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CPRI Annual Report 2013

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Preface

The Central Potato Research Institute has contributed significantly in the field of potato research and development in the country. Due to development of numerous high yielding potato varieties and technologies for different agroclimatic conditions of the country, potato production has increased manifold. India produced a record 42.34 million tonnes of potato from 1.86 million ha area during the year 2010-11. Recognizing the pioneering efforts of CPRI during the last five years, the Institute has bestowed with Sardar Patel Outstanding ICAR Institution award for the year 2010-11 by the Council.

Like previous years, this year also the institute continued its efforts towards development of new varieties with desired traits and many production, protection and post-harvest technologies. Altogether, 62 new accessions were added to the germplasm collection of CPRI. Institute has now a total of 3,962 accessions of cultivated, semi-cultivated and wild species which are being maintained, evaluated and utilized for specific traits. Potato varieties Kufri Gaurav and Kufri Garima were notified for commercial cultivation and nine advance stage hybrids namely, J/2-14, MS/7-645, PS/5-73, PS/5-75, PS/7-7, MS/6-819, MS/6-1947, PS/6-88, MP/04-578 were introduced in AICRP for multi-location trials during this year. Two hybrids (SM/00-42 and VMT5-1) possessing high degree of late blight resistance were also introduced into AICRP (P) for multilocation trials. Whole genome sequencing of Indian *Phytophthora* strain (A2 mating type) covering around 14X of its genome size (appx. 240 Mb) and *R. solanacearum* covering around 25X of its 5.8 Mb genomic sizes were also completed. This information on genome sequence of two most important pathogens of potato will be exploited for better management of these pathogens. The decision support systems like Potato Pest Manager (PPM) and Computer Aided Advisory System for Potato Crop Scheduling (CAASPS) developed earlier, were web enabled and are hosted on application server. Early and accurate detection of potato viruses and other pathogens is the key to improving seed health and management of diseases and pests. This important objective was pursued and various detection protocols were developed which include, detection of PLRV and PVY in aphids (RT-PCR), ToLCNDV-potato in whiteflies (PC-PCR), duplex RT-PCR for PVA & PVS, PVY & PVS, and real time PCR for PVX and phylotype detection in *Ralstonia solanacearum*. Efficiency of late blight management was further improved by developing JHULSACAST based late blight forecasting model for Tarai region of Uttarakhand. A total of 31,972 *in vitro* culture tubes, 81,376 microtubers, 7,60,974 minitubers of different varieties were produced as nucleus seed material through high-tech system. A total of 31505.52 quintals nucleus and breeder seed was produced on an area of 159.18 hectares. For improving the efficiency as well as quality of seed , the institute established aeroponic facilities at Shimla and Shillong station which have since been operationalized. Beside above activities, the institute organized a large number of in house and sponsored trainings for farmers and extension functionaries for transfer of potato technologies which will go a long way in improving the potato productivity in the country.

I would like to appreciate the sincere efforts of entire team of scientists and other staff for carrying out all the research activities as per plan and bringing out this comprehensive report. My sincere thanks and appreciation to all the scientists and technical staff who were involved in compilation, editing and printing of this report. I sincerely thank Joint Director, CPRIC, Modipuram, Project Coordinator, AICRP (Potato) and all heads of division and regional stations for their efforts and timely submission of reports. Finally, my heartfelt thanks to DG, ICAR, DDG (Horticulture) as well as RAC members for providing the necessary guidance, direction and suggestions in orienting and improving the research programmes of the institute.

(BirPal Singh)
Director

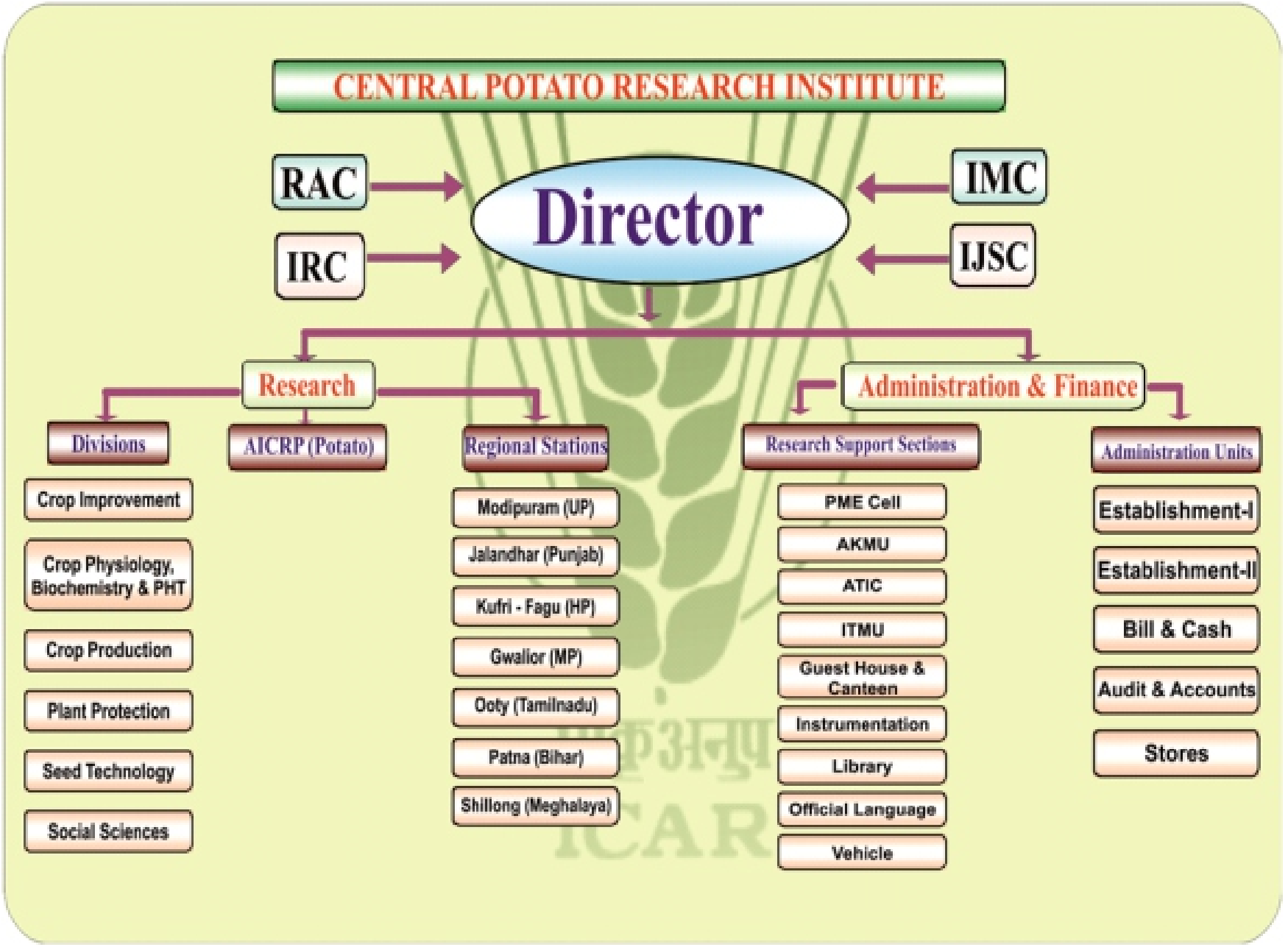
Contents

CPRI- An Introduction

The Central Potato Research Institute is one of the premier research institute of Horticulture Division of ICAR. It was established in August 1949 at Patna (Bihar) on the recommendation of the then Agricultural Advisor to the Government of India, Sir Herbert Steward. Later, the institute was shifted to Shimla (H.P.) 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 institute conducts its Research and Developmental activities with the help of its six divisions namely, Division of Crop Improvement, Crop production, Plant protection, Seed technology, Crop Physiology, Biochemistry and Post Harvest Technology and Social Sciences. It has one major campus at Modipuram (UP) and six regional stations which are located across the country viz. Kufri Fagu (HP), Jalandhar (Punjab), Gwalior (MP), Patna (Bihar), Shillong (Meghalaya) and Ooty (Tamil Nadu) to look after location specific research and extension activities. The All India Co-ordinated Research Project on Potato (AICRP-Potato) is also located in the institute which has been functioning since 1971. It has 25 regional centers located in nearly all agro-climatic zones of the country to test the performance of new potato varieties and technologies.

The institute has created state-of-the-art laboratories for conducting basic and strategic research in the field of biotechnology, genomics, genetics and plant breeding, plant protection, plant physiology, biochemistry and post harvest management. It has an Agricultural Knowledge Management Unit (AKMU) which provides Local Area Network (LAN) facility to all scientists, administrative staff and other staff. One Agricultural Technology Information Centre (ATIC) is also functioning in the institute since 2002 on the principle of "Single Window Delivery System". It provides all the relevant information on potato technology to visiting farmers, scientists and other stakeholders. The institute is continuously striving for development of suitable potato varieties and technologies for potato growers of the country. The institute organizes various trainings, demonstrations, *kisan melas*, exhibitions etc for transfer of potato technology to the end user. Because of its achievement in the field of potato R&D, CPRI bagged Sardar Patel Outstanding ICAR Institution Award for year 2011. Currently it has a dedicated team of 68 scientists, 168 technical staffs and 106 adminis-trative staffs.


CENTRAL POTATO RESEARCH INSTITUTE
RAC
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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)
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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 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 aegis of 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 the country in the years to come and at the same time enhancing the farm income. Our entire efforts are directed to achieve this goal.

- 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 moden technologies for potato production.
- To provide consultancy in potato research and development.

Work of the Institute is being carried out under 18 well defined research programmes. In addition to regular research programmes, 14 externally funded research projects sponsored by various organizations are also under operation. Two of these are being funded by International Agencies. Production of Breeders' seed is being done by the Institute under a Revolving Fund Scheme.

Staff & Finance

The institute has 595 sanctioned staff strength comprising of 108 scientific, 178 technical, 102 administrative and 207 supporting staff. The staff position as on 01.04.2013 was 470 including 68 scientific, 168 technical, 106 administrative and 128 supporting staff. The expenditure of the institute for the year (Plan & Non Plan & RFS) was Rs 52.71 crores and receipts Rs. 4.96 crores including RFS. The CPRI generated some parts 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 348.48 lakhs this year and the scheme has been most successful and widely acclaimed. During the year Dr. PM Govindakrishnan, PS has assumed the charge to the post of Project Coordinator, AICRP (P). Three scientists were retired and four were transferred from the institute. In technical category, 27 technicals were promoted, 11 were retired, 5 were transferred within institute and 1 outside the institute. In administrative category, 1 person was promoted, 3 retired, 3 transferred within the institute and 1 from NRCM Solan to CPRI Shimla. In skilled supporting staff, 16 were promoted under 33.33% departmental promotion quota from SSS to technical and administrative posts, 8 in each category and 4 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 institute 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, the Government of India has notified this laboratory as 'Accredited Test Laboratory' for testing and certification of tissue culture raised potato micro plants and minitubers.

