and Umamaheswari, R. 2011. Ecofriendly management of Potato Cyst Nematodes under field conditions. Abstract published in National Symposium on "Nematodes: A Challenge Under Changing Climate and Agricultural Practices" held at Kovalam, Kerala during 16- 18 November, 2011. pp: 91.

8. Manorama, K., Somasekhar Nethi, Joseph, TA and Umamaheswari R. 2011. Eco-friendly management of potato cyst nematodes under field conditions.In: Proceedings of National Symposium on 'Nematodes: A challenge under changing climate and agricultural practices' held at Kovalam, Thiruvananthapuram, Kerala from 16th to 18th November, 2011, pp. 91

9. Muthuraj, R. and Joseph, T.A. 2011 "Potato seed production technology in India"Imparting the training on seed certification and seed test training to agricultural department officials of Megalaya state' Training programme organized by directorate of seed certification and organic certification, Coimbatore, held at CPRS, Muthorai on 29th September 2011 published in the seed certification training Manual : pp. 78-94.

10. Sharad Mohan, Umamaheswari, R. and Ganguly A.K. 2011. Cross generic isolation of Pasteuria isolated from H. cajani to Globodera spp. In: Proceedings of National Symposium on 'Nematodes: A challenge under changing climate and agricultural practices' held at Kovalam, Thiruvananthapuram, Kerala from 16th to 18th November, 2011, pp. 115

11. Sharma Sanjeev and Singh, B.P. 2011. Present status of population structure of P. infestans in India. Paper presented in National Symposium on Technological Interventions for Sustainable Agriculture held at Hill Campus Ranichauri, Uttarakhand w.e.f. 3-5 May, 2011.

12. Sharma Sanjeev. 2011. Managing Phytophthora infestans through host resistance. Paper presented in International workshop on Phytophthora diseases of plantation crops held at Rubber Research Institute of India, Kottayam, Kerala w.e.f. 12-14 September, 2011.

13. Sharma, N.N, Shandil, R.K, Sharma, S. Thakur, G. Tomar, G. Kaushik, S.K., Singh B.P. and Chakarbarti, S.K. 2012. Impact of genotypic backgrounds on RB (Rpi-blb) mediated late blight resistance in potato and tomato. Paper presented in International Conference on Plant Biotechnology for Food Security: New Frontiers held at NASC, New Delhi w.e.f. 21-24 February, 2012.

14. Singh Manjit. 2011. Mechanical technologies for small and marginal potato farmers. In the proceedings of the 15th Shri Vasant Rao Naik Memorial National Agriculture Seminar on Technologies for Sustainable Horticulture for Rainfed Areas" held at Dr. Punjab Rao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) on January 20-21, 2012.

15. Singh S.K. Tarasankar, A Kumar, Kumar, S. Singh, S.S. and Singh, K.M. 2011. Potato quality seed production for livelihood improvement. In souvenir 4th International Conference on Life Science Research For Rural and Agricultural Development (ICLRAD-2011) held at Central Potato Research Station, Patna during 27 - 29 December, 2011. pp. 59.

16. Singh, B.P. and Sharma Sanjeev. 2011. Management strategies for potato diseases. Paper presented in National

Symposium (NZ) of Indian Phytopathological Society on "Strategic issues in plant pathological research" held at CSK HPKV, Palampur on 25-26 November,

17. Singh, D.K. and Pandey, N.K. 2011. Role of ICT in Marketing of Horticultural Produce, In proceedings of National Conference on Horti-Business: Linking Farmers with Market held at Dehradun (Uttarakhand) during 28-31 May, 2011, pp 75-76.

18. Singh, Manjit. 2011. Potentials and constraints for the use of power tiller in potato cultivation. In the proceedings of the National Seminar on Augmenting productivity of mountain farming through Agril. Engg. interventions" held at CSKHPKVV, Palampur on 16-17 November, 2011.

19. Singh, S.K, Singh, R.K. and Bakade, R.R 2011. Standardization of fertilizer dose for Kufri Surya for early planting in Indo-Gangetic plains of Bihar. In souvenir of 4th International Conference on Life Science Research For Rural and Agricultural Development (ICLRAD-2011) held at Central Potato Research Station, Patna during 27 to 29 December, 2011.pp. 63.

20. Singh, S.K. and Kumar, M. 2011. Quality potato seed production through hi-tech system. Paper presented in National seminar on Development of Agriculture in Bihar held at Patna on 22-23 September, 2011.

21. Somani, A. K. 2011. National Seminar on transfer of technology of strategic pesticides use to enhance agriculture production and food security on 18th June, 2011 organized by the ICAR and Dhanuka Agritech Ltd , at N. Delhi.

22. Srivastava, A.K. Gurjar, M.S. Yadav, S.K. Bag, T.K. Gopal J. and Singh, B.P. Evaluation of potato germplasm for late blight resistance under natural epiphytotic condition (Abst.). 3rd Global Conference, Plant Pathology for Food Security, January, 10-13, 2012, MPUAT, Udaipur, Rajasthan pp. 93.

23. Sundresha, S. Singh, B. Patil, V.U. Chakrabarti, S.K. Prat, Bachem, S.C. V. Bhardwaj, Rawat, S. and B.P. Singh. 2012. Effect of temperature on Stsp6A gene (FT-homologue) expression and tuberization in Indian potato cultivars. Proceedings of International Conference on Plant Biotechnology for Food Security: New Frontiers, 21-24, February 2012, National Agricultural Science Centre (NASC), Pusa, New Delhi.

24. Thakur, G. Sharma, S. Tomar, G. Shandil, R.K. Sharma, N.N. Kaushik, S.K. Singh B.P. and Chakarbarti S.K. 2012. Molecular mapping of late blight horizontal resistance in Solanum chacoense. Paper presented in International Conference on Plant Biotechnology for Food Security: New Frontiers held at NASC, New Delhi w.e.f. 21-24 February, 2012.

25. Tiwari, J.K. Poonam, S.K. Luthra, J. Gopal, B.P. Singh. 2011. Phenotyping of potato somatic hybrids between Solanum tuberosum L. and S. etuberosum Lindl. : First report of tuberization in India. In: Abstracts and papers National Conference on Advancement in Convergence of technologies. Sept 8-9, 2011, Amity University, Haryana, Allied Publishers Pvt. Ltd. New Delhi. pp. 146.

26. Tomar Sonica,. Khan M.A, Lal Mehi, Singh B.P. and Kumar Satish 2011. Isolation and characterization of biosurfactant producing bacteria with antimicrobial activity against P. infestans. "International Workshop, Seminar and Exhibition on Phytophthora diseases of plantation crops and their management-PHYTOPHTHORA-2011" (Sept12-18), Rubber Research Institute of India, Kottayam, Kerala. pp. 141.

27. Tomar, G. Jeevalatha, A. Thakur, G. Sharma, N.N. Shandil, R.K, Azmi, W.

Singh, B.P, and Chakrabarti S.K. RNAi technology for resistance development against apical leafcurl virus in potato. (In.) International conference on plant biotechnology for food security: New frontiers "held during Feb, 21-24th , 2012 at NASC complex, New Delhi.

28. Touseef Hussain, Lal, Mehi.Singh, B.P, Frioz Anwar and Gunjan 2011. A PCR based protocol for detection of Phytophthora infestans from potato and tomato. "International Workshop, Seminar and Exhibition on Phytophthora diseases of plantation crops and their management- PHYTOPHTHORA-2011" (Sept12-18), Rubber Research Institute of India, Kottayam, Kerala. pp.112.

29. Trehan, SP, Kumar, R and Singh, BP. 2011. Water use efficiency of a promising hybrid JX 576 in comparison to some released potato cultivars. Presented in National Seminar on Development in Soil Science: 2011 held at the University of Agricultural Sciences, Dharwad during November 16-19, 2011.

30. Umamaheswari, R., Muthuraj R., Manorama K., Ravichandran G. and Joseph T.A. 2011. Current Status of potato cyst nematodes in the Nilgiris of Tamil Nadu. In: Proceedings of National Symposium on 'Nematodes: A challenge under changing climate and agricultural practices' held at Kovalam, Thiruvananthapuram, Kerala from 16th to 18th November, 2011, pp. 66.

D. **Scientific/Technical review/Book Chapters**

1. Arora, R. K. 2011. Emerging issues in management of major soil and tuber borne diseases of potato.In: Plant Pathology in India: Vision 2030 (Eds. T.S.Thind, R.K. Jain, Pratibha Sharma, S.M.PaulKhurana, RashmiAggrawal, R.K. Sharma, Dinesh Singh, S.C.Dubey and A. Kumar). Indian Phytopathological Society, New Delhi pp .59-69.

2. Arora, R.K. and Vinay Sagar. 2012. Major Tuber borne Diseases of Potato. In: "Current Status of Economically Important Diseases of Crops in India" Indian Phytopathology (submitted).

3. Bag, T.K. and Singh, P.C. 2011. Root Rot Complex of Pea. In: Sustainable Management of Agricultural Crops (Eds. S. K. Biswas and S. R. Singh) Daya Publishing House, New Delhi. pp 222-233.

4. Bag, T.K. Loganathan, M. and Sudhakar Pandey. 2011. Disease Management in Cucurbitaceous Vegetables. In: Sustainable Disease Management of Agricultural Crops (Eds. S. K. Biswas and S. R. Singh) Daya Publishing House, New Delhi pp 50-61.

5. Khan, M.A. and NC Upadhayay. 2012. Soil chemical and biological processes under integrated nutrient management. In 'System Based Integrated Nutrient (Edited by B Gangwar and VK Singh). New India Publishing Agency, New Delh. India. pp. 251-260.

6. Khare, M.N., Arora, R.K. and B.P. Singh. 2012. Certification of potato for planting and export. CPRI.Bulletin. (Submitted).