The biotechnology laboratory of the institute, created in 1992, presently houses all the facilities for transgenic research, DNA fingerprinting, molecular breeding, micro propagation 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. Recently, Aeroponic facility was created in CPRI, Shimla, CPRIC, Modipuram, CPRS, Patna and CPRS, Shillong for soil less disease free seed potato production. CPRI library is the second largest 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, hostels etc.

Research Highlights

Crop Production

- WOFOST (World Food Studies) crop growth model was calibrated and validated for cv Kufri Pukhraj. Climate change impact on potato productivity in Punjab state was carried out using WOFOST crop growth model and it was estimated that the productivity of potato cultivars in Punjab will not be affected in 2020 over the baseline scenario but will decline in 2055 (-2.62% to 5.3%). However, if the present distribution of potato acreage within Punjab remains unaltered in future, there will be benefits from climate change as the potential productivity of potato will increase (+3.1 to +3.6%) in 2020 but it will again decline to baseline values in 2055.
- The work on *Kharif* potato in plateau areas was carried out at the farm of Agricultural Research Station, Madenur, Hassan, Karnataka during summer, 2012. Potato variety Kufri Himalini was the top yielder (18.2 t/ha), whereas, the top yielder in hybrid was SM/92-338 and LB-17 yielding 11.4 t/ha and 11.0 t/ha, respectively. Potato variety Kufri Surya followed by Kufri Himalini performed well in Hassan areas of Karnataka. Under delayed monsoon onset conditions, the optimum time of planting was identified as 30th May to 10th June. However, potato variety Kufri Pukharaj is suitable for early planting i.e. *in the first fortnight of May*.
- The decision support systems (DSSs) *viz.* Potato Pest Manager (PPM) and Computer Aided Advisory System for Potato Crop Scheduling (CAASPS) were web enabled and are hosted on application server.
- In long term manurial/fertilizer experiment at Modipuram, Meerut, system productivity was higher in maize–potato–onion (91.3 t/ha) followed by paddy–potato–wheat (67.6 t/ha) during 2012. Among the seven treatments, the soil organic carbon was more, both before and after potato harvest indicating its built up in soil due to nutrients supply through organic manure to all crops of the rotations since 2006. The nutrient budgeting revealed that irrespective of nutrient supply option, available soil nitrogen and phosphorous improved, while available potassium decreased after potato harvest. The soil organic carbon and available nitrogen were more in organically manured plots.
- The two row tractor operated potato combine harvester (Prototype–I) was improved for better separation and to reduce tuber bruising. The modifications increased the separation of soil and provided 85% clean tubers. The conventional chain conveyor in the prototype combine harvester was replaced with specially designed and fabricated improved chain conveyor with PVC cover which reduced the tuber bruising to less than 2%.
- Fabrication work of a manually/engine operated small grader for experimental plots and also for the small farmers, was carried out. The major systems of the grader are main frame, grading mechanism and power transmission system. The prototype grader was tested both manually and also with the help of a diesel engine. Fabrication work of the main frame of the grader and of three numbers of grading sieves having 20, 32 & 52 mm size square openings for their subsequent use in the grading mechanism of the improved square wire mesh type of potato grader for pre-cold storage of potatoes was carried out.
- A new aeroponic growth chamber was designed and constructed from bricks, cement and sand. This was compared with thermocol and polythene chambers for thermal conductance and temperature variation inside. New ceramic nozzles were also compared with the PVC nozzles for misting in aeroponic growth chambers. Design of growth chambers was improved for better space use efficiency to accommodate 26% more plants per unit area.

Crop Improvement

- A total of 62 accessions were added to the gene bank increasing the strength of present germplasm collection at CPRI to 3,962 accessions of cultivated, semi-cultivated and wild species from more than 30 countries.
- Potato varieties Kufri Gaurav and Kufri Garima were notified for commercial cultivation in 19th Meeting of Central Sub-Committee on Crop

Standards Notification & Release of Varieties for Horticultural Crops. Nine advance stage hybrids namely J/2-14, MS/7-645, PS/5-73, PS/5-75, PS/7-7, MS/6-819, MS/6-1947, PS/6-88, MP/04-578 are being introduced in AICRP for multi-location trials.

- Whole genome sequencing of Indian *Phytophthora* strain (A2 mating type) covering around 14X of its genome size (appx. 240 Mb) and R. solanacearum covering around 25X of its 5.8 Mb genomic sizes was completed.
- Overexpression of 17.6HSP gene in potato cv. Kufri Chandramukhi for heat stress tolerance was completed by cloning in pBI121 binary vector driven by CamV35S promoter. Analyzed transcriptional response profiles of heat shock proteins in heat tolerant (Kufri Surya) and heat susceptible (Kufri Chandramukhi) potato cultivars.
- Out of total, 720 protoplast isolation & electrofusions of C-13 (+) S. cardiophyllum/ S. microdontum/ S. acaule/ S. lesteri/ S. jamesii/ S. trifidum/ S. stoloniferum/ S. capsibaccatum, 50 microshoots of C-13 (+) S. cardiophyllum were regenerated for molecular and phenotypic characterization. Out of 44 wild Solanum species, screened against late blight resistance by in vitro assay, 14 wild Solanum species were identified for allele mining study.

Plant Protection

- The new population of *Phytophthora infestans* (mt DNA haplotype Ia) has replaced the old population (Ib haplotype) within a decade of its introduction.
- Developed JHULSACAST late blight forecasting model for Tarai region of Uttarakhand.
- Hybrids (SM/00-42 and VMT5-1) possessing high late blight resistance were introduced into AICRP (P) for multilocation trials.
- Identified genotypes possessing R1 and R3a genes and hybridized to combine them in a single host background. Fifteen clones were identified possessing both genes through MAS.
- Standardized protocols for detection of PLRV and PVY in aphids (RT-PCR), ToLCNDV-potato in whiteflies (PC-PCR), duplex RT-PCR for PVA & PVS, PVY & PVS, and real time PCR for PVX and phylotype detection in *Ralstonia solanacearum*. The whole genome of five isolates of PLRV and two isolates of PAMV were cloned and sequenced. Beside, complete genome of four isolates of *Ralstonia solanacearum* was also sequenced.
- Application of *Trichoderma viride* or boric acid was effective for management of both common scab and black scurf of potato while that of abamectin benzoate (12 ml a.i./ha) and spiromesifen (48 g a.i./ha) alone or in combination against mite.
- Integration of soil solarization with neem cake + *Trichoderma virde* recorded highest yield of potato and minimum cyst nematode population. Beside, intercrop with radish was also found effective.

Seed Technology

- A total of 31,972 in vitro culture tubes, 81,376 microtubers and 7,60,974 minitubers of different varieties were produced as nucleus seed material through high-tech system.
- A total of 31505.52 quintals nucleus and breeder seed was produced on an area of 159.18 hectares under conventional and hi-tech seed production system.
- The average weight of aeroponic minituber was highest in Kufri Khyati while highest number of minituber per plant in aeroponics was in Kufri Frysona at three days harvesting interval and at 20x20 cm planting distance.
- The weight loss of microtubers varied from 23.7 to 73.3% in different packing materials in all three grades of Kufri Chandramukhi after about 8 months storage at 4ºC temperature followed by two months at ambient conditions of Shimla.
- Microplant height was more in single node with vertical insertion in the MS media as compared to double node and horizontal placing in varieties Kufri Bahar, Kufri Jyoti and Kufri Lauvkar.

Crop Physiology, Biochemistry and Post harvest Technology

- Vapour treatment of potatoes with salicylaldehyde induced complete sprout inhibition and showed no effect on processing quality/taste of potatoes up to 75 days of storage at 24°C.

- A 20 ppm concentration of 1,4-dimethyl-naphthalene was found sufficient to delay sprouting in seed potatoes under diffused light storage with positive effect on tuber yield. Residues of 1,4-DMN on potato skin reduced during storage and were well related with the end of dormancy in different cultivars.
- Malondialdehyde content (a useful biomarker to assess lipid peroxidation), increased with duration of storage and was found higher at 4°C than at 12°C. Contents differed among varieties and correlated well with keeping quality.
- During early planting, Kufri Surya out yielded Kufri Pukhraj when planted by 5th September in Jalandhar
- Two drought tolerant hybrids namely WS/05-146 and WS/05-108 have been shortlisted on the basis of 3 years replicated trials for further studies.

Social Sciences

- Survey in the state of Uttar Pradesh revealed that Kufri Bahar was the most predominant potato variety occupying 68.63% potato area followed by K. Pukhraj (19.71% area). All other potato varieties constituted only 11.66% potato area in the state.
- It was also observed that farm saved seed potato was the major source of seed for farmers in UP contributing more than 80 per cent followed by other progressive farmers (9.4%) and seed from government farms (3.61%).
- Overall seed replacement rate in UP was found to be 19.35 per cent which is lower than optimum rate of 33 per cent.
- A survey in HP revealed that K. Jyoti was most predominant variety in selected three districts covering 48.25%, 84.5% and 80.62% area in Shimla, Mandi and Kangra districts respectively.
- The average yield of potato recorded on farmer's field was maximum 16.16 t/ha in Kangra district while it was only 13.3 t/ha in Shimla and 11.9 t/ha in Mandi district.
- An eight day Model Training Course on "Technology for quality seed potato production and certification" was organized by the division. The effectiveness of this programme was measured and it was found that participants knowledge increased by 32.4% after training. Altogether 12 trainings under MM-I was conducted in HP and there was 20-25% increase in knowledge level of farmers after training.
- Under TSP scheme, three kisan melas, two awareness camp and two trainings were organized in different tribal districts of HP, MP, Chhattisgarh and Odisha state. Nearly 7000 tribal farmers benefitted from these extension programmes.

Executive Summary

Crop Production

WOFOST (World Food Studies) crop growth model was calibrated and validated for Kufri Pukhraj. Climate change impact on potato productivity in Punjab state was carried out using WOFOST crop growth model and it was estimated that the productivity of potato cultivars in Punjab will not be affected in 2020 over the baseline scenario but will decline in 2055 (-2.62% to 5.3%). However, if the present distribution of potato acreage within Punjab remains unaltered in future, there will be benefits from climate change as the potential productivity of potato will increase (+3.1 to +3.6%) in 2020.

At Shimla, the temperature within the range of 15-22ºC influenced the *in vitro* mycelial growth of each isolate of *Phytophthora infestans* (optimum growth was at 18°C). No growth was observed at 30 and 32°C. At Modipuram, incubation period was high and lesion area was less up to 15 ºC while from 18 to 25 ºC incubation period was less and lesion area was more. Heavy rains along with late blight caused up to 75% yield loss in fields at Modipuram. At Shimla, *R. solanacearum* strains (r1bv3, r1bv4, r1bv2T, r3bv2) survived better at 20-28ºC and r3bv2 and r1bv2T were able to survive at 32ºC even after five months of incubation. None of the strains survived beyond one month of incubation at 37ºC or higher temperature. At Gwalior, thrips and white fly population was highest in September. At Modipuram, the lower temperatures, lower RH and higher rainfall in September 2012 compared to 2011 resulted in more burning due to mite but lesser burning due to leafhopper.

At Patna the highest tuber yield of 24.4 t/ha was recorded in potato+onion (1:1) followed by 22.7 t/ha in potato+ onion (1:2) intercropping. The potato equivalent yield (PEY) of 36.3 t/ha) was also higher in this system. Potato-cabbage crop sequence, gave the highest PEY of 52.0 t/ha under Shillong, Meghalaya conditions.

At Shimla potato tuber yield was 64% higher over control when recommended production technologies were followed. Application of N,P&K alone increased the tuber yield by 43% over control. Thus the primary reason of low productivity at farmers' field can be attributed to lesser application of fertilizer N,P&K.

The work on *Kharif* potato in plateau areas was carried out at the farm of Agricultural Research Station, Madenur, Hassan, Karnataka during summer, 2012. Potato variety Kufri Himalini was the top yielder (18.2 t/ha), whereas, the top yielder in hybrid was SM/92-338 and LB-17 yielding 11.4 t/ha and 11.0 t/ha, respectively. Potato variety Kufri Surya followed by Kufri Himalini performed well in Hassan areas of Karnataka and under delayed onset conditions, the optimum time of planting is 30th May to 10th June. However, potato variety Kufri Pukharaj is suitable for early planting *i.e.* in the first fortnight of May.

At Madenur, Hassan the first appearance of late blight was recorded on 20th July, 2012. The prophylactic spray (just at the time of canopy closure) with mancozeb @ 0.2% followed by two more sprays at weekly intervals recorded minimum intensity of late blight (12.5%) followed by dimethormoph (13.25%), fenamidon (13.75%), cymoxanil (17.25%) and azoxystrobin (18.25%). This treatment also gave higher tuber yield (20.9 t/ha). Potato variety Kufri Girdhari recorded the minimum incidence of late blight (21.25%) followed by Kufri Shailaja (26.25%), Kufri Himalini (27.5%), Kufri Pukhraj (40%), Kufri Surya (55%) and Kufri Jyoti (55%).

Controlled release formulations of metribuzin herbicide (CMC- metribuzin 2G and CMC+ Kaolin-metribuzin 2G) gave comparable tuber yields of 24.9 & 25.2 t/ha, respectively over metribuzin (24.1 t/ha) and weed free plots (24.5 t/ha) at Modipuram. The post emergence application of herbicide bentazone (1.5 kg/ha) reduced total weed dry weight by 89.8% over weedy check at Modipuram. While at Gwalior, bentazone (1.0 kg/ha) reduced weed dry weight by 79.6 % over weedy check, and recorded comparable tuber yield (11.1 t/ha) in comparison to weed free plot (12.4 t/ha). Herbicide sulfosulfuron @ 50 g /ha was more effective in controlling weeds at Modipuram. From economic point of view, metribuzin @ 1.0 kg/ha as pre-emergence was more effective in controlling the weeds in potato crop in the NEH region of Shillong.

The decision support systems (DSSs) *viz*. Potato Pest Manager (PPM) and Computer Aided Advisory System for Potato Crop Scheduling (CAASPS) were web enabled and are hosted on application server.

The chlorophyll content index (CCI) is a good index and can be used to work out supplementary N requirement of potato.

At Jalandhar, out of 331 F_1C_3 clones planted, 19 were selected. The yield range of the selected clones was 587 to 720 g/plant as compared to 567 g/plant of

control Kufri Gaurav. Germplasm J-93-58 has an edge over Kufri Gaurav in N efficiency.

At Patna Kufri Gaurav gave highest agronomic efficiency at lowest N level (80 kg/ha) followed by Kufri Pukhraj, Kufri Khyati and Kufri Arun. At Patna, Kufri Gaurav recorded highest total root fresh weight, secondary root /shoot ratio and secondary root volume at 30 days after planting under field conditions. In a sand culture, efficient cultivars like Kufri Gaurav, Kufri Pukhraj and Kufri Khyati had higher root surface area and fresh root weight of secondary roots as compared to old cultivars like Kufri Jyoti.

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 cultivars Kufri Giriraj, Kufri Megha and Kufri Jyoti at Shillong.

The 19 hybrids/genotypes out of 35 tested under replicated field trial produced equal/or higher yield than popular variety Kufri Pukhraj at all soil moisture levels and have been selected for conducting IInd year replicated trial during next crop season.

The irrigation at 1.0 time of cumulative pan evaporation (CPE) up to stolen formation, 1.50 times CPE from stolen formation to early tuber bulking stage and 1.25 times CPE applied up to maturity produced significantly higher total yield under drip irrigation at Modipuram. Nitrogen fertilizer given in two splits 50% at planting+50% at earthing-up /or stolen formation stage gave higher yield (31.2 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 and sprinkler irrigation methods. The extent of increase in tuber yield was in the order of 75.23%, 42.85 % and 2.95% under silver poly mulch, pine needle mulch and black poly-mulch, respectively in comparison to no mulch condition at Shimla.

In long term manurial/fertilizer experiment at Modipuram, Meerut, system productivity was higher in maize–potato–onion (91.3 t/ha) followed by paddy–potato–wheat (67.6 t/ha) during 2012. In Kufri Chipsona-1, organic, inorganic and integrated nutrient supply options were at par in tuber production while in Kufri Gaurav, the highest tuber yield was obtained through fertilizer application and was significantly more than 100% NPK through organic manure. Among the seven treatments, the soil organic carbon was more, both before and after potato harvest and thus indicating its built up in soil, due to nutrients supply through organic manure to all crops of the rotations, since 2006. The nutrient budgeting revealed that irrespective of nutrient supply option, available soil nitrogen and phosphorous improved, while available potassium decreased after potato harvest. The soil organic carbon and available nitrogen were more in organically manured plots.

The 2-row tractor operated potato combine harvester (Prototype–I) was improved for better separation and to reduce tuber bruising. The modifications increased the separation of soil and provided 85% clean tubers. The conventional chain conveyor in the prototype combine harvester was replaced with specially designed and fabricated improved chain conveyor with PVC cover which reduced the tuber bruising to less than 2%. A trash separator was also designed and evaluated. The diabolo rollers and the rubber roller were also developed, fitted and evaluated. Both were found partially effective to reduce clod formations and fragmentation of the clods to facilitate their separation that also contributed to achieve collection of clean produce. A new prototype of 2-row potato combine harvester with provision for inspection of produce and collection of tubers in bags was designed and is under development.

Fabrication work of a manually/engine operated small grader for experimental plots and also for the small farmers, was carried out. The major systems of the grader are main frame, grading mechanism and power transmission system. The prototype grader was tested both manually and also with the help of a diesel engine. Fabrication work of the main frame of the grader and of three numbers of grading sieves having 20, 32 & 52 mm size square openings, for their subsequent use in the grading mechanism of the improved square wire mesh type of potato grader for pre-cold storage of potatoes, was carried out.

A new aeroponic growth chamber was designed and constructed from bricks, cement and sand. This was compared with thermocol and polythene chambers for thermal conductance and temperature variation inside. New ceramic nozzles were compared with the PVC nozzles for misting in aeroponic growth chambers. Design of growth chambers was improved for better space use efficiency to accommodate 26% more plants per unit area. Soilless production system was further improved by modifying planting trays and mini tuber picking system. A mini soilless production system was developed for conducting experiments on nutrient supply and for raising vegetable crops other than

potato. Design of pallet was modified for handling 750 kg loose tubers per batch for seed treatment with fork lift.

Crop Improvement

The division of crop improvement has three research programmes aimed at genetic improvement of the potato. 'Management and Enhancement of Potato Germplasm' is basic programme of the division which aims at collection, conservation, evaluation and documentation of germplasm. During the year, 62 accessions were added to the gene bank and thus at present CPRI maintains more than 3,962 accessions of cultivated, semi-cultivated and wild species of potato. These are being conserved in field gene banks, *in vitro* repository, and true potato seeds. A large number of accessions were evaluated for various biotic and abiotic stresses, adaptability and physio-biochemical qualities and promising accessions were identified. Information generated have been maintained in the electronic databases.

The second programme is on 'Breeding for Improved Varieties' which aims at developing improved varieties for table and processing purposes having resistance to important diseases and pests. A number of new breeding populations were generated during the years by conventional hybridization and new clonal materials were evaluated in early as well as advanced generations. Based on consistent performance over the years, advance stage hybrids namely J/2-14, MS/7-645, PS/5-73, PS/5-75, PS/7-7, MS/6-819, MS/6-1947, PS/6-88 & MP/04-578 are being introduced in AICRP for multi-location trials.

The third programme is on 'Biotechnology in Potato Improvement' which aims at use of molecular biology tools for genetic improvement of the potato. During the year whole genome sequencing of Indian *Phytophthora* strain (A2 mating type) and *Ralstonia solanacearum* was completed. Transcriptional response of heat shock proteins in heat tolerant (Kufri Surya) and heat susceptible (Kufri Chandramukhi) potato cultivars to a range of 24^{0}C heat stress in plant leaf tissues were analysed. In transgenic study, overexpression of 17.6 HSP gene in potato cv. Kufri Chandramukhi for heat stress tolerance, gene construct was made in pBI121 binary vector driven by CamV35S promoter. Out of 44 wild *Solanum* species, 14 species were selected for allele mining study for late blight resistance genes. Interspecific somatic hybridization was carried out between the androgenic dihaploid (C-13) of common potato *S. tuberosum* and the wild *Solanum* species. In total, 720 protoplast isolation and electrofusions of C-13 (+) *S. cardiophyllum*, C-13 (+) *S. microdontum*, C-13 (+) *S. acaule*, C-13 (+) *S. lesteri*, C-13 (+) *S. jamesii*, C-13 (+) *S. trifidum*, C-13 (+) *S. stoloniferum*, C-13 (+) *S. capsibaccatum.* Gene expression of AMT, AS and COXI in leaf tissues particularly under N stress successfully explained the variation of N efficieny in three cultivars Kufri Gaurav, Kufri Pukhraj and Kufri Jyoti which differ widely in N efficiency.

Plant Protection

Late blight incidence in the sub-tropical plains was again insignificant this year because of low temperature. No change in race spectrum, mating types and metalaxyl tolerance was observed in *Phytophthora infestans*. Analysis of mitochondrial haplotypes revealed that the new population (Ia) has displaced the old population (Ib) in most of the regions within a decade of its introduction in India. The genotypic characterization by SSR markers revealed that primers Pi63 and Pi04 could detect polymorphism in Indian population of *P. infestans*. Real-time PCR protocol was standardized to detect latent infection in host tissues and quantification of inoculum load of *P. infestans*. JHULSACAST model successfully forecasted late blight appearance in north west Indo-Gangetic plains of Uttar Pradesh and Punjab. Besides, JHULSACAST model has also been developed for tarai region of Uttarakhand. A Decision Support System validated for need based application of fungicides proved again better over blanket fungicidal recommendation. The non-linear reciprocal hyperbola equation developed earlier for prediction of yield loss was again validated which showed deviation from 2.29 to 9.23% between observed and predicted values. 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 during this year also. Similarly, botanical formulation developed and tested (1.0%) in field against late blight of potato showed better results against control treatment. Seven transgenic lines (4 from siRNA and 3 from amiRNA) of Kufri Khyati and Kufri Pukhraj were selected on the basis of late blight resistance and real time PCR analysis of *Avr3a* gene in transformed potato lines and non–transformed control plants confirmed the silencing of the *Avr3a* gene upon *P. infestans* challenge inoculation.