7. Mandal, A.K. Kashyap, P.L. Gurjar, M.S. Sanghera, G.S. Kumar, S. and Dubey, S.C. 2012. Recent Biotechnological Achievements in Plant Disease Management. In: Current Concepts in Crop Protection (Eds. Susanta Banik). Stadium Press (India) Pvt. Ltd., New Delhi. pp. 77-129.

8. Manoj Kumar, Yadav, R.S. Singh, Gaurav Mahajan, Subhash Babu, Sanjay Kumar Yadav, Rakesh Kumar, Mahesh Kumar Singh, Amitesh Kumar Singh and Amalesh Yadav 2011. Ridge Planted Pigeonpea and Furrow Planted Rice in an Intercropping System as affected by Nitrogen and Weed Management. In Weed Control (Ed. Andrew J. Price) InTech Europe Publisher, Croatia. pp31-

9. Minhas, J.S. 2012. Potato production strategies under abiotic stress. In: Improving crop resistance to abiotic stress (Tuteja, N., Gill, S.S., Tiburcio, A.F. and Tuteja, R., Eds.). Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim. pp. 1153-1165

10. Minhas, J.S. 2012. Potato production strategies under abiotic stress. In: Improving crop resistance to abiotic stress (Tuteja, N., Gill, S.S., Tiburcio, A.F. and Tuteja, R., Eds.). Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim. pp. 1153-1165.

11. Upadhayay, N.C. and M.A. Khan. 2012. System based nutrient budgeting. In 'System Based Integrated Nutrient Management' (Edited by B Gangwar and VK Singh). New India Publishing Agency, New Delh. India. 288-296.

E. Misc. Publications

1. Application for Sardar Patel Outstanding ICAR Institution Award 2011
2. Bazar Glut se bachne ka Aasaan Upaay-kheton me dher lagakar bhaderit Karen Aalloo (Folder)
3. CPRI Vision 2030
4. Desi Bhandar grahon main Aalloo ke kand shalab keet ke niyantran ke liye CIPC ka upchar (Hindi Folder)
5. Production of disease free quality planting material propagated through tubers and rhizomes (Book).
6. Samahit Hindi Magazine No.8

F. Sequence Submitted to NCBI

1. Chakrabarti, S.K., Patil, V.U., Pattanayak,D., Rawat,S., Priya,S., Sindhu,R., Singh,Y., Singh,B.P., Naik,P.S. and Pandey,S.K. 2011. Complete genomic sequence of Solanum tuberosum BAC clone RH126J23. GenBank submission no. HQ896309
2. Chakrabarti, S.K., Patil,V.U., Pattanayak,D., Rawat,S., Priya,S., Sindhu,R., Singh,Y., Singh,B.P., Naik,P.S. and Pandey,S.K. 2011. Complete genomic sequence of Solanum tuberosum BAC clone RH066A20. GenBank submission no. HQ896308
3. Chakrabarti,S.K., Patil,V.U., Pattanayak,D., Rawat,S., Priya,S., Sindhu,R., Singh,Y., Singh,B.P., Naik,P.S. and Pandey,S.K. 2011. Complete genomic sequence of Solanum tuberosum BAC clone RH201H22. GenBank submission no. HQ896310
4. Chakrabarti,S.K., Patil,V.U., Pattanayak,D., Rawat,S., Priya,S., Sindhu,R., Singh,Y., Singh,B.P., Naik,P.S. and Pandey,S.K. 2011. Complete genomic sequence of Solanum tuberosum BAC clone RH198H19. GenBank submission no. HQ896311
5. Sundaresha,S., Patil,V.U., Sindhu,R., Bist,C.S., Sanju,S., Thakur,A., Pattanayak,D., Singh,B.P. and Chakrabarti,S.K., 2011. G-protein alpha subunit gene of Phytophthora infestans Indian isolate (A2 type), complete CDS.
6. Sundaresha,S., Patil,V.U., Sindhu,R., Bist,C.S., Sanju,S., Thakur,A., Pattanayak,D., Singh,B.P. and Chakrabarti,S.K., 2011. G-protein beta subunit gene of Phytophthora infestans Indian isolate (A2 type), complete cds.
7. Sundaresha,S., Patil,V.U., Sindhu,R., Bist,C.S., Sanju,S., Thakur,A., Pattanayak,D., Singh,B.P. and Chakrabarti,S.K., 2011. Phytophthora infestans Gpr11 of Indian isolate (A2 type), complete cds.

Institute Activities

Important meetings & Visitors

Dr S. Ayyappan, Secretary DARE and Director General, Indian Council of Agricultural Research (ICAR) visited CPRI, Shimla on 2-3 June, 2011 during which he chaired the Steering Review Committee of the Mini Mission-I for the central sponsored scheme of "Horticulture Mission of North East and Himalayan States" and also visited CPRI, its regional stations Kufri and Fagu and other ICAR regional stations located at Shimla. During his visit he also inaugurated the "Kisan Bhawan" at CPRI, a hostel with the capacity to accommodate 18 guests/farmers from different corners of the country visiting CPRI.

Dr HP Singh, Deputy Director General (Hort), ICAR, New Delhi visited CPRS, Shillong on 6th May, 2011. He visited field, tissue culture lab and poly houses of the station. He was accompanied by Dr RP Medhi, Director, NRC for Orchids, Sikkim.

The Steering Committee Meeting

The Steering Committee Meeting was held on 2nd June presided over by Hon'ble Director General, ICAR. The meeting was attended by various dignitaries including Vice Chancellors of SAUs, Directors and Nodal Officers from ICAR Institutes, Additional Commissioner (Horticulture), Govt. of India, Directors of Research of different SAUs and Directors of Horticulture of various Hill States.

RAC Meeting

The institute Research Advisory Council meeting was held at CPRI, Shimla on 16-17 August, 2011 under the chairmanship of Dr. KR Dhiman, VC, university of Horticulture & forestry Nauni. Important decisions were taken to guide the research agenda of CPRI during the meet.

IRC Meetings

The first IRC Meeting held on 29th April, 2011 at CPRI, Shimla. The meeting was attended by 37 scientists from Shimla and Regional Stations of CPRI. The basic objective of this meeting was to review the progress made in different research programmes of the Institute. Programme Leaders presented the achievements made during 2010-11 under various research programmes of the Institute during this meeting.

The second IRC meeting was held on 19-20 August, 2011 at CPRI Shimla under the chairmanship of Dr BP Singh, Director, CPRI. The

meeting was attended by 55 scientists from CPRI headquarters and regional stations. The objective of the meeting was to review the action taken on the recommendations of IRC meeting of 2010 and discuss/finalize the work plan for 2011-12. Special presentations were also made on research prioritization, technology development and on involvement of technical officers as programme associates.

Group meeting of AICRP (Potato)

The 29th Group meeting of AICRP (Potato) was organized at Indira Gandhi Krishi Vishwa Vidyalaya, Raipur during September 10-12, 2011. The meeting was attended by delegates from Indian Council of Agricultural Research, State Agriculture Universities and representatives from Industries. A farmers interface was also organized on the occasion and the farmers were addressed by Dr Charan Das Mahant, Hon'ble Minister of State for Agriculture and Food Processing Industries, Govt. of India and also by Shri Chander Shekhar Sahu, Hon'ble Minister of Agriculture, Veterinary, Fisheries and Labour, Govt. of Chhatisgarh. During the workshop the action taken on the recommendations of 28th Group meeting were reviewed in the presence of Dr HP Singh, Hon'ble Deputy Director General (Horticulture), ICAR, New Delhi.

NAIP CAC Meeting at Shimla

The 6th meeting of Consortium Advisory Committee was held on 3rd September, 2011 at CPRI, Shimla Dr PC Gaur, Chairman, CAC chaired the meeting. The action taken report on recommendation of 5th CAC meeting was presented and a proposal for extension of the NAIP Sub-Project till June, 2014 was presented by Dr BP Singh. All issues related to implementation and recommendations of last CAC as well as the issues related to progress of work presented by CPI and Co-PIs were discussed at length.

Institute Management Committee Meeting

The 6th meeting of X Institute Management Committee was held at Muthorai on 18th July, 2011. The meeting was chaired by Dr BP Singh, Director, CPRI and was also attended by Dr Umesh Srivastava, ADG (Hort) and two special invitees.

Institute Joint Staff Council Meeting

The VII meeting of the IJSC was also held along with on 18th July, 2011. This meeting was chaired by Dr BP Singh, Director, CPRI taking up the grievances of staff and solving them through discussion and requested the cooperation of all staff members for the progress of the Institute.

Important Conferences & Training

National Conference on "Genomics for

sustainable food and nutritional security was held on 26th November, 2011 at CPRI, Shimla. The conference was presided over by Hon'ble DDG, Dr. PH Singh and was organized by CPRI & IPA, Shimla.

Model Training Course

During the period under report, CPRI organized two Model Training Courses for 8 days each from 20-27 September, 2011 and 14-21 October, 2011 with respect to "Production for processing potatoes and post harvest technology" and "Healthy seed potato production : Conventional vs Hightech" respectively. The trainings were sponsored by Directorate of Extension, Govt. of India, New Delhi. The main objectives of these trainings was to improve the knowledge and skills of Extension Offices of State Agriculture/Horticulture Departments regarding the processing aspects, post harvest operations and healthy seed potato production through conventional and high-tech methods like tissue culture techniques. As many as 33 extension functionaries from 14 States participated in these two trainings.

Other Trainings

- A group of 50 farmers from Banaskantha district of Gujarat, visited Jalandhar station on 15-16 June, 2011. The group was given a training on agro-techniques for potato production, potato disease control, seed production and potato storage technology. The training was sponsored by ATMA.
- Two trainings for progressive farmers of Nawada, Purnia and Monghyr districts of Bihar was conducted by CPRS, Patna on 24th August and 30th September. A total of 65 farmers were benefited from these trainings.
- One off farm training on "Post Harvest Management in Potato" dated 8th August, 2011 and one on-farm training on "TPS Technology for potato production" dated 2.09.11 were conducted at CPRS, Shillong. Almost 100 farmers from nearby villages participated in these trainings.
- A farmers' training-cum-field day was organized on 28thJuly, 2011 at CPRS, Muthorai, Ootacamund. Twenty one farmers from Nanjanad and Hosahatty villages of Nilgiris district participated in this programme.
- A training on "Improved potato production technology" was conducted at CPRS, Shillong on 18-19 Sept., 2011. An on-farm training was conducted on 'Post Harvest Management in Potato" on 7-8 Sept., 2011 in Mawkhan and Mawklot villages in Meghalaya. More than 150 farmers participated in the training programmes.