For development of late blight resistant cultivars, 16100 seedlings were screened out of which 2190 resistant seedlings were retained for further studies.

Early generation (F_1C_1-F_1C_5) hybrids (1620) were evaluated and 485 hybrids were retained for further evaluation. In advanced generation, 15 hybrids were evaluated and 8 were retained for further evaluation. Hybrids SM/00-42 and VMT5-1 were introduced into AICRP (Potato) for multilocation trials. Out of 68 accessions screened for presence of *R1* and *R3* genes, 5 accessions possessed *R1* and 12 possessed *R3a* gene. Besides, 7 accessions possessed both genes. Hybridization was attempted to combine *R1* and *R3a* genes in single host background and 15 clones were identified possessing both genes through MAS.

Potato Virus Y was mass propagated, purified and used to raise antisera. Out of seventy four germplasm accessions were tested for PVY and PVX resistance, 25 CP Nos. were found having combined resistance to PVX and PVY, 26 to PVY and 17 to PVX, respectively. One thousand one hundred and twenty two samples were tested for PVX, PVS, PVY, PVA, PVM, PLRV, CMV, PMTV, TMV, TNV, TRSV, TSV, TSWV, PYDV by DAS-ELISA and PSTVd by RT-PCR under Accredited Test Laboratory (NCS-TCP). Ninety three samples were planted in the quarantine glass house and tested for the presence of PVT, PYDV, AVB, APMoV, APLV, TRV, TRSV and *Clavibacter*. A total of one hundred and sixty eight samples were tested for PSTVd and 293 for PVX, PVY, PLRV, PVA, PVS and PVM through RT-PCR; out of which fourteen samples were found infected with PSTVd. Dipstick kits for PVX and PVA were validated and the results were compared with ELISA. RT-PCR protocol was developed to detect the PLRV and PVY from aphids. Besides, duplex RT-PCR protocol was developed for the simultaneous detection of two viruses (PVA and PVS; PVY and PVS) from infected leaf and tubers. Real Time PCR protocols based on TaqMan chemistry have been standardized for *Potato virus X*. Purified CP protein of PVX and PVY was injected in rabbits and antisera was received to prepare ELISA kit. Transgenic lines of Kufri Badshah (2 lines-GTLC2-90, GTLC2-127) and Kufri Pukhraj (5 lines - KPLC2-30, KPLC2-37, KPLC2-53, KPLC2-54 and KPLC2-44) carrying hairpin replicase constructs which were found resistant to ToLCNDV-potato were planted in containment facility and the tubers have been harvested for further use. The CP gene region and whole genome of eight isolates were compared with ToLCNDV isolates from other crops. The whole genome of five isolates of PLRV and two isolates of PAMV were cloned and sequenced. The complete genome of four isolates of *R. solancearum* was sequenced using 454 DNA sequencer.

Collected, purified and maintained isolates of *Ralstonia solanacearum*, *Rhizoctonia solani* and *Streptomyces* species. Isolates of *R. solanacearum* were characterized into biovars and their phylotype affiliation was determined. The results revealed prevalence of phylotype I, II and IV in Meghalaya whereas phylotype I and II in Uttarakhand. Taqman real time PCR assay using 756R/F could detect the isolates belonging to phylotype I and II but could not phylotype IV because of slight variation in nucleotide sequence in probe region. Hence, new primer probe using the upstream region of the *R. solanacearum* UDP-3-O-acyl-GlcNAc deacetylase gene was designed. Morphological characterization of 48 *Streptomyces* strains revealed that strains were variable in their appearance and in production of pigments on the medium. The phylogenetic analysis of 16S rRNA gene sequences showed that 14 isolates were closely related to *S. scabies* and *S. europaescabies*, 12 to *S. bottropensis* and 4 to *S. stelliscabies*. Whereas, eight isolates were grouped with the non-pathogenic strains like *S. griseus* and *S. coelicolor*. Nine isolates were distantly separated from other 39 isolates. This study revealed the association of both pathogenic (*S. scabies, S. europaescabies, S. bottropensis*) and non-pathogenic (*S. griseus, S. coelicolor*) strains with potato tubers. PCR analysis of pathogenicity genes in the PAI and the 16s rRNA gene revealed only 20 strains as *txtAB* positive, 8 as *nec1* positive, 4 as *tomA* positive and 3 strains had all three PAI marker genes. Whereas, 25 strains were negative for all the three PAI marker genes. Six strains of *Streptomyces* spp. isolated from deep pitted common scab (Str-2 & 8, *S.stelliscabies*, Str-17, *S.aureofasicns*), russet scab (Str-31 & 34, S. *europascabies*) and corky scab (Str-46, *S. scabies*) were evaluated for development of the disease under three different moisture regimes. Observations recorded at harvest on potato tubers revealed that no strain developed scab under the minimum irrigations, two strains (Str-2 and Str-46) developed scab lesions under moderate irrigation and all six strains developed lesions at high irrigation regimes. Application of *Trichoderma viride* (Strain A-7) in furrows at planting could significantly decrease severity of common scab to 12.1% as compared to 26.9% in the control. Application of *T.viride* (A7) or boric acid was effective for the management of both common scab and black scurf diseases of potato. Application of *T.viride* reduced severity of black scurf from 37.4% in the untreated control to 18.5% and common scab disease severity from 23.2% to 4.0%. Similarly application of boric acid could reduce black scurf to 2.7% and common scab to13.0%. Heat sterilized saw dust impregnated

with nutrients applied to seed tubers by mixing with gum arabic as an adhesive served as a carrier of chemicals and biocontrol agents. It was a good osmo-priming material and prevented anaerobic conditions around the seed tubers. *Trichoderma viride* (A-7), boric acid or azoxystobin applied to seed tubers along with the saw dust controlled black scurf disease without affecting crop emergence or the yield. Application of azoxystrobin @0.06% as a component along with saw dust reduced severity of black scurf to 3.5% as compared to 54.1% in untreated control.

At Modipuram, *Myzus persicae* crossed the critical level in the second week of December. During off season, whitefy was recorded on tomato, chillies, brinjal, bhindi, urd, green gram, tori and bathua. By molecular studies glasshouse whitefly was identified as *Trialeurodes vaporariorum.* The ability of the whitefly to acquire ToLCNDV was also established and confirmed the viruliferous nature of *T. vaporariorum*. Standardized the print capture-polymerase chain reaction (PC-PCR) protocol for detection of ToLCNDV-potato in whiteflies. Besides, reverse transcription polymerase chain reaction (RT-PCR) assay was designed to detect PVY in field collected aphids. Application of abamectin benzoate 1.9EC (12 ml a.i./ha) alone or in combination with spiromesifen (48 g a.i./ha) provided protection against mites. Four plant species found promising against whitefly and aphids.

For breeding cyst nematodes and late blight resistant varieties, 53,200 hybrid TPS were produced from 23 bi-parental crosses. Nine thousand five hundred seedlings were screened for late blight and 1011 selections were made. In early generations, 1007 hybrids were evaluated and 602 hybrids were selected. Out of 53 advance generation hybrids evaluated, 43 were selected on the basis of agronomic traits, resistance to late blight and cyst nematodes. Soil solarisation in combination with neem cake + *Trichoderma viride* recorded the maximum yield and minimum PCN multiplication. As trap crops for PCN, the susceptible Kufri Jyoti attracted more juveniles than the resistant Kufri Swarna and recorded 31% reduction in nematode population. Intercropping with radish recorded lowest Rf value for PCN. Integration of chemical and non-chemical management options significantly recorded higher yield and lower nematode reproduction.

Crop Physiology, Biochemistry & Post harvest technology

Out of 137 successful crosses for heat tolerance, 1,06,830 seeds were extracted. 751 selections were made from the seedlings raised from these seeds in the glass house and field.In the field selection at Modipuram,187clones were selected from F_1C_2-F_1C_4stage for further evaluation. Heat tolerance in advanced hybrids was quantified by leaf bud tuberization test under controlled conditions and hybrid HT/07-239 showed better heat tolerance than control variety Kufri Surya. Slow release formulations of growth retardant, Paclobutrazole at 5 ppm spray 30 days after planting improved tuber yield and harvest index under heat stress conditions. At Jalandhar, Kufri Surya was found to be suitable for planting up to 10th September for yield advantage over K Pukhraj. For drought tolerance 2 hybrids were selected from 2005 series, 10 from 2006 and 2007 series, 21 from 2009,38 from 2010 and 132 from 2011 series. Three hybrids; WS/07-159, WS/07-138 and WS/06-073 were able to maintain lower mean crop canopy temperature during crop growth period under mild water stress.

Dip treatment of potatoes with paclobutrazol reduced sprouting and total losses up to 90 days of storage in heaps. Foliar spray of paclobutrazol increased the dry matter (%), decreased the reducing sugar and sucrose content and improved the chip colour of potatoes at harvest. In studies with naturally occurring compounds, vapour treatment of potatoes with salicylaldehyde (300 ppm) induced complete sprout inhibition at 24°C and showed no effect on processing quality/taste of potatoes up to 75 days of storage. Tuber treatment with mentha oil (5%) induced significant sprout inhibition without any increase in rotting in potatoes as compared to control at 18°C**.** A commercial formulation of 1,4-Dimethyl-naphthalene (1,4 DMN) significantly reduced sprout length and sprouting index in seed potatoes of two varieties stored in diffused light storage up to 180 days. A 20 ppm concentration of DMN was found sufficient to delay sprouting with positive effect on tuber yield. In studies on dormancy release and sprouting at 18°C, a decrease in 1,4-DMN residues on potato tuber skin was recorded after 120 days when the dormancy is terminated. Residues of DMN were well related with the end of dormancy in the three cultivars.

CIPC treated potatoes of Kufri Chipsona-1 and Kufri Surya with low reducing sugar contents and recording lower total losses up to 60 days can be exported as table as well as processing potatoes whereas, Kufri Jyoti, Kufri Pukhraj and Kufri Bahar were found suitable for only table purpose. Out of six Indian and one exotic processing cultivar evaluated

under heap storage up to 90 days in North-western plains, Kufri Chipsona-1 and Kufri Surya recording low storage losses (<7%), can meet the short-term needs of the processing industry with 1/4th of the refrigerated storage cost. Mature and cured potatoes of Kufri Chipsona-1 and Kufri Jyoti could be stored at 12°C for table purpose up to 300 days with acceptable losses (<10%) and minimum sugar accumulation, while cv. Kufri Pukhraj could be stored upto 180 days.

Malondialdehyde content (a useful biomarker to assess lipid peroxidation), increased with duration of storage and was found higher at 4°C than at 12°C. Contents differed among varieties and correlated well with keeping quality. Ascorbate peroxidase activity was also higher at 4°C compared to 12°C showing thereby greater formation of active oxygen species at relatively lower temperature storage.

Seed Technology

During the year a total of 17,736 tubers of different potato cultivars were indexed at Modipuram, Jalandhar, Gwalior, Patna and Kufri. Total production of 31505.52 quintals nucleus and breeder seed was achieved in an area of 159.18 hectares under conventional and hi-tech seed production system in four centers of plains as well as one center of Kufri/Fagu hills. Out of this, 24825.94 quintals was breeder seed from 118.25 hectare area. About 71.9% breeder seed was produced by conventional system and rest 28.1% by high-tech system. A total number of 7,17,914 minitubers have been produced from microplants, microtubers and <3 g minitubers at different stations. A total number of 43,985 aeroponic minitubers were produced in this year at Modipuram and Shimla. A total of Rs.3,96,95,409 was generated under revolving fund scheme through sale of breeder seed of potato during 2011-12. A total of 1318.60 quintals quality seed was produced in 9.49 hectare area at Ooty and the revenue generated was approximately rupees 20.28 lakhs while183.73 quintals was achieved in 2.46 hectare area at Shillong with about 2.51 lakhs revenue generation.

The average yield by number was more in conventional system at Jalandhar while germination, number of leaves, stems/plant and plant height was almost same at Modipuram. Higher number of stems and leaves in conventional system while number of tubers were more in hi-tech system at Gwalior. The elongated tubers from G-I of K. Bahar after planting yielded about 29.5% long shaped tubers by number while normal tuber after planting further yielded 48.2% long shaped tubers in G-II. Phenotypically changed tubers were maximum in K. Surya and virus incidence was also more in such tuber at Gwalior. During virus profiling in Punjab, about 40% fields were infected with PALCV and 51.4% by PLRV. The average weight of aeroponic minituber was maximum in K. Khyati while maximum number of aeroponic minituber per plant was in K. Frysona. There was delayed rooting in microplants as compared to hardened plants in aeroponic system at Shimla. The maximum number of minituber/plant was at 3 days harvesting interval and at 20x20 cm planting distance. The weight loss in aeroponic minituber varied from 24 to 50% in different packing material in different varieties after 6 months of storage at 4ºC temperature followed by about 2.5 months in ambient conditions of Shimla. Paper box and brown paper bags was not suitable for sprouting of aeroponic minitubers in any of the varieties. The weight loss of microtubers varied from 23.7 to 73.3% in different packing materials in all three grades of K. Chandramukhi after about 8 months storage at 4ºC temperature followed by 2 months at ambient conditions of Shimla. The microtubers stored in ventilated bottles were better than plastic petriplates and polythene bags with almost similar weight loss in hermetic and non-hermetic culture room storage. Gentamycin (10 ppm), streptomycin, amphotericin and antimyotic at lowest test concentration (1%) was not suitable for in-vitro growth of microplants of K. Lauvkar, K. Sindhuri and K. Sadabahar. The MS media prepared in gelrite was better for in-vitro growth of microplants of K. Chipsona-3. Microplant height was more in single node with vertical insertion in the MS media as compared to double node and horizontal placing in varieties K. Bahar, K. Jyoti and K. Lauvkar. Among four synthetic media, Gamborg's (B5) modified medium may be suitable alternate medium for potato micropropagation. The microtuber treated with gelatin performed better in terms of establishment, number of tubers and total tuber yield in net house. The concentration of ammonium nitrate (10-15mM) in MS media was better for in-vitro growth of all the test varieties except K. Jyoti.

Social Science

During the year 2012-13, a survey was conducted in Uttar Pradesh to find out seed potato utilization pattern of the potato growers and their constraints. Variety wise potato area was assessed and it was found that Kufri Bahar was the predominant potato variety occupying 68.63% potato area followed by K. Pukhraj (19.71%). All other potato varieties constituted only 11.66% potato area in the state. It was found that farm saved seed potato was the major

source of seed contributing more than 80 per cent followed by other progressive farmers (9.4%) and seed from government farms (3.61%). Seed replacement rate was also studied and it was found to be highest in K. Chandramukhi (31.95%) followed by K. Chipsona varieties (24.00%) and K. Lauvkar (21.14%). It was found that 50% respondents with higher seed potato expenditure invariably has higher potato yield, cost of cultivation, net income and benefit-cost ratio compared to the 50% respondents with lower expenditure on seed potato. Expensive inputs was found to be the severest problem for potato farmers with relative importance of 20.41% followed by shortage of fertilizers (RI=17.81%), electricity failure (RI=15%), expensive cold storage (RI=9.65%). Hence, infrastructure and logistics related constraints dominated the problem matrix of the farmers in UP. Another survey of 100 potato growers was carried out in three districts of HP namely Shimla, Mandi and Kangra. The varietal adoption pattern was observed in these three district and it was found that K. Jyoti was most predominant variety in all three districts covering 48.25%, 84.5% and 80.62% area in Shimla, Mandi and Kangra district respectively. Application of NPK fertilizers in Shimla and Mandi was found to be 126:64:44 and 30:61:26 Kg/ha against the recommended dose of 120:100:100 Kg/ha. The average yield of potato recorded was maximum 16.16 t/ha in Kangra district while it was only 13.3 t/ha in Shimla and 11.9 t/ha in Mandi district.

Moreover, 42 potato technology demonstrations were laid out in HP, Bihar, UP and Meghalaya states of India. Analysis of data revealed that new varieties of CPRI like K. Himalini, K. Khyati, K. Surya etc. are having 20-40% 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 conducted one 8-days Model Training course for extension officers of different state department of agriculture. The impact of Model training course revealed that there was 32.4% gain in knowledge level of extension functionaries after conduct of training. In addition to this, 8 more trainings were conducted in CPRI, Shimla and several 1-2 days trainings at its regional stations to train farmers in improved methods of potato cultivation. Four kisan mela and two awareness camps were also organized in different parts of the country. The experts from institute also took part in 21 Live Phone in programmes/ agricultural talk and chat show on AIR and Shimla Doordarshan.

Research Programmes

Research Programmes, Programme Leaders and Associates

Research Programmes and Institute Code No.	Programme Leader and Associates
Management and enhancement of potato germplasm P1-2010/1-IPR-F30/0210	Dr. Vinay Bhardwaj **Associates:** Drs. Vinod Kumar, Dalamu, Raj Kumar, Jagesh Kumar Tiwari, SK Luthra, Ratna Preeti Kaur, TA Joseph, S Eradasappa, Sanjeev Sharma, A Jeevalatha, AK Somani, Kamlesh Malik, MS Gurjar, R Uma Maheswari, Ashiv Mehta, Name Singh, Bandana, SP Trehan, KR Naik (Dharwad), MS Nagaraj (Hassan), Anil Gupta (Hissar), Kameshwar Sen and Shruti Gupta
Breeding for improved varieties P1-2010/2-IPR-F30/0210	Dr. SK Luthra **Associates**: Drs. Raj Kumar, Shambhu Kumar, VK Gupta, Ratna Preeti Kaur, Sanjay Rawal, SP Trehan, SK Singh, Mehi Lal, RK Arora, Rahul R Bakade, Ashiv Mehta, Vinay Bhardwaj, Bandana, AK Srivastava, Jagesh Kumar Tiwari, VK Yadav, Harvir Singh, Ravinder Sharma, Ramesh Chand and Vineet Sharma
Biotechnology in potato improvement P1-2010/3-IPR-F30/0210	Dr. JK Tiwari **Associates**: Drs. VU Patil, Shashi Rawat, Basawraj Raigond, Vinay Bhardwaj, Sanjeev Sharma, Brajesh Singh, Raj Kumar, SK Luthra, S Sundaresha and Dalamu
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, TA Joseph, R Muthuraj, R Uma Maheswari, Islam Ahmed, Ashwani Kumar, Sushil Kumar and Yogesh
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, SK Yadav, Sushil Kumar and Yogesh
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, MA Khan, Anuj Bhatnagar, Mahesh Kumar and Avinash Chaudhary
Farm machines for potato cultivation P1-2010/7-IPR-N20/0210	Er. Manjit Singh **Associates**: Ers. Sunil Gulati, Sukhwinder Singh, RK Rana, Tarlochan Singh, Jagdish Chander and Gurdev Singh
Management of late blight P1-2010/8-IPR-H20/0210	Dr. SK Kaushik **Associates:** Drs. BP Singh, Sanjeev Sharma, Mehi Lal, RK Arora, MA Khan, Vinay Bhardwaj, AK Srivastava, TA Joseph, Shashi Rawat, Ravinder Kumar, S Sundaresha, Islam Ahmad, Subhash Chand and BS Parihar
Molecular characterization, detection and management of potato pathogens P1-2010/9-IPR-H20/0210	Dr. (Ms) A Jeevalatha **Associates**: Drs. Baswaraj Raigond, Vinay Sagar, Sanjeev Sharma, VU Patil, Jagesh Kumar Tiwari, EP Venkatasalam, Ravinder Kumar, S Sundaresha and Tarvinder Kochar

Research Programmes and Institute Code No.	Programme Leader and Associates
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, A Jeevalatha, Malkhan Singh Gurjar and Rahul Bakade
Integrated pest management in potato P1-2010/11-IPR-H20/0210	Dr. (Mrs.) Kamlesh Malik **Associates**: Drs. Anuj Bhatnagar, Vallepu Venkateswarlu and Sridhar Jandrajupalli
Management of potato nematodes P1-2010/12-IPR-H10/0210	Dr. R Uma Maheswari **Associates**: Drs. K Manorama, TA Joseph and G Chandran
Nutritional value of potato and potato products P1-2010/15-IPR-Q10/0210	Dr. R Ezekiel **Associates**: Drs. Ashiv Mehta, Brajesh Singh, Pinky Raigond, Bandana and Vineet Sharma
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 Raigond, MA Khan, Yogesh Gupta and Vineet Sharma
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 Shelly chopra
Production of breeder seed of potato through conventional and hi-tech system. P1-2010/16-IPR-F00/0210	Dr. KK Pandey **Associates**: Drs. BP Singh, EP Venkatasalam, Vinod Kumar, Ashwani Kumar Sharma, SK Kaushik, Dhruv Kumar, Vinay Singh, JS Minhas, RK Arora, AK Somani, SP Singh, MJ Sadawarty, Manoj Kumar, SK Singh, Rahul Bakade, Sukhwinder Singh, R Muthuraj, G Ravichandran, Ratna Preeti Kaur, RK Singh, TK Bag, S Erdasappa, Pravesh Jassal, Sumita Sharma, RK Verma, Balak Ram Singh, KP Singh, NK Sood, Jasvir Singh, Santosh Kumar, Pushpender Kumar, Satinder Kumar, Kapil Kumar Sharma, Akhilesh Kumar, Arun Kumar Singh, YP Singh, RK Samadiya, Sanjay Sharma and V. Rajinderan
Impact of potato technologies developed by the Institute P1-2010/17-IPR-C00/0210	Dr. NK Pandey **Associates:** Drs. Rajesh K Rana, Dhiraj Kumar Singh, SK Yadav, Ravinder Kumar, TK Sinha and Ashok Kumar Chauhan
Climate change impact and adaptation strategies for potato crop PI-2011/18-IPR-F27/0210	Dr. VK Dua **Assciates**: Drs. Shashi Rawat, Sanjay Rawal, SK Singh, SP Singh, Mehi Lal, Sanjeev Sharma, Vinay Sagar, BP Singh, Kamlesh Malik, Anuj Bhatnagar, Islam Ahmad and Sushil Kumar