Hindi Chetna Mass

CPRI celebrated Hindi Chetna Mass from 14th September to 13th October, 2011 during this one month celebration various competitions were held covering all the staff. Along with headquarters Hindi Diwas was also celebrated at CPRI stations viz. Modipuram, Jalandhar, Patna, Gwalior, Ooty and Shillong. On the concluding day the winners of the competitions were honored with prizes. Dr. & Prof. AND Bajpai, Vice Chancellor, HP University Shimla was Chief guest of the function during Hindi chetna mass at Shimla

Foreign visits by CPRI Scientists

1.	Dr. SK Kaushik, Joint Director, CPRIC, Modipuram, under went training in the area of Biosecurity (Horticulture), in the lab of Prof. KV Raman (Plant Breeding), College of Agriculture and Life Sciences, Cornell University, Ithaca, USA during May 05 – August 02, 2011.
2.	Dr. Raj Kumar, Sr. Sci., CPRS, Jalandhar, under went training in the area of "Genome Resource Conservation " (Horticulture)" under invitation from Dr. Wayne Nelles, Head Capacity Strengthening Deparment, International Potato Centre, La Molina, Peru from June 29 to September, 26, 2011.
3.	Dr. G. Ravichandraran, Sr. Sci. CPRS, Muthorai under went training in the area of Molecular Diagnostics (Horticulture), under invitation from Dr. Robert R. Martin, Research Laboratory, USDA-ARS, Corvallis, OR, USA, w.e.f. September 30, 2011 to December, 30,2011.
4.	Dr. RK. Arora, PS, CPRS, Jalandhar attended Bureau meeting of the UNECE Specialized Section on Standardization of Seed Potatoes at Prague, Czech Republic from October 03-05, 2011.
5.	Dr. Eradasappa E., Scientist, CPRS, Patna under went training in the area of Apomixis (Horticulture) in the lab of Dr. T.M. Sharbel, Apomixes Research Group Leader, Department of Cytogenetics and crop Analysis, Leibinz Institute of Plant genetics and Crop Plant Research (IPK), Gatersleben, Germany w.e.f. October, 14, 2011 to January, 11, 2012.
6.	Dr. Bir Pal Singh, Director, Dr. Jai Gopal, Head, Dr. PM Govindakrishnan, PS , CPRI, Shimla, Dr. S.K. Luthra, Sr. Sci. & Dr. VK Gupta, Sr. Sci. CPRIC, Modipuram participated in the Annual Meeting of the BMZ/GTZ funded project "Enhanced food and income security in SWCA through potato varieties with improved tolerance to abiotic stress" Tashkent. w.e.f. 7-10 November, 2011.
7.	Dr. SK Chakrabarti, Head, Plant Protection, CPRI, Shimla participated in the European Union-India Science & Technology Day, Vienna, Austria from 1-2 December, 2011.
8.	Dr. Bir Pal Singh, Director, CPRI, Shimla participated as a resource person in the training course on "Integrated Disease Management on Potato" Bangladesh from 24th February to Ist March, 2012.
9.	Dr. SP Trehan, PS, CPRS, Jalandhar attended in the INSA Collaborative/Exchange programme titled "Evaluation of Potato cultivars/Hybrids/ germplasm for nutrient efficiency traits under controlled and field conditions" at University of Gottingen, Germany w.e.f. 6th- 19th March, 2012.
10.	Dr. Vinod Kumar, Sr. Scientist, CPRS, Kufri under went training in the area of Genome Resource and Cyro- preservation, Leibniz Institute for Plant Genetics and Crop Plant Research, Gaterseben, Germany w.e.f. January 09 to April 07, 2012.

Education, Training, Awards & honours

Conference/Seminar/Symposium and Workshop

Sl. No.	Name & Designation	Training Programe	Date & Venue
1.	Dr Sanjeev Sharma Sr. Scientist, CPRI, Shimla	National Consultation-cum-Training on Diagnostics in Horticultural Crops	CPRI, Shimla on 16.04.2011
2	Dr. Jai Gopal, Head Division of Crop Improvement, CPRI, Shimla	DST Sponsored Programme on "Science Administration and Research Management" at	Hyderabad w.e.f. 18-29 April, 2011
3.	Dr. NC Upadhyay P.S, CPRIC, Modipuram	Kharif AICRP–Groundnut Workshop	Maharana Pratap University of Agri. & Tech., Udaipur on 22-24 April, 2011
5.	Sh. AK Singh, Chief Admin. Officer, CPRI, Shimla	Training programme on employers perspective on labour laws	Hyderabad w.e.f. 10-12 May, 2012
6.	Sh. Mairaj Ul Haque, AAO, CPRIC, Modipuram	Training programme on "Establishment Rule (ER)	ISTM,New Delhi w.e.f. 02.05.2011 to 06.05.2011
7.	Sh. AK Singh, Chief Admin. Officer, CPRI, Shimla	Three days workshop on "Personal Growth through Emotional Intelligence"	ISTM, New Delhi w.e.f. 02.5.2011 to 04.05.2011
8.	Dr. Sanjeev Sharma, Sr. Sci. CPRI, Shimla	National Symposium on "Technological Interventions for Sustainable Agriculture	Uttarakhand w.e.f. 3-5 May, 2011.
9.	Drs T.K. Bag and A.K. Srivastava CPRS, Shillong	20th Regional committee meeting	ICAR Research Complex for NEH Region, Umiam, Barapani 793 103 w.e.f. 5th to 7th May 2011
10.	Sh. HN Sharma, AAO, Estt.I, CPRI, Shimla	Training programme on "Reservation in Services for Scheduled Caste, Scheduled Tribes and OBC's (RIS).	ISTM New Delhi w.e.f. 23.05.2011 to 26.05.2011.
11.	Dr. Anuj Bhatnagar, Sr. Scientist, CPRS, Gwalior.	National conference on " Horti Business Linking Farmers with Market"	Dehradun w.e.f. May 28-31, 2011.
12.	Dr. Manoj Kumar, Sr. Scientist, CPRI, Shimla,	National conference on " Horti Business Linking Farmers with Market"	Dehradun w.e.f. May 28-31, 2011.

Sl. No.	Name & Designation	Training Programe	Date & Venue
13.	Dr. Vinay Singh, Sr. Sci. & Dr. Dhruv Kumar, Sr. Sci.CPRIC, Modipuram	National conference on " Horti Business Linking Farmers with Market"	Dehradun w.e.f. May 28-31, 2011.
14.	Dr. Rajesh Kumar Rana, Sr. Sci. CPRI, Shimla.	National conference on " Horti Business Linking Farmers with Market"	Dehradun w.e.f. May 28-31, 2011.
15.	Dr. AK Somani, Head, CPRS, Gwalior	National Seminar on "Transfer of Technology of Strategic Pesticides use to Enhance Agricultural Production & Food Security"	New Delhi June 1st, 2011.
16.	Dr. T.K. Bag CPRS, Shillong	"Steering review Committee Meeting of Horticulture Mission for North East and Himalayan States (MM-I)"	CPRI Shimla on 2nd June 2011.
17.	Dr. VK Gupta, Sr. Scientist, CPRIC, Modipuram	For participation in International Training course on "Molecular Markers in Horticulture"	IIHR, Bangalore w.e.f. 1-14 June, 2011.
18.	Kumar Devendra	Brain Storming Session on "Prioritization of Plant Physiological research for the 12th Five Year Plan Period"	On June 5-6, 2011 at IARI New Delhi
19.	Sh. Jivan Kumar, AAO, CPRS, Jalandhar	Two residential training programme for Administrative Personnel	IIPA, New Delhi w.e.f. 6.6.2011 to 24.06.2011
20.	Dr. MA Khan, Sr. Scientist, CPRIC, Modipuram	Participation in the one day Seminar on "Food Safety Analysis"	New Delhi on 13th June, 2011
21.	Dr. T.K. Bag CPRS, Shillong	Meeting Cum Workshop on "Towards more effective role of Heads of Divisions and Regional Stations in ICAR Institutes"	Central Institute of Agricultural Engineering, Bhopal 462 038, Madhya Pradesh from 14th to15th June 2011.

Sl. No.	Name & Designation	Training Programe	Date & Venue
22.	Sh. Mairaj Ul Haque, AAO, CPRIC, Modipuram	Technical workshop on "Pay Fixation, MACPS, Pension, T.A. LTC, CEAS, Lead Advances & APAR"	New Delhi 16-18 June, 2011.
23.	Dr. S Rawal CPRIC, Modipuram	Project review meeting of CIP- CPRI (ICAR) Collaboration	CPRI Shimla on 21 June, 2011
24.	Dr. Shashi Rawat, Sr. Scientist, CPRI Shimla	Training programme on "Computational Genome Analysis using ANVAYA"	IASRI, New Delhi w.e.f. 22-24 June, 2011
25.	Dr. SK Singh	International Conference on Organic farming	Department of Agriculture, Government of Bihar in Collaboration with ICAR-Research Complex for Eastern Region, Patna on 22-24 June, 2011.
26.	Dr. Rajesh Rana, Sr. Scientist, Dr. Vinay Bhardwaj, Sr. Sci. & Dr. Dhiraj Kumar Singh, Scientist., CPRI, Shimla.	Training programme on Data Analusis using SAS under the Consotria-based research project "Strengthening Statistical Computing for NARS"	IASRI, New Delhi w.e.f. 20-25, June, 2011
27.	Dr. NC Upadhayay, PS, CPRIC,Modipuram	Participation in the International conferernce on Organic Agriculture"	ICAR, Research Complex for Eastern Region, Patna w.e.f. 22-24 June, 2011.
28.	Kumar Devendra	lecture on potato storage in Special seminar	Agra cold storage owners Association, Agra on 1 July 2011
29.	Dr. Mrs. Ashiv Mehta, PS, CPRS, Jalandhar	Attending the workshop for Innovators on TDB funded scheme	Srinagar on 11 July, 2011
30.	Dr. Mehi Lal, Scientist, CPRIC, Modipuram	Participation in the National training programme on" Trends in Bioinformatics and compution systems: Exploring Interconnections for Molecular biological application"	Mau Nath Bhanjan, UP w.e.f. July 16-19, 2011.

Sl. No.	Name & Designation	Training Programe	Date & Venue
31.	Dr. Mehi Lal, Scientist, CPRIC, Modipuram	"Discussion of progress of the project CSS on Horticulture Mission for North East and Himalayan States (MM-I)"	NRC for Orchids, Pakyong, Sikkim on 26th July, 2011
32.	Dr. NC Upadhyay PS, CPRIC,Modipuram	National Workshop of AICRP on Soil test crop response correlation.	Indian Institute of Soil Science, Bhopal on 28 July, 2011
33.	Dr. R. Ezekiel, Head, CPB & PHT, CPRI, Shimla, Dr. Devendra Kumar, PS & Dr. Vandana, Scientist, CPRIC, Modipuram	Attending Brain storming session with DG	IARI, New Delhi w.e.f. 5-6 August, 2011
34.	Dr. Ms. Bandna, Scientist, CPRIC, Modipuram	Participation in the National Consultation of Gender Perspective in Agriculture	NASC, Complex N. Delhi w.e.f. August 8-9, 2011.
35.	Dr. Vinay Singh, Sr. Scientist, CPRIC, Modipuram	Attending the MDP on "Data Mining and for Decision Support in Agriculture"	IIM, Lucknow w.e.f. 1-12 August, 2011
36.	Dr. T.K. Bag CPRS Shillong	Research Advisory Committee meeting	CPRI Shimla from 16th to 17th August 2011
37.	Dr. T.K. Bag CPRS Shillong	The scientists meet on Revolving Fund Scheme Management Committee RFSMC) and seed project	CPRI Shimla on 18th August, 2011.
38.	Drs T.K. Bag and S.K. Yadav	2nd IRC	CPRI Shimla from 19th to 20th August 2011
39.	Sh. Joginder Singh Thakur, Asstt., CPRI, Shimla.	Two residential training programme for Administrative Personnel	IIPA, New Delhi w.e.f. 12.9.2011 to 30.09.2011
40.	Dr. BP, Singh, Director, CPRI, Shimla.	For participation in the training programme on employers perspective on labour laws	Hyderabad w.e.f. 2-4 August, 2011

Sl. No.	Name & Designation	Training Programe	Date & Venue
41.	Dr. Anuj Bhatnagar, Sr. Scientist, CPRS, Gwalior	Participation in the "Agricultural Entomology for the 21 Century"	NBAII, Bangalore w.e.f.25-26, August, 2011.
42.	Dr. Jagesh Kumar, Scientist, Division of Plant Protection, CPRI, Shimla	National Conference on "Advancement in Convergence of Technology 2011"	Amity University, Haryana w.e.f. September 8-9, 2011.
43.	Drs. R. Ezekiel, SS Lal, PM Govindakrishnan	AICRP – Potato workshop	Indira Gandhi Krishi Vishwavidyalaya, Raipur during September 10-11, 2011
44.	Drs. SP Trehan, SK Singh, S Rawal , K Manorama, TA Joseph, MK Jatav, T.K. Bag, A.K. Srivastava and M.S. Gurjar	29th Group Meeting of AICRP (Potato)	Indira Gandhi Krishi Vishwa Vidhyalaya, Raipur on 10 -12 September, 2011
45.	Dr Sanjeev Sharma, CPRI Shimla	International Workshop on Phytophthora Diseases of Plantation Crops	Rubber Research Institute of India, Kottayam, Kerala w.e.f. 12-14 September, 2011.
46	Drs. PM Govindakrishnan , VK Dua CPRI Shimla	National Stakeholders Consultation on Climate Change Platform	CRIDA, Hyderabad during September 19-20, 2011
47.	Dr. SK Singh CPRS Patna	Seminar cum Farmers Meeting on new aspects of seed production	Dayal Associates Group, Patna at Muzafferpur, Bihar on 21 September, 2011
48.	Dr. Vinay Bhardwaj, Sr. Scientist	Participation in the National Training Programme on"Allele Mining" sponsored by NAIP	IISR, Calicut w.e.f. September 12-25, 2011
49.	Dr. Rajesh Kumar Rana CPRI Shimla	Workshop on Policy and Prioritization, Monitoring and Evaluation(PME) Support to Consortia based Research Projects in Agriculture.	NAARM, Hyderabad w.e.f. September 22-27, 2011.
50.	Dr. SK Singh CPRS Patna	National Seminar on Development of Agriculture in Bihar- A farmer's journey from field to industry..	Inductus Foundation at Patna on 22-23 September, 2011

Sl. No.	Name & Designation	Training Programe	Date & Venue
51.	Dr. Mrs. Kamlesh Malik CPRIC Modipuram	"National Meeting on Agricultural Entomology"	NBA, Bangalore w.e.f. 25-26 Sept., 2011.
52.	Smt. Tarvinder Kochar CPRI Shimla	National workshop cum seminar on "Advances in electron microscopy & allied fields"	Shoolini University, Solan w.e.f. Sept. 23-29, 2011.
53.	Dr Sanjeev Sharma, CPRI Shimla	Seminar on Blight of Potatoes and its Preventive Measures in West Bengal	National Horticulture Board, Kolkatta on 30.09.2011.
54.	Drs S.K. Yadav and M.S. Gurjar CPRS Shillong	Round Table discussion on "New Frontiers on Climate Resilient Farming System for Livelihood Security	ICAR Research complex or NEH region, Umiam-793103 Meghalaya from 30th Sept. to 1st Oct., 2011.
55.	Dr. G. Ravichandran CPRS, Ooty	International training on 'Molecular diagnostics (Horticulture)	USDA-ARS, Corvallis, Oregon, USA under NAIP from 30th Sep, 2011 to 30th Dec, 2011.
56.	Drs. SK Chakrabarti, Vinay Bhardwaj, CPRS, Shillong	ABSP-II meeting	Jaipur w.e.f. 1-6 October, 2011
57.	Sh. NK Sharma, Sh. Jagbir singh CPRS Jalandhar	Workshop on "Fixation of pay" for officers dealing with pay fixation	ISTM, New Delhi w.e.f. 03.10.2011 to 05.10.2011
58.	Drs. Jeevalatha A and Baswaraj R CPRI Shimla	"National dialogue on application of Nanotechnology in Agriculture	organized at Central Institute of Fisheries Education, Mumbai during Oct, 8-9th,, 2011
59.	Dr. Sundaresha S CPRI Shimla	National training on "Allele Mininng: Basic Principles, Methods and Applications"	TNAU, Coimbatore, w.e.f. October 10-21, 211.
60.	Dr. (Ms.) Pinky CPRI Shimla	Training programme on "Nano-cellulose and its composites in Agriculture"	CIRCOT, Mumbai w.e.f. 10-24 October, 2011
61.	Drs. SS Lal, Devendra Kumar CPRI Shimla & CPRIC Modipuram	Participation in the Global Agri Connect 2011 Conference cum Exhibition	IARI, New Delhi w.e.f. 14-16 October, 2011
62.	Dr. (Mrs) Ashiv Mehta CPRS Jalandhar	'CSIO-CPRI Interactive Meet with prospective Potato Storage Technology Users on Computer based Instrumentation System for quality Preservation of Stored Potatoes'	CSIO Chandigarh on October 17, 2011

Sl. No.	Name & Designation	Training Programe	Date & Venue
63.	Dr. Dhiraj Kumar CPRI Shimla	Training programme on "Quantitative Methods for agricultural policy research" Division of Economics,	IARI, New Delhi w.e.f. 17-22 October, 2011
64.	Dr. (Ms.) Bandana CPRIC Modipuram	Training programme on "Non-thermal, Non-chemical processing and membrane technology in food systems" Spon. By NAIP	CIAE, Bhopal w.e.f. 12-21 October, 2011
65.	Dr. TA Joseph CPRS Ooty	State Variety Screening Committee meeting	TNAU Coimbatore on 24.10.11
66.	Dr. NC Upadhayay, CPRIC Modipuram	Annual Rabi–Summer Groundnut Research Group Meeting	University of Agri. & Tech., Bhubaneshwar on 2–3 November, 2011
67.	Dr. Sanjeev Sharma CPRI Shimla	Training programme on "Monitoring and Forecasting of Plant Disease epidemics under climate change scenario	" Centre for advanced faculty training, New Delhi w.e.f. October 10 to November 1, 2011
68.	Dr. Vinay Sagar CPRI Shimla	Refreshers course on "Agricultural Research Management" for Newly Recruited Sr./PS form Non-ICAR Institutes	NAARM, Hyderabad w.e.f. 03-23 November, 2011.
69.	Drs. Jeevalatha A, Baswaraj R CPRI Shimla	"2nd National dialogue on application of nanotechnology in Agriculture	During Nov, 11-12th, 2011 at Tamil Nadu Agricultural University, Coimbatore.
70.	Drs. Shashi Rawat, Sundaresha CPRI Shimla	Training on Sequencing Software's	New Delhi w.e.f. 15-16 November, 2011
71.	Dr. R. Umamaheswari CPRS Ooty	National Nematology Symposium on "Namatodes: A challenge under changing climate and agricultural practices"	Kovalam, Trivandrum w.e.f. November 16-18, 2011
72.	Dr. SP Trehan CPRS Jalandhar	National Seminar on "Developments in Soil Science- 2011"	UAS, Dharward w.e.f. November 16-19, 2011.