Results Framework Document (2012-13)

Objectives	Weight	Action	Success Indicators	Unit	Weight	Progress
Management and utilization of genetic resources for improved quality and production	40	Evaluation of genetic resources.	Germplasm evaluated.	Number	18	222 germplsams evaluated
		Development of improved hybrids, varieties and elite germplasm.	Breeding lines developed/ Varieties released/ Elite material registered.	Number	22	4 (2 hybrids introduced into AICRP) (2 germplsamregistererd)
Production management and value addition.	35	Production of potato nucleus and breeder seed.	Nucleus and Breeder's seed produced.	Quantity (Tonnes)	15	• A total of 3040 tons of nucleus and breeder seed has been produced at four seed production centreof CPRI.
		Development of production, protection, post-harvest technologies, farm implements, softwares, protocols & gene constructs.	Technologies developed.	Number	20	5 technologies developed. • Developed resource management strategies for *kharif* potato in plateau areas. • Design and development of tractor operated potato combine harvester • Developed ELISA kit for detection of ordinary strain of PVY using purified virus particles. • Developed ELISA kit based on recombinant coat protein for detection of ordinary strain of PVY. The titre of antiserum was 1:3200 dilution. • A procedure for the preparation of French fries with low oil content (5%) was developed.
Dissemination of knowledge	13	Organizing/providing training, demonstrations, Kisan Melas, Awareness camps, Exhibitions and Consultancies.	Trainings & Demonstrations organised Kisan Melas, Awareness camps and Exhibitions organised and Consultancies provided.	Number	8	• 14 (9 Trainings & 5 Demonstrations) • Number 4 (3 Kisan Melas and 1 Awareness Camp).

Contd.....

Objectives	Weight	Action	Success Indicators	Unit	Weight	Progress
Efficient Functioning of the RFD System	3	Timely submission of RFD for 2012-13	On-time submission	Date	2	21st March, 2012
		Timely submission of Results for 2012-13	On-time submission	Date	1	30th April, 2013
Administrative Reforms	5	Implement ISO 9001	Prepare ISO 9001 action plan	Date	1	4th June, 2012
			Implementation of ISO 9001 action plan	Date	2	24th March, 2013
		Implement mitigating strategies for reducing potential risk of corruption	% of implementation	%	2	100%
Improving Internal Efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100%
			Independent Audit of implementation of public grievance redressal system	%	2	100%

Division of Crop Improvement

Management and enhancement of potato germplasm

Collection:

Efforts are continued to augment the potato germplasm collection at CPRI, which is the designated as National Repository for potato germplasm. During the year under report, 21 accessions were imported from CIP, 13 accessions from Netherlands, 10 from USA, 4 from China, 7 from Australia and 7 from New Zealand and in total 62 accessions were added to cultivated germplasm collection. The present germplasm collection at CPRI consists of more than 3,900 accessions of cultivated, semi-cultivated and wild species from more than 30 countries.

Conservation:

One thousand three hundred ninety four Tuberosum accessions, 768 Andigena accessions and 69 indigenous samples were maintained in fields at Jalandhar. Nearly 1325 Tuberosum accessions and 90 indigenous samples were maintained in fields at Kufri. Ten dihaploids of Indian commercial varieties were maintained in glasshouses at Shimla. In total, 327 accessions (both in tuber and TPS forms) of 95 wild species were conserved at CPRI, Shimla. Besides, 39 elite clones of 15 *Solanum* species are being conserved in *in-vitro* condition.

Nearly 1750 Tuberosum accessions were maintained in *in vitro*. Mini-tubers of 164 accessions from *in-vitro* repository were produced and added to the field germplasm collection (Fig.1). Eight accessions (CP 1759, 2025, 2294, 2390, 4094, 4095, 4096 and LBY-17) were made free from all viruses through meristem tip culture.

Fig.1: Conversion of recently imported accessions from in-vitro to mini tubers

Evaluation:

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

Table 1. Evaluation of potato germplasm

Character	Location	No. of accessions evaluated	Promising accessions
Adaptability	Kufri		
	Replicated	28	None
	Row Trial	192	CP nos. 1687, 1763, 1996, 2263 and 2181
	Jalandhar		
	Spring	100	None
	Modipuram	68	CP nos. 3558, 3605, 3627, 3654, 3662, 3676, 3684, 3687, 3785, Kufri Surya and Kufri Pukhraj
	Autumn (early)		
	Autumn (Main)	65	CP nos. 3467, 3473, 3598, 3630, 3687, 3773, 3774, 3785, Kufri Khyati, Kufri Sadabahar, Kufri Pukhraj and Kufri Bahar

Character	Location	No. of accessions evaluated	Promising accessions
Late blight			
Foliage	Kufri (field)	276	15-HR; 24-R; 77-MR
	Shillong (field)	77	2-R (CP 3605 and CP 3841) ; 11-MR
	Shimla(Lab)	117	2-HR(CP 3775 & CP 4183); 38-R; 33-MR
Tuber	Shimla(Lab)	117	1-HR (CP 1358); 11-R; 16-MR
Stem necrosis	Gwalior	29	1-HR (CP 3786); 2-R (CP 3870 & CP 3871); 5-MR (confirmed for 4 years)
Viruses PVX & PVY	Shimla	74 (1st time)	20- R (PVX and PVY) ; 26-R (PVY); 17-R (PVX)
PSTVd	Shimla	75	10 accessions viz., CP Nos. 1920, 2003, 2160, 2412, 2448, 3080, 3143, 3149, 3178 and 3352 were infected.
Leaf hopper and Mites	Modipuram	62	Only one accession (CP 3620) accessions showed less than 5 % mite damage. Nine accessions namely CP Nos. 3468, 3483, 3508, 3588, 3625, 3676, 3678, 3687 and 3771 had hoperburn in the range of 0-5%.
Cyst nematodes	Ooty	297	47 accessions were resistant to both the species of PCN.
Keeping quality	Jalandhar	111	17- Best keepers; 42-good keepers and 19-average keepers. (CP nos. 3080, 3108, 3134, 3145, 3151, 3160 , 3183 and JEX/A-107) having medium to long dormancy and total weight loss less than the best control were promising
Chipping	Jalandhar	75	Four accessions viz. CP 3124, CP 3134, CP 3180 and CP 3182 were found to be suitable for chipping.
Vitamin C	Jalandhar	129	CP Nos. 1466, 1492, 1539, 1581, 1586 and JEX/A Nos. 21, 26, 202, 216, 288, 827, 907, 918, 920 and 1152 were promising.
Water use efficiency	Modipuram	33	7 accessions viz., CP Nos. 1304, 1316, 1330, 1343, 1969, 1987 and 2013 were promising.
Foliage maturity	Patna	82	17 accessions were found early maturing

Assessment of genetic stability of *in vitro* conserved potato using DNA markers

Four *in vitro* conserved potato genotypes namely Kufri Jyoti, SS1763-09 (*S. albicans*), Phulwa and C-13 (Dihaploid of K. Chipsona-2) and their derivatives *in vitro* conserved over 1-3 years were assessed for genetic stability. After *in vitro* conservation, two sets of plants were regenerated i) minitubers production in the earthen pots and ii) conservation in the next years. Thus, after the three years of conservation, mother plant and minitubers produced after 1st, 2nd and 3rd year conservation were used in DNA analysis for assessment of genetic stability.

The genetic stability of *in vitro* propagated potato was assessed using random amplified polymorphic DNA (RAPD), inter simple sequence repeat (ISSR), simple sequence repeat (SSR) and amplified fragment length polymorphism (AFLP) markers. Micropropagated potato mother plant and its derivatives were conserved *in vitro* using standardized protocols. During the study, a total of 38 (10 RAPD, 11 ISSR, 12 SSR and 5 AFLP) primers produced a total of 360 (42 RAPD, 54 ISSR, 96 SSR and 168 AFLP) clear, distinct and reproducible amplicons. DNA banding profiles and cluster analyses of micropropagated progeny plants were similar (100%) to the corresponding mother plant except 70-100% in AFLP method. Dendrogram analysis based on the Jaccard's coefficient classified the genotypes into four clusters (I-IV), each cluster consisting of mother plant and its derivatives. Principal component analysis (PCA) also plotted mother plant and its derivatives in a cluster together.

Thus DNA analyses confirmed the true-to-type nature of the *in vitro* raised plants except AFLP (70-100%) (Fig.2).

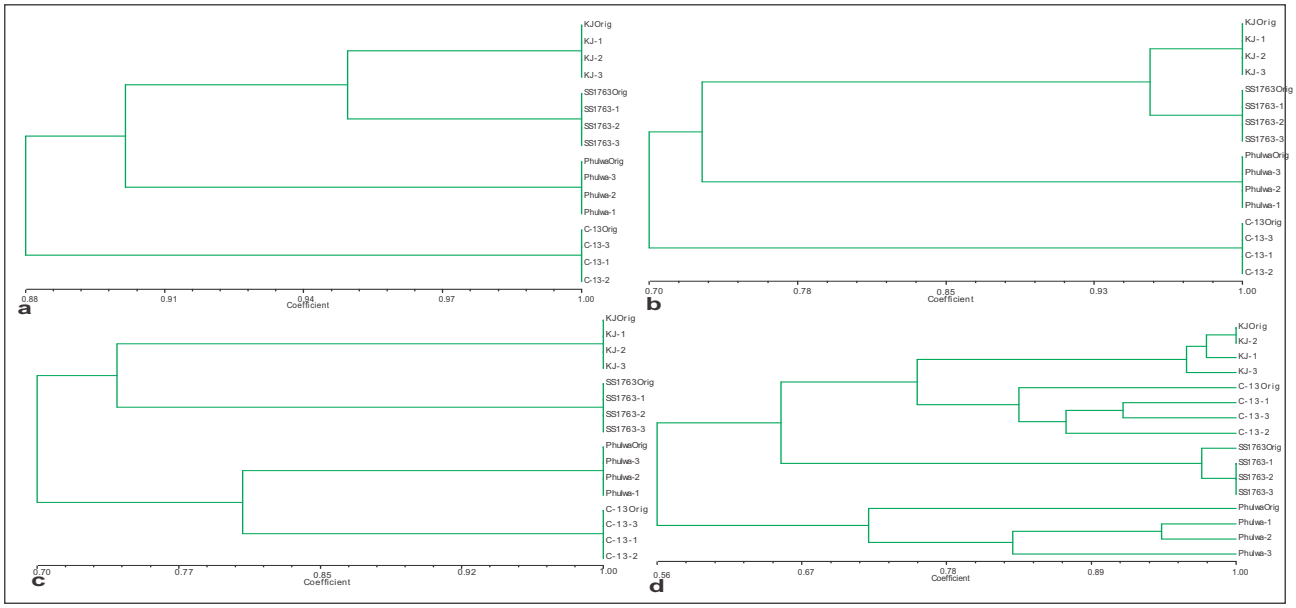


Fig. 2 Dendrogram of the potato genotypes based on the Jaccard's coefficient of a) RAPD, b) ISSR, c) SSR and d) AFLP markers

Genetic enhancement of Tuberosum and Andigena

Crosses were attempted at Kufri with the objective to break undesirable linkages between late blight resistance and late foliage maturity in tuberosum germplasm. A total of 26,348 hybrid TPS were obtained from 47 successful crosses. Seedlings were raised at Jalandhar, and at 90 days harvest, single tuber of each of 1935 promising clones of 32 crosses were selected. In F_1C_1 generation 96 clones were evaluated and 11 clones were selected.