Sl. No.	Name & Designation	Training Programe	Date & Venue
73.	Dr. Rakesh Mani Sharma, CPRI, Shimla	National Conference on "Agricultural Librarians and User Community (NCALUC)"	Nauni, Solan w.e.f. 17-19 November, 2011
74.	Sh. Surender Paul CPRI, Shimla	National Conference on "Transformation of Agricultural Libraries in the Collaborative Era"	Nauni, Solan w.e.f. 1 7-19 November, 2011
75.	Er. Manjit Singh CPRS Jalandhar	Stake Holder's meeting.	CPRS Jalandhar on 20 November, 2011
76.	Er. Sunil Gulati CPRS Jalandhar	Stake Holder's meeting.	CPRS Jalandhar on 20 November, 2011
77.	Dr. Rakesh Mani Sharma CPRI Shimla	Participation in a day long seminar on Digital Libraries "Discovery to Delivery" e-content 2011	Chandigarh on 21st November, 2011.
78.	Dr. R. Ezekiel CPRI Shimla	National Seminar on Sustainable Crop Productivity through Physiological Intervention"	Mumbai w.e.f. 24-26 November 2011
79.	Drs. Sanjeev Sharma, Jeevalatha A. CPRI Shimla	"National conference on genomics for sustainable food and nutritional security"	26th Nov, 2011 CPRI, Shimla.
80.	Dr. (Mrs.) Kamlesh Malik CPRIC Modipuram	Attending the XVI Group meeting of AINP on "White Grubs & other soil arthoropods"	AAU, Jorhat w.e.f. 9-10 December, 2011
81.	Dr. RK Arora CPRS Jalandhar	Attending " Brain Storming Session and 64th Annual Meeting of Indian Phytopathology"	Hyderabad w.e.f. December 2-4, 2011.
82.	Drs. R. Umamaheswari, R. Muthuraj CPRS Ooty	42nd State Variety Release Committee Meeting.	Chennai on 7.12.2011 and presented the State Variety Release Proposal of the hybrid OS/93-D-204 (K. Neelima).
83.	Dr. SK Chakrabarti CPRI Shimla	National symposium on "Perspective in the Plant Health Management" & 63rd Annual Meeting of IPS	AAU, Anand Gujarat w.e.f. December 14-16, 2011.

Sl. No.	Name & Designation	Training Programe	Date & Venue
84.	Dr. (Mrs.) Ashiv Mehta CPRS Jalandhar	DST National Programme on "Entrepreneur Development and Management for Scientists and Technologist"	Ahmedabad w.e.f. 19-23 December, 2011
85.	Drs. Shambhu Kumar, Sr. Scientist, RK Singh, SK Singh CPRS Patna	4th International Conference on Life Science Research for Agricultural and Rural Development (ICLRAD 2011)	Patna w.e.f. 27-29 December, 2011.
86.	Dr. TK Bag CPRS Shillong	3rd Global conference on"Plant Pathology for food security	MPUAT, Udaipur, Rajasthan w.e.f. 10-13 January, 2012.
87.	Dr. M.S. Gurjar CPRS Shillong	3rd Global Conference, Plant Pathology for Food Security,	MPUAT, Udaipur, Rajasthan from 10th to 14th January, 2012
88.	Sh. Malkhan Singh Gurjar CPRS Shillong	3rd Global Conference on "Plant Pathology and Food Security"	Udaipur, Rajasthan w.e.f. 10-13 January, 2011
89.	Sh. Malkhan Singh Gurjar CPRS Shillong	15th Shri Vasant Rao Naik Memorial National Agriculture Seminar on Technologies for Sustainable Horticulture for Rainfed Areas .	Dr Punjab Rao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) on January 20-21, 2012.
90.	Dr. VK Dua CPRI Shimla	National Dialogue on Climate Resilient Horticulture	IIHR, Bangalore during 28-29 January, 2012
91.	Drs. VK Gupta , Mehi Lal CPRIC Modipuram	"Hands on training on Molecular Biology Tools and Their Application in Agriculture"	SVPUAT, Meerut w.e.f. January 18 to Feb. 02, 2012.
92.	Dr. NK Pandey CPRI Shimla	29th Group Meeting of AICRP	Indira Gandhi Krishi Vishva Vidyalaya, Raipur on 10 Sept.
93.	Er. Manjit Singh CPRS Jalandhar	National Agricultlure Seminar on "Technologies for Sustainable Horticulture for Rainfed Areas"	DPRDKV, Akola, Maharashtra w.e.f. January 17-24, 2012.
94.	Dr Sanjeev Sharma CPRI Shimla	Refresher Course on "Agricultural Research Management" for Newly Recruited Sr./PS form Non-ICAR Institutes	NAARM, Hyderabad w.e.f. January 19 – 08 February, 2012.

Sl. No.	Name & Designation	Training Programe	Date & Venue
95.	Dr. Davendra Kumar, CPRIC Modipuram	Training programme on "Naturally occurring nutraceuticals, crop protectants and other biomolecules for application in human and crop health"	IARI, New Delhi w.e.f. 23 January to 2 February, 2012.
96.	Dr. MA Khan CPRIC Modipuram	Training programme on "Naturally occurring nutraceuticals, crop protectants and other biomolecules for application in human and crop health"	IARI, New Delhi w.e.f. 23 January to 2 February, 2012.
97.	Dr. T. A. Joseph CPRS Ooty	Thirteenth Scientific Advisory Committee Meeting	UPASI-KVK, Glenview, Coonoor on 09.02.2012
98.	Dr. Ravinder Kumar CPRI Shimla	National training programme on "Development of gene chip for microbial identification using DNA probes"	Mau Nath Bhanjan w.e.f. 28 January to 10th February, 2012
99.	Drs. Devendra Kumar, MA Khan CPRIC Modipuram	2nd International Conference on "Agrochemicals, protecting crops, health and natural environment: role of chemistry for sustainable agriculture"	IARI, New Delhi w.e.f. 15-18 February, 2012.
100.	Dr. MA Khan CPRIC Modipuram	International Conference on "Agrochemicals Protecting Crops, Health and Natural Environment: role of Chemistry for sustainable Agriculture"	New Delhi w.e.f. 15-18 February, 2011.
101.	Dr. Shashi Rawat CPRI Shimla	International Conference on "Plant biotechnology for food security"	New Delhi w.e.f. February 21-24, 2012.
102.	Dr. SK Chakrabarti CPRI Shimla	International Conference on "Plant Biotechnology for Food Security: New Frontiers- 2012"	New Delhi w.e.f. February 21-24, 2012.
103.	Sh. Malkhan Singh Gurjar CPRS Shillong	Training programme on "Molecular techniques for identification of potato pathogens"	CPRI, Shimla w.e.f. February 25 - March 15, 2011.
104.	Dr. SK Singh CPRS Patna	Consortium Advisory Committee (CAC) cum Annual Workshop of NAIP Project on Sustainable livelihood improvement through need based integrated farming system models in disadvantaged districts of Bihar component -3	ICAR- Research Complex for Eastern Region, Patna on 3 March, 2012

Sl. No.	Name & Designation	Training Programe	Date & Venue
105.	Dr Sanjeev Sharma	Review meeting of PhytoFuRa project	IIHR, Bangalore on 3-4 March, 2012.
106.	Dr Jeevalatha A, Baswaraj R CPRI Shimla	"National consultation meet on Nano Agriculture Mission	During 11-12th March, 2012 at NASC complex, New Delhi.
107.	Ers. Manjit Singh, Sunil Gulati CPRS Jalandhar	Interaction meet of scientists of Farm Machinery & Power and Mechanical Engineering disciplines.	CIAE, Bhopal on March 16-18, 2012
108.	Dr. SS Lal CPRI Shimla	National seminar on "Indian Agriculture: Preparedness for Climate Change"	ISAS, New Delhi w.e.f. 24-25 March, 2012.
109.	Dr. JS Minhas CPRS Jalandhar	National Seminar on "Frontiers and Future Challenges in Horticultural Crops"	PAU, Ludhina w.e.f. 15-17 March, 2012.
110.	Drs. PM Govindakrishnan, SS Lal, CPRI Shimla	ICAR Network Project on Climate Change	NASC, New Delhi 22-23 March, 2012
111.	Dr. SP Trehan CPRS Jalandhar	INSA-DFG collaborative exchange programme on "Evaluation of potato cultivars/hybrids/germplasm for nutrient efficiency traits under controlled and field conditions	University of Goettingen, Germany on 7-19 March, 2012

Awards & honours

2011	**K.C.Mehta and Manoranjan Mitra Award (2011) in recognition of research work by Indian Phytopathological Society, New Delhi.**	**Arora, R.K**
2011	**Invited and participated in the brain storming session on Plant Pathology in India: Vision 2030 organized by Indian Phytopathological Society, New Delhi at Hyderabad, December 2, 2011.**	**Arora, R.K**
2011	**Awarded Young Scientist Award (2011) in recognition of research work by Indian Society of Hill Agriculture, Uttarakhand.**	**Sharma, Sanjeev**

Classified abstract of expenditure in respect of Non- Plan & Plan for the year 2011-12

		Non Plan		Plan
		Govt. Grants	Resource Generation	
	Establishment Charges			
	Pay and Allowances			
1	Pay of Officers	64024595.00	0.00	0.00
2	Pay of Establishment	54616403.00	0.00	0.00
3	Dearness Allowance	66036953.00	0.00	0.00
4	House Rent Allowance	13738048.00	0.00	0.00
6	Transport Allowance	8005655.00	0.00	0.00
7	Bonus	1185278.00	0.00	0.00
8	Other Allowances	16002888.00	0.00	0.00
10	Overtime	0.00	0.00	0.00
	Pay and Allowances :	**223609820.00**	**0.00**	**0.00**
	Wages			
11	Wages of Temporary Labourers	15839211.00	0.00	0.00
	Establishment Charges :	**239449031.00**	**0.00**	**0.00**

		Non Plan Govt. Grants	Resource Generation	Plan
	Travelling Expenses			
12	Travelling Allowances - within India	1543949.00	0.00	2898523.00
13	Travelling Allowances - Abroad	0.00	0.00	0.00
	Travelling Expenses :	1543949.00	0.00	2898523.00
	Other Charges			
	Assets Acquired			
14	Land	0.00	0.00	1162480.00
15	Buildings and Original Works	0.00	0.00	22636660.00
16	Tool, Plant and Equipment	817145.00	0.00	41211168.00
17	Furniture, Fixture and Fittings	336573.00	0.00	554047.00
18	Typewriters, Computers, Accounting and Other	1312034.00	0.00	134447.00
19	Livestocks	0.00	0.00	0.00
20	Vehicles and Vessels	0.00	0.00	0.00
21	Library Books and Journals	693883.00	0.00	2999040.00
Assets Acquired :		**3159635.00**	**0.00**	**68697842.00**
	Other Contingent Expenditure			
22	Chemicals, Glassware/Plasticware and	10375039.00	8100000.00	18645963.00
23	Livestock required for research work	2880.00	0.00	0.00
24	Fertilizers	829502.00	0.00	1627620.00
26	Petrol, Oil and Lubricants	91652.00	700000.00	340066.00
27	Electricity Charges	1674335.00	2832000.00	1125650.00
28	Water Charges	60348.00	0.00	114849.00

		Non Plan		Plan
		Govt. Grants	Resource Generation	
29	Rent	0.00	0.00	0.00
30	Telephone/Fax Charges - Office	42374.00	300016.00	105957.00
32	Postage	0.00	199984.00	74065.00
33	Staff paid from Contingencies	4442351.00	0.00	3305522.00
34	Muncipal/Property Tax	0.00	0.00	70000.00
35	Stationery	570907.00	0.00	216553.00
36	Printing and Binding	258540.00	400000.00	128947.00
37	Refreshment/Entertainment	23741.00	0.00	9345.00
38	Other Office Contingencies	630840.00	2168000.00	447119.00
39	Other Research Contingencies	464429.00	900000.00	1568572.00
40	TA/Honm to Non Officials	297089.00	0.00	98765.00
44	Other Administrative Expenditure	0.00	0.00	494431.00
46	Sports and Tournaments	0.00	303992.00	0.00
47	Other Miscellaneous Expenditure	4417750.00	541008.00	4015801.00
	Other Contingent Expenditure :	24181777.00	16445000.00	32389225.00
	Other Charges :	27341412.00	16445000.00	101087067.00
	Maintenance and Petty Works			
48	Repair and Maintenance of Office Buildings	2950097.00	3000000.00	0.00
49	Repair and Maintenance of Residential Buildings	2401052.00	0.00	0.00
50	Petty/Minor works	643923.00	0.00	0.00
	Maintenance and Petty Works :	**5995072.00**	**3000000.00**	**0.00**
	Grand Total	**274329464.00**	**19445000.00**	**103985590.00**

	Amount
Revenue Receipts	
Sale of Farms Produce	10641477.00
Sale of Vehicle, other Machine Tools	467600.00
Income from Royalty, Sale of Publications and Advertisement	128249.00
Licence Fee	1065189.00
Interest earned on Loans and Advances	871201.00
Interest earned on short term deposits	1133627.00
Recoveries of Loans and Advances	1657927.00
Miscellaneous Receipts	6403896.00
Grand Total	**22369166.00**

Promotions / Retirements/ Transfers / Deaths

Scientific Category

APPOINTMENTS

1. Dr. Raj Kumar, Scientist (SS), Seed Tech. has joined at CPRS, Patna on inter-institutional transfer on 17.10.2011.
2. Sh. Vallepu Venkateshwarly, Scientist(Agril. Ento.) has joined his duties in the forenoon of 26.12.2011 in the division of Plant Protection at CPRI, Shimla.
3. Sh. Sridhar Jandrajupalli, Scientist(Agril. Entomology) has joined his duties in the forenoon of 26.12.2011 in the division of Plant Protection at CPRI, Shimla.
4. Dr. Ravinder Kumar, Scientist(Plant Pathology) has joined his duties in the forenoon of 5.9.2011 in the division of Plant Protection, CPRI, Shimla.
5. Dr.(Ms.) Dalamu, Scientist(Hort.-Veg. Sci.) has joined in the division of Crop Improvement, CPRI, Shimla on 5.9.2011.

RETIREMENTS/TERMINATIONS

1. Dr. SV Singh, PS, CPRIC, Modipuram retired on superannuation on 31.7.2011.
2. Dr. Rajpal Singh, PS, CPRIC, Modipuram retired on superannuation on 29.2.2012.
3. Sh. AC Soundharam, Scientist dismissed with effect from 4.1.2012.

TRANSFER AFTER SELECTION TO THE HIGHER POSTS

1. Dr. PS Naik, Project Coordinator has been relieved from 8.7.2011(AN) to join his new assignment as Director, IVRI, Varansi.
2. Dr. D Pattanayak, Sr. Scientist, Bio-technology has been relieved w.e.f. 16.7.2011(AN) to join as PS at National Research Centre on Plant Bio-technology, Pusa Campus, New Delhi.
3. Dr. Jai Gopal, Head, Division of Crop Improvement, CPRI, Shimla has been relieved on 5.1.2012(AN) to join his new assignment as Director, Directorate of Onion and Garlic Research, Pune.
4. Dr. SK Chakarbarti, Head, Division of Plant Protection, CPRI, Shimla has been relieved from 31.3.2012(AN) to join his assignement as Director , Central Tuber Crop Research Institute, Thiruvanthapuram.

WITHIN INSTITUTE

1. Dr. R. Ezekiel, PS has assumed the charge to the post of Head, Division of Crop Physiology, Biochemisty and Post Harvest Technology., CPRI, Shimla w.e.f. 7.5.2011(FN).
2. Dr. Manoj Kumar, Sr. Scientist has joined to the post of Head, CPRS, Patna w.e.f. 15.7.2011.

Technical Category

Promotion

Field Farm Technician (Cat. I & II)

1. Sh. Shiv Bir Singh, CPRIC, Modipuram, promoted T-6 w.e.f. 1.1.2010
2. Smt. Shelly Chopra, CPRI, Shimla, promoted T-6 w.e.f. 23.1.2010
3. Sh. SK Rastogi, CPRS, Patna, promoted T-6 w.e.f. 1.1.2010
4. Sh. Kapil Kr. Sharma, CPRS, Jalandhar, promoted T-6 w.e.f. 23.2.2010
5. Shri Kameshwar Sen, CPRI, Shimla, promoted T-6 w.e.f. 5.1.2011
6. Shri Om Pal, CPRIC, Modipuram, promoted T-6 w.e.f. 13.10.2010
7. Sh. Prem Lal, CPRS, Jalandhar, promoted T-5 w.e.f. 3.2.2010
8. Dr. Sumita Sharma, CPRI,Shimla, promoted T-5 w.e.f. 28.5.2010
9. Sh. Arjun Kr. Sharma, CPRS, Patna, promoted T-5 w.e.f. 8.6.2009
10. Sh. Gautam Pd. Singh, CPRS, Patna, promoted T-5 w.e.f. 3.2.2010
11. Sh. Shiv Kumar Lal Karna, CPRS, Patna, promoted T-5 w.e.f. 1.1.2011
12. Sh. Devi Chand. Sharma, CPRS, Kufri, promoted T-5 w.e.f. 3.2.2010
13. Sh. E. Syiemlieh, CPRS, Shillong, promoted T-5 w.e.f. 3.2.2010
14. Sh. Pushpender Kr., CPRIC,Modipuram, promoted T-5 w.e.f. 11.2.2009
15. Sh. Jasvir Singh, CPRIC,Modipuram, promoted T-5 w.e.f. 16.2.2008
16. Sh. Avinash Chaudhory, CPRIC, Modipuram, promoted T-5 w.e.f. 30.6.2009
17. Sh. Harvir Singh, CPRIC, Modipuram, promoted T-5 w.e.f. 30.9.2009
18. Sh. Akhilesh Kumar Singh, CPRS, Jalandhar, promoted T-5 w.e.f. 24.07.2009
19. Sh Sanjay Kumar Sharma, CPRS, Gwalior, promoted T-5 w.e.f. 14.05.2009
20. Sh. V. Rajendran, CPRS, Ooty, promoted T-5 w.e.f. 1.1.2010
21. Sh. I Abdul Rashid, CPRS, Ooty, promoted T-5 w.e.f. 3.2.2010
22. Sh. RK Samadhiya, CPRS, Gwalior, promoted T-5 w.e.f. 25.3.2010
23. Sh. Jagat Ram, CPRI, Shimla, promoted T-5 w.e.f. 3.2.2010
24. Sh. Vinod Kumar, CPRI, Shimla, promoted T-5 w.e.f. 6.2.2011
25. Sh. Shibi Kant Arya, CPRS, Patna, promoted T-4 w.e.f.1.1.2010
26. Sh. Rakesh Srivastava, CPRS, Patna, promoted T-4 w.e.f.12.7.2010
27. Shri Sudershan Singh, CPRI, Shimla, promoted T-4 w.e.f.25.1.2010
28. Sh. Yash Pal Sharma, CPRI,Shimla, promoted T-4 w.e.f.1.7.2009
29. Sh. Sheesh Ram, CPRI, Shimla, promoted T-4 w.e.f.5.5.2010
30. Sh. Kharaiti Lal, CPRI, Shimla, promoted T-4 w.e.f.5.5.2010
31. Sh. Anil Kumar, CPRS, Patna, promoted T-4 w.e.f.9.8.2010
32. Sh. B. Langstieh, CPRS, Shillong, promoted T-4 w.e.f.16.1.2011
33. Sh. Naresh Chand, Shimla, promoted T-3 w.e.f.28.2.2010
34. Sh. Sita Ram Sahu, CPRS, Kufri, promoted T-3 w.e.f. 9.4.2009
35. Sh. Praveen Kumar, CPRS, Gwalior, promoted T-3 w.e.f. 7.3.2010
36. Sh. Kulwinder Singh, CPRS, Jalandhar, promoted T-3 w.e.f. 4.3.2010