For andigena improvement, crosses were attempted among andigena cross populations to develop second cycle andigena cross populations and in total 16,742 seeds from 35 crosses were raised. Depending upon the availability 15-75 tubers representing different genotypes were selected for further use in hybridization and evaluation.

In first clonal generation, 30-45 genotypes per cross of 5 cross population from andigena hybrid x andigena hybrid crosses were retained for evaluation. Beside this 15-45 genotypes per cross of 8 populations derived from crosses among andigena populations were also selected. In F_1C_2 and F_1C_3 generations, 15-60 genotypes per cross of 22 cross populations from andigena hybrid x andigena hybrid crosses were retained for evaluation.

Nine hybrids from andigena hybrids x andigena hybrids crosses and backcross of andigena hybrids were evaluated for yield at 90 days in replicated trials but none of these outperformed the best control Kufri Pushkar.

Evaluation of Wild Species

Screening for late blight resistance

One hundred fifty three clones of thirty two species were evaluated at CPRS, Kufri for late blight in natural epiphytotic condition. Thirty one clones (Table 2) were highly resistant or resistant (AUDPC $\leq$200). Under lab conditions, 48 clones of eighteen wild potato species were screened for foliar late blight resistance by detached leaf method (Fig.3) using complex races of *Phytophthora infestans*. Two clones were highly resistant (lesion area up to 1.0 cm^2), thirty were resistant (lesion area 1.1 to 2.5 cm^2) and sixteen were moderately resistant (lesion area 2.51 to 6.0 cm^2).

Screening for bacterial wilt resistance

Seventy six clones of different wild species were screened for bacterial wilt resistance at Hassan, Karnataka, hot spot for bacterial wilt. Ten clones were highly resistant (0-5% wilting) while 2 clones (Table 2) were resistant (5-20% wilting).

Table 2. Promising wild potato clones for different traits

Trait	*Highly Resistant*
Late Blight by detached leaf method	SS Nos.-2345-03 (*S. bukasovii*), 1735-02 (*S. demissum*)
	Resistant
	SS Nos.-1769-0 and 1770-12 (*S. arnezii*), 2593-01 (*S. chacoense* ssp. *chacoense*), 1827-01 (*S. circaeifolium* ssp. *circaeifoilum*), 2700-01 and 2727-04 (*S. demissum*), 2264-04 (*S. hjertingii*), 1652-09 (*S. jamesii*), 2306-03 and 2297-0 (*S. megistacrolobum*), 2138-0, 2609-21 and 2610-04 (*S. microdontum*), 1724-09 (*S. sparsipilum*), 2267-0 and 2267-03 (*S. spegazzinii*), 2706-03 (*S. stenophyllidium*), 2710-0, 2710-25, 2713-03 and 2713-09 (*S. stoloniferum* ssp. *stoloniferum*), 2045-15, 2053-0, 2057-0, 2058-01, 2064-05, 2781-14, 2781-24, 2781-26 and 2783-0 (*S. tuberosum* ssp.*andigena*)
Late Blight in natural epiphytotic condition	
	Highly Resistant
	SS Nos.-1730-0 (*S. cardiophyllum*), 1767-0 (*S. ambosinum*), 1770-08 (*S. arnezii*), 1817-17 (*S. commersonii*), 1825-08 and 1825-09 (*S. cardiophyllum* ssp. *cardiophyllum*), 1846-06 and 2727-03 (*S. demissum*), 2053-0 and 2054-12 (*S. tuberosum* ssp. *andigena*), 2169-01 (*S. bulbocastanum* ssp. *bulbocastanum*), 2604-11 (*S. marinasense* ssp. *toralapanum*), 2609-06, 2609-07, 2609-09, 2609-11, 2609-15, 2609-18, 2609-20, 2610-01, 2610-02, 2610-09 and 2610-10 (*S. microdontum*)
	Resistant
	SS Nos.-1763-04 and 1763-13 (*S. albicans*), 2609-14, 2609-16 and 2609-19 (*S. microdontum*), 2706-0 (*S. stenophyllidium*), 2727-04 (*S. demissum*), 2781-28 (*S. tuberosum* ssp. *andigena*)
Bacterial wilt	***Highly Resistant***
	SS Nos.-2038-02, 2040-10, 2045-08 and 2044-05 (*S. tuberosum ssp.andigena*), 1659-02 (*S. mona*), 1724-06 (*S. sparsipilum*), 1725-44 (*S. spegazzinii*), 1848-20 and 1732-0 (*S. demissum*), 2044-44 (*S. tuberosum ssp.andigena*)
	Resistant
	SS Nos.-1725-83 (*S. spegazzinii*), 2064-10 (*S. tuberosum* ssp.*andigena*)

Germplasm registered

Two parental lines developed at CPRI have been registered as elite germplasm by ICAR/ NBPGR:

SS 1735-02 (INGR 13048): An elite wild potato clone (*Solanum demissum*; 2n=6x; 4 EBN) possessing very high resistance against late blight and low cold induced sweetening even after 6 months of cold storage.

MP/97-921 (INGR 13049): An elite parental line (Fig. 3) possessing high dry matter (>24% in hills & 22% in plains); superior chip colour (even after six months cold storage), low reducing sugar and sucrose content; high resistance to late blight; ideal free amino acid and phenol content and extreme resistance to PVY. (Fig. 4)

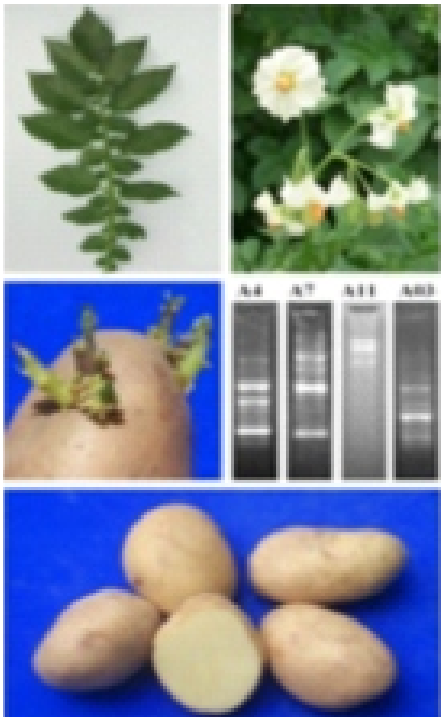
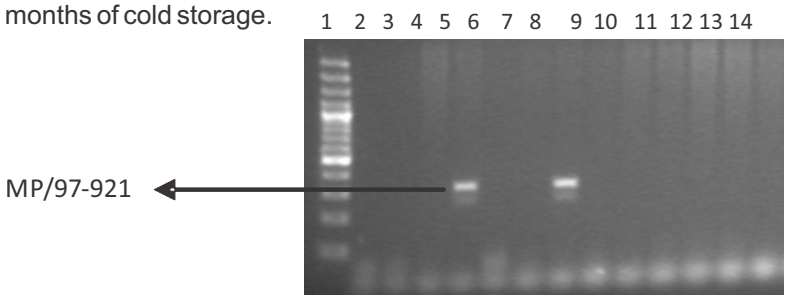


Fig. 3.



SCAR marker validation for the presence of *Ryadg* gene

Fig. 4. Lane 1, Marker; Lane 2-14: K. Lalima, K. Badshah, K. Girdhari, MP/97-921, K Sheetman, K. Megha, MP/04-578, CP 1765, CP 2407, CP 2011, MP/98-172, MP/05-05 and MP/05-41

Documentation:

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

Development of Improved Varieties

Project 1. Breeding improved varieties for plains

Hybridization and seedling raising: A total of 3, 82, 978 true potato seeds were obtained from the 284 successful crosses and at harvest 8,629 promising clones were selected at Jalandhar, Modipuram and Patna.

Initial clonal stages: In initial clonal stages (F_1C_1 to F_1C_3), 17,560 clones were evaluated at 60/75/90 DAP and 1,934 promising clones were selected.

Replicated yield trials: Seventy eight advanced stage hybrids were evaluated in 12 yield trials at 60/75/90 DAP at Jalandhar, Modipuram & Patna and 30 promising hybrids were selected. In preliminary yield trials, 19 promising hybrids namely J/7-5, J/7-15, J/7-21, J/7-24, J/7-25, J/7-37, J/7-61 and J/7-67 (Jalandhar), MS/9-723, MS/9-912, MS/9-1061, MS/9-1083, MS/9-2185, MS/9-2196 and MP/4-816 (Modipuram), PS/8-8, PS/8-23, PS/8-31 & PS/8-52 (Patna) were selected from 56 hybrids evaluated. In confirmatory yield trials, 9 promising hybrids namely J/2-14, J/5-252 and J/6-182 (Jalandhar), MS/8-861, MS/8-1148 & MS/8-1463 (Modipuram), PS/5-73, PS/5-75 and PS/7-7 (Patna) were selected from 19 hybrids evaluated. In final yield trial, J/92-14 (Jalandhar) and MS/7-645 and MS/7-2191 (Modipuram) were selected.

Proposal for introduction of advanced stage hybrids in AICRP: Based on consistent performance over the years, five advance stage hybrids namely J/2-14 (Jalandhar), MS/7-645 (Modipuram), PS/5-73, PS/5-75 and PS/7-7 (Patna) are being proposed for introduction in AICRP for multi-location trials.

J/2-14 (Vangogh x MS/90-512)**:** The hybrid produced 7.9% and 10.3% higher yield over control Kufri Khyati at 60 and 75 days harvests, respectively. The hybrid J/2-14 significantly out yielded Kufri Khyati at 90 days harvest. The hybrid possesses creamy long oval tubers with shallow eyes and yellow-cream flesh.