37. Sh. Ram Singh, CPRI, Shimla, promoted T-3 w.e.f. 7.5.2011

38. Smt. Manjit Syal, CPRI, Shimla, promoted T-3 w.e.f. 4.6.2011

39. Sh. Hari Kishore, CPRI, Shimla, promoted T-3 w.e.f. 4.6.2011

40. Smt. Asha Thakur, CPRI, Shimla, promoted T-3 w.e.f. 4.6.2011

41. Sh. Bhuneshwar Prasad, CPRS, Patna, promoted T-3 w.e.f. 15.5.2011

42. Sh. P. Roy Khungbuh, CPRS, Shillong, promoted T-I-3 w.e.f. 4.10.2008

Lab. Technician (Cat.-I & II)

1. Sh. Dharminder Verma, CPRI, Shimla, promoted T-6 w.e.f. 15.6.2010

2. Sh. DP Gautam, CPRI, Shimla, promoted T-4 w.e.f. 21.2.2010

3. Sh. Dharminder Kumar Gupta, CPRI, Shimla, promoted T-3 w.e.f. 6.6.2011

4. Smt. Madhu Bala, CPRI, Shimla, promoted T-3 w.e.f.12.6.2011

Press & Editorial Staff (cat.-I & II)

1. Sh.R.S. Kapoor, CPRI, Shimla, promoted T-6 w.e.f. 29.6.2011

2. Smt. Kusum Singh, CPRIC, Mod., promoted T-6 w.e.f. 29.6.2011

3. Sh. Rajneesh Rajput, CPRI, Shimla, promoted T-6 w.e.f. 29.6.2011

Retirements

1. Sh. Hoshiar Singh, T-5, CPRS, Jalandhar on 3.4.2011

2. Sh. Surinder Singh Daulla, T-5, CPRS, Jalandhar on 30.4.2011

3. Sh. Shiv Kumar Lal Karna, CPRS, Patna on 30.4.2011

4. Sh. SK Rastogi, T-5, CPRS, Patna on 30.6.2011

5. Sh. Balbir Singh, T-5,Tractor Driver, CPRIC Modipuram on 31.7.2011

6. Sh. Nawab Ali, T-5, Tractor Driver, CPRIC Modipuram on 31.8.2011

7. Sh. Pardeep Thapliyal, CPRIC Modipuram on 30.11.2011

8. Sh. Prem Lal, T-4, CPRS, Jalandhar on 31.12.2011

9. Dr. Kopil Dey, T (T-8), CPRS, Patna on 31.12.2011

10. Sh. RS Kapoor, T-5, CPRI, Shimla on 31.1.2012

11. Sh. Raj Kumar, T-6, CPRS, Jalandhar on 31.3.2012

Transfer:

- Sh. Baljinder Singh, T-4, from CPRS Jalandhar, to CPRI, Shimla, on 20.10.2011

- Sh. Tilak Raj, T-5, from CPRS, Kufri to CPRI, Shimla, on 5.4.2011

- Sh. Yogesh, T-5, CPRS, Patna to CPRI, Shimla, on 6.4.2011

- Sh. Kamal Singh, T-1, CPRS, Jalandhar to CPRIC, Modipuram on 1.4.2011

- Sh. Baljinder Singh, T-4, from CPRI, Shimla to CPRS, Jalandhar, on 12.1.2012

Administrative Category

Promotions:-

1. Sh. Jai Ram Thakur, UDC, CPRI, Shimla promoted as Assistant w.e.f. 26.04.2011 (FN) in the Pay Band of Rs. 9300-34800+Grade Pay 4200/-.

2. Sh. Jagtar Singh, AAO, CPRI, Shimla promoted to the post of Administrative Officer in the Pay Band of Rs. 15600-39100+Grade Pay of Rs. 5400/- at ICAR Research Complex, Goa. Relieved in the afternoon of 13.05.2011 (AN).

3. Sh. Jeet Ram, Assistant, CPRI, Shimla promoted as Assistant Admn. Officer w.e.f. 28.05.2011 (AN) in the Pay Band of Rs. 9300-34800+Grade Pay of Rs. 4600/-

4. Smt. Meena Verma, UDC, CPRI, Shimla promoted as Assistant through LDCE w.e.f. 27.06.2011 (AN) in the Pay Band of Rs. 9300-34800+ Grade Pay of Rs.4200/-

5. Sh. Jagbir Singh, UDC, CPRIC, Modipuram promoted as Assistant through LDCE w.e.f. 27.06.2011 (AN) in the Pay Band of Rs.9300-34800+ Grade Pay of Rs.4200/-.

6. Smt. Babli Bhawani, UDC, CPRI, Shimla promoted as Assistant through LDCE w.e.f. 27.06.2011 (AN) in the Pay Band of Rs. 9300-34800+Grade Pay of Rs. 4200/-.

7. Sh. Surinder Singh, UDC, CPRIC, Modipuram promoted as Assistant through LDCE w.e.f. 18.10.2011 in the Pay Band of Rs. 9300-34800+Grade Pay of Rs. 4200/-.

8. Sh. Roshan Lal Verma, Personal Assistant, CPRI, Shimla promoted as Private Secretaty w.e.f. 25.02.2012 in the Pay Band of Rs.9300-34800+Grade Pay of Rs. 4600/-.

Retirement:-

1. Sh. Tulsi Ram, Assistant, CPRI, Shimla retired on 30.06.2011.

2. Sh. Joginder Prasad, Assistant, CPRS, Patna retired on 31.12.2011.

3. Sh. Vijay Krishan Dhir, Private Secretary, CPRS, Jalandhar retired on 31.01.2012.

Transfer:-

1. Sh. Kamal Chand Verma, LDC, transferred from CPRS, Patna to CPRS, Gwalior and joined at CPRS, Gwalior on 05.04.2011.

2. Sh. Atar Singh, LDC transferred from CPRS, Gwalior to CPRIC, Modipuram and joined at CPRIC, Modipuram on 02.05.2011.

3. Sh. Daljeet Singh, LDC transferred from CPRS, Gwalior to CPRS, Jalandhar and joined at CPRS, Jalandhar on 02.05.2011.

4. Sh. Devendra Kumar, Assistant transferred from CPRI, Shimla to CPRS, Kufri and joined at CPRS, Kufri on 01.11.2011.

5. Sh. Suresh Kumar Verma, Steno Grade-III, transferred from CPRI, Shimla to CPRS, Jalandhar on 08.11.2011.

6. Sh. Ashish Kalyan, LDC transferred from CPRS, Kufri to CPRS, Gwalior and joined at CPRS, Gwalior on 02.11.2011.

7. Sh. Ashok Kumar, LDC, transferred from CPRS, Gwalior to CPRIC, Modipuram and joined at CPRIC, Modipuram on 07.03.2012.

Skilled Supporting Staff Category

FINANCIAL UPGRADATON GRANTED UNDER MACP SCHEME:

Name of the Officials	Present Pay Band+Grade Pay	Date of grant of *I/II/III MACPS	Pay Band and Grade Pay granted after MACPS
Sh. Khem Chand CPRI, Shimla	Rs.5200-20200+2000	3rd GP Rs.2400 w.e.f. 14.05.2011	Rs.5200-20200+ Rs.2400
Sh.Dakur Sah, CPRS, Patna	Rs.5200-20200+1900	2nd GP Rs.2000 w.e.f. 14.06.2011	Rs.5200-20200+Rs.2000
Sh.Ram Babu Rai, CPRS, Patna	Rs.5200-20200+1900	2nd GP Rs.2000 w.e.f. 17.05.2011	Rs.5200-20200+Rs.2000
Sh.Ram Babu, CPRS, Gwalior	Rs.5200-20200+1900	2nd GP Rs.2000 w.e.f. 20.07.2011	Rs.5200-20200+Rs.2000
Sh. Mohan Lal, CPRS, Gwalior	Rs.5200-20200+1900	2nd GP Rs.2000 w.e.f. 20.07.2011	Rs.5200-20200+Rs.2000
Sh.Hari Singh, CPRS, Gwalior	Rs.5200-20200+1900	2nd GP Rs.2000 w.e.f.20.07.2011	Rs.5200-20200+Rs.2000
Ms. Muni Devi, CPRS, Kufri	Rs.5200-20200+1900	2nd GP Rs.2000 w.e.f. 02.08.2011	Rs.5200-20200+Rs.2000
Ms. Indira Devi CPRS, Kufri	Rs.5200-20200+1900	2nd GP Rs.2000 w.e.f. 20.08.2011	Rs.5200-20200+Rs.2000
Sh. Mansha Ram, CPRI, Shimla	Rs.5200-20200+1900	2nd GP Rs.2000 w.e.f. 28.02.2011	Rs.5200-20200+Rs.2000
Ms. Vimla Devi, CPRS, Gwalior	Rs.5200-20200+1800	1st GP Rs.1900 w.e.f. 17.04.2011	Rs.5200-20200+Rs.1900

PROMOTIONS :

1. Sh.Rajvir Singh,SSS has joined CPRIC, Modipuram on dated 12.12.2011 (A.N.)
2. Sh. Raj Kumar, SSS has joined CPRIC, Modipuram on dated 12.12.2011 (A.N.)
3. Sh. Sudesh Pal singh, SSS has joined CPRIC, Modipuram on dated 12.12.2011 (A.N.)
4. Sh.Tej Bir Singh, SSS has joined CPRIC, Modipuram on dated 12.12.2011 (A.N.)
5. Sh. Gyanendra Kumar, SSS has joined CPRIC, Modipuram on dated 12.12.2011 (A.N.)
6. Sh. Rishipal, SSS has joined CPRIC, Modipuram on dated 12.12.2011 (A.N.)

RETIREMENT :

Sl. No.	Name of employee, designation and present place of posting	Date of birth	Date of retirement
1.	Sh. Mahip Yadav, SSS, CPRS, Patna	01.07.1951	30.06.2011
2.	Sh. Khlain Singh, SSS, CPRS, Shillong	01.09.1951	31.08.2011
3.	Sh. Shiv Narain, SSS, CPRS, Gwalior	05.08.1951	31.08.2011
4.	Sh. Pratap Singh, SSS, CPRS, Kufri	18.08.1951	30.09.2011
5.	Sh. M Pandy, SSS, CPRS, Muthorai	18.05.1951	31.05.2011
6.	Sh. Dharambir, SSS, CPRIC, Modipuram	03.09.1951	30.09.2011
7.	Sh. Fakira Tanti, SSS, CPRS, Patna	04.01.1952	31.01.2012
8.	Sh. Flask Nongkynrih , SSS, CPRS, Shillong	01.03.1952	29.02.2012
9.	Sh. Roopu, SSS, CPRI, Shimla	01.03.1952	29.02.2012

UNTIMELY DEMISE :

1. Sm. Chinta Devi, Skilled Support Staff, CPRS, Patna expired as on 25.04.2011.
2. Sh. Adi Lal, Skilled Support Staff, CPRS, Kufri expired as on 09.09.2011.
3. Sh. Shiv Narayan, Skilled Support Staff, CPRS, Gwalior expired as on 17.10.2011.

Personnel

Director:

Dr. BP Singh

AICPIP Unit

1 Dr. MK Jatav, Scientist(SS)

Division of Crop Improvement

1. Dr. Vinay Bhardwaj, Sr. Scientist
2. Sh. Virupakshagauda U Patil, Scientist
3. Dr. Jagesh Kumar, Scientist
4. Dr.(Ms.) Dalamu, Scientist

Division of Seed Technology

5. Dr. KK Pandey, PS & Head
6. Dr. EP Venkatasalam, Scientist (SS)

Division of Crop Production

7. Dr. S.S. Lal, PS & Head
8. Dr. M.C. Sood, PS
9. Dr. PM Govindakrishnan, PS
10. Dr. VK Dua, Sr. Scientist

Division of Social Sciences

11. Dr. NK Pandey,PS & Head
12. Dr. Rajesh Kumar Rana, Sr. Scientist
13. Sh. Dhiraj Kumar Singh, Scientist

Division of Plant Protection

14. Dr. Sanjeev Sharma, Sr. Scientist
15. Dr. Vinay Sagar, Sr. Scientist
16. Dr.(Ms) Jeevalatha A, Scientist
17. Dr. Baswaraj R., Scientist
18. Dr. Ravinder Kumar, Scientist
19. Dr. Sundersha S, Scientist
20. Sh.. Vallepu Venkateswarlu, Scientist
21. Sh. Shridhar Jandrajupalli, Scientist

Division of Crop Phy. & PHT

22. Dr. R. Ezekiel, PS & Head
23. Dr. Brajesh Singh, Sr. Scientist
24. Dr. (Ms) Pinky, Scientist

ARIS Cell

25. Dr. Shashi Rawat, Sr. Scientist

CPRI Campus, Modipuram

26. Dr. SK Kaushik, Joint Director
27. Dr. NC Upadhayay, PS
28. Dr. Devendra Kumar, PS
29. Sh. Rambir, Sr. Scientist
30. Dr. (Mrs.) Kamlesh Malik, PS
31. Dr. SK Luthra, Sr. Scientist
32. Dr. Name Singh, Sr. Scientist
33. Dr. Vinay Singh, Sr. Scientist
34. Dr. Anuj Bhatnagar, Sr. Scientist
35. Dr. RK Verma, Sr. Scientist (Presently working with CITH, RS, Mukteshwar)
36. Dr. MA Khan, Sr. Scientist
37. Er. Sukhwinder Singh, Scientist (SG)
38. Dr. Sanjay Rawal, Sr. Scientist
39. Sh. Dhruv Kumar, Scientist (SG)
40. Dr. Vijai Kishore Gupta, Sr. Scientist
41. Dr. Mehi Lal, Scientist
42. Dr.(Ms) Bandna, Scientist

CPRS, Jalandhar

43. Dr. JS Minhas, Head
44. Dr. RK Arora, PS
45. Dr. (Mrs.) Ashiv Mehta, PS
46. Er. Manjit Singh, PS
47. Dr. SP Trehan, PS
48. Dr. Raj Kumar, Sr. Scientist
49. Er. Sunil Gulati, Scientist (SG)
50. Dr.(Ms) Ratna Preeti Kaur, Scientist

CPRS, Gwalior

51. Dr. AK Somani, PS & Head
52. Dr. Shiv Pratap Singh, Sr. Scientist
53. Dr. Murlidhar .J.Sadawarti, Scientist

CPRS, Shillong

54. Dr. TK Bag, Head
55. Sh. AK Srivastava, Scientist
56. Dr. Sanjay Kumar Yadav, Scientist
57. Sh. Malkhan Singh Gurjar, Scientist

CPRS, Muthorai

58. Dr. TA Joseph, Sr. Scientist & Acting Head
59. Dr. (Mrs.) K. Manorama, Sr. Scientist
60. Dr. G. Ravichandran, Sr. Scientist
61. Dr. R. Muthu Raj, Sr. Scientist
62. Dr. Uma Maheshwari, Scientist
63. Dr.(Mrs.) TC Kumari Sangitha, Scientist,

CPRS, Kufri

64. Dr. Ashwani Kumar Sharma, Sr. Scientist
65. Dr. Vinod Kumar, Sr. Scientist

CPRS, Patna

66. Dr. Manoj Kumar, Head, CPRS, Patna
67. Dr. Shambhu Kumar, Sr. Scientist
68. Dr. SK Singh, Sr. Scientist
69. Dr. Raj Kumar Singh, Scientist(SS)
70. Sh. Eradassapa. E, Scientist
71. Sh. Rahul R Bakade, Scientist

Station- wise staff sanctioned of all categories as on 31.3.2012

Scientific Category

Sl. No.	Name of the station	Principal Scientist			Sr. Scientist			Scientist			Total		
		S	F	V	S	F	V	S	F	V	S	F	V
1.	Shimla including AICPIP	5	5	-	10	3	7	29	19	10	44	27	17
2.	Kufri	-	-	-	1	-	1	2	2	-	3	2	1
3.	Jalandhar	1	1	-	2	-	2	10	7	3	13	8	5
4.	Modipuram	1	1	-	4	2	2	16	14	2	21	17	4
5.	Gwalior	1	1	-	1	-	1	3	2	1	5	3	2
6.	Patna	1	1	-	1	1	-	9	4	5	11	6	5
7.	Ooty	1	-	1	-	-	-	3	6	(-)3	4	6	(-2)
8.	Shillong	1	1	-	-	-	-	5	3	2	6	4	2
	Total	11	10	1	19	6	13	77	57	20	107	73	34

*Excluding RMP

Administrative Category

Staff position at CPRI & its Regional Station as on 31.03.2012

Name of Post	Shimla	Modipuram	Jalandhar	Patna	Shillong	Gwalior	Ooty	Kufri	Total
CAO	01	-	-	-	-	-	-	-	01
Sr. F&AO	-	-	-	-	-	-	-	-	-
AO	01	-	-	-	-	-	-	-	01
AAO	05	01	01	01	-	01	-	-	09
AF&AO	02	-	-	-	-	-	-	-	02
AD(OL)	01	-	-	-	-	-	-	-	01
Asstt.	17	02	01	01	03	-	01	01	26
Sr. Clerk	11	03	04	-	-	-	01	01	20
LDC	16	05	04	03	-	03	-	-	31
Private Secy.	03	-	-	01	-	-	-	-	04
PA	06	01	-	-	-	-	01	-	08
Steno Grade-III	-	-	01	-	-	01	-	-	02
Total	**63**	**12**	**11**	**06**	**03**	**05**	**03**	**02**	**105**

Technical Category

Grade	Shimla	Modipuram	Jalandhar	Patna	Gwalior	Shillong	Ooty	Kufri	Total
TO, T-9	1	1	-	-	-	-	-	-	2
TO, T(7-8)	2	1	1	1	1	-	-	-	6
TO, T-6	6	10	3	1	-	-	-	-	20
TO, T-5	13	14	6	2	5	1	3	3	47
Tech. T-4	6	5	3	4	1	2	-	-	21
Tech. T-3 / T-I-3	13	5	4	4	1	3	-	2	32
Tech. T-2	13	1	4	4	3	1	2	1	29
Tech. T-1	5	4	-	1	2	1	-	2	15
Total	**59**	**41**	**21**	**17**	**13**	**8**	**5**	**8**	**172**

Skilled Supporting Staff Category (CPRI & REGIONAL STATIONS)

Grade	Sanctioned	Filled	Vacant
SS Grade-I	82*	52	30
S Grade-II	65	54	11
SS Grade-III	39	27	12
SS Grade-IV	18	05	13
Sub Total	204	138	66
Canteen Staff			
Cook	1	1	0
Tea Maker	1	1	0
Wash Boy	1	1	0
Grand Total	**207**	**141**	**66**

Staff in position as on 1.4.2012 of CPRI showing number of SCs, STs, OBCs & Women

Category	Sanctioned	Filled	SC	ST	OBC	Women
Technical	207	172	35	7	9	11
Administrative	121	109	29	07	05	27

HkkOdOvOiO
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

Printed At : Azad Offset Printers, 144, Press Site, Ind. Area - 1, Chandigarh
0172 - 4611489, 2021253, 2021254 www.azadoffsetprinters.com