MS/7-645 (K. Anand x K. Chipsona-3): The hybrid produced 24%, 11% and 14% higher tuber yield than K. Bahar, K. Pukhraj and K. Sadabahar, respectively at 90 days. The hybrid possesses light yellow, oval tubers with shallow eyes and light yellow flesh. The hybrid possesses good keeping quality and field resistance to late blight at Modipuram.

PS/5-73 (K. Lauvkar x K. Pukhraj): The hybrid produced 4% higher tuber yield than K. Pukhraj at 75 days. The hybrid possesses white oval tubers with fleet eyes and creamy flesh. The hybrid possesses high dry matter and good keeping quality.

PS/5-75 (CP2376 x K. Kanchan): The hybrid produced 8.6% higher tuber yield than K. Arun at 75 days. The hybrid possesses red flattened oval tuber with fleet eyes and creamy flesh. The hybrid possesses high dry matter and good keeping quality.

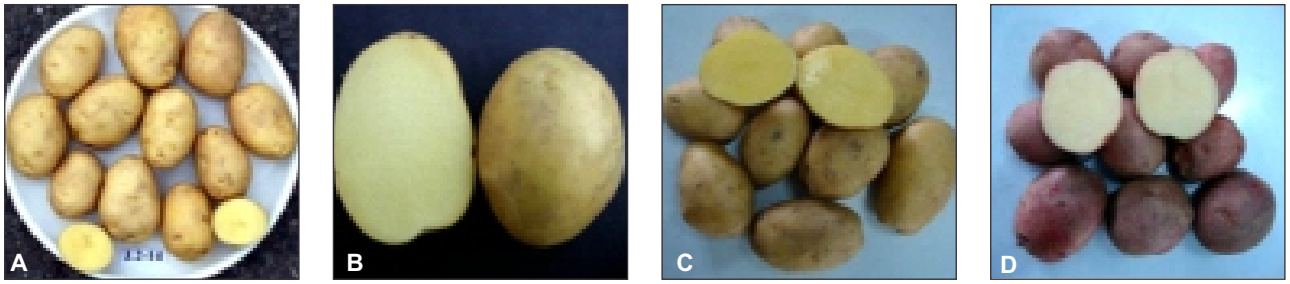


Fig. 5: Tubers of J/2-14 (A), MS7-645 (B), PS/5-73 (C) and PS/5-75 (D) proposed for AICRP

Advanced hybrid introduced in AICRP: Following advanced hybrid were introduced in to AICRP for multi-location trials.

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 possesses yellow oval tubers with shallow eyes, light yellow flesh 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 possesses yellow oval tubers with shallow eyes, light yellow flesh, good keeping quality and field resistance to late blight.

PS/6-88 (K. Arun x CP 3192): 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. The hybrid possesses 17.8% dry matter, medium dormancy with good keeping quality.

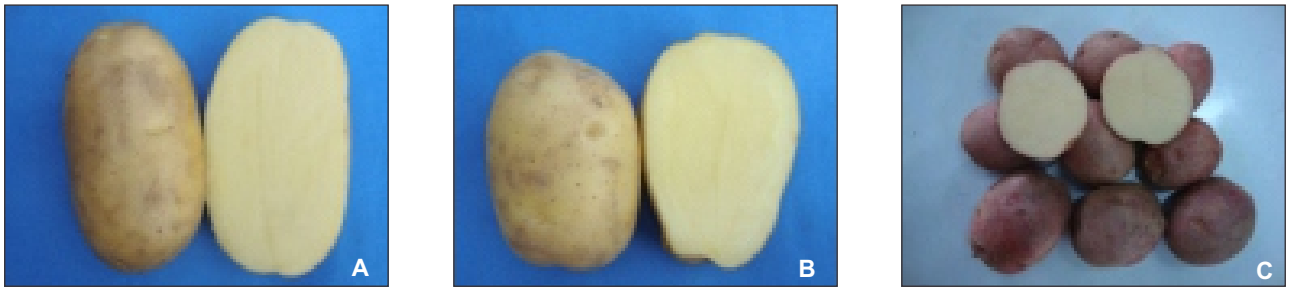


Fig. 6: Tubers of advanced potato hybrids introduced in AICRP

Notification of potato varieties: Potato varieties Kufri Gaurav and Kufri Garima were notified for commercial cultivation in 19th Meeting of Central Sub-Committee on Crop Standards Notification & Release of Varieties for Horticultural Crops held on 24th July 2012 at Krishi Anusandhn Bhawan II, New Delhi.

Optimization of fertilizer requirements of newly released varieties: Fertilizer requirements of newly released potato varieties namely Kufri Sadabahar (Fig.3) and Kufri Garima (Fig.4) were worked out and economic optimum doses were computed based upon two years of field trials during 2010-12. In Kufri Sadabahar, economic optimum dose of nitrogen, phosphorous and potassium were 236.8, 71.1 and 122.2 kg ha^{-1}, respectively. However in Kufri Garima, the optimum nitrogen, phosphorous and potassium doses were 238.0, 48.6 and 155.2 kg ha^{-1}, respectively.

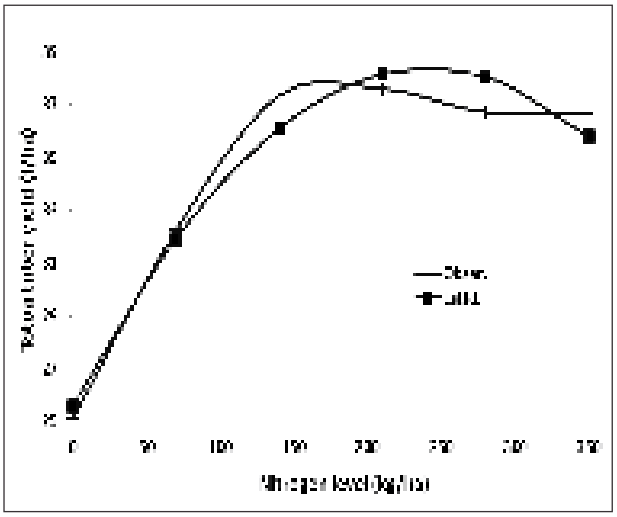


Fig. 7a.

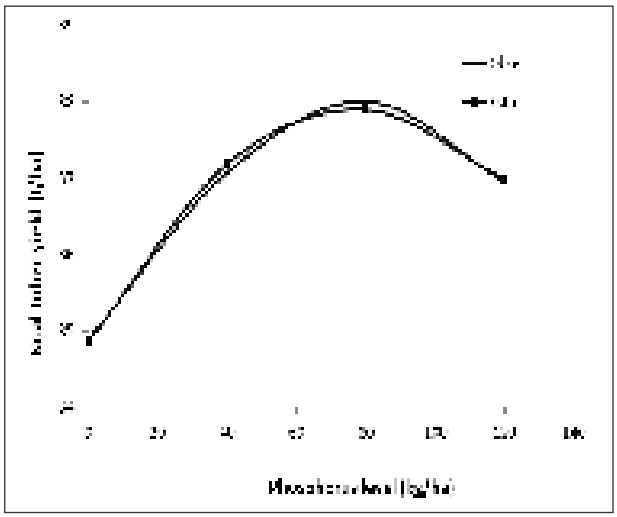


Fig. b.

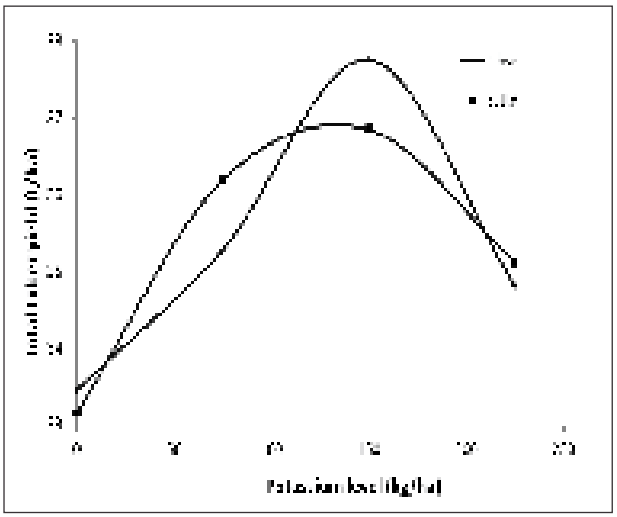


Fig. c.

Fig. 7. (a-b-c) Optimization of fertilizer requirements of newly released varieties (K. Garima)

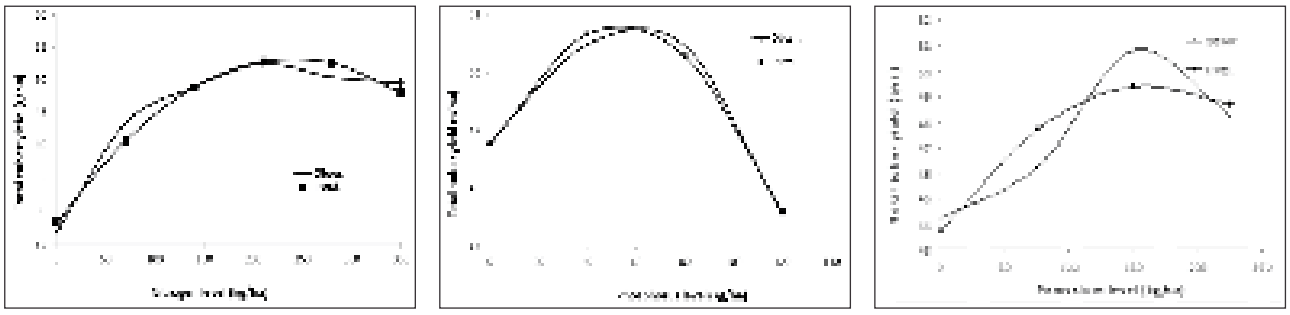


Fig. 8: Response curve of expected and observed total tuber yield of Kufri Garima for Nitrogen, Phosporus and Potash

Optimization of nitrogen requirement of advanced hybrids at Patna: The experiment aimed at standardization of phosphorus and potassium fertilizer dose of red skin hybrids 2000P55, & 2001P55. In first trial, four graded levels of Phosphorus (0, 25, 50 and 100 Kg P_2O_5 ha^{-1}) at constant dose of N (160 Kg ha^{-1}) and Potassium (150 Kg K_2O ha^{-1}) and in second trial four levels of Potassium (0, 50, 100 and 150 Kg K_2O ha^{-1}) at constant dose of Nitrogen (160 Kg ha^{-1}) and Phosphorus (100 Kg P_2O_5 ha^{-1}) were applied. Economic optimum dose of N @160 Kg /ha, P @ 60 Kg P_2O_5 and K @ 100 Kg K_2O was suitable dose for the new red skin hybrids.

Evaluation of advanced stage hybrids for late blight resistance at Jalandhar: Twenty advanced hybrids were evaluated for resistance to late blight in field. On the basis of area under disease progress curve (AUDPC), hybrids J-7-28, J-7-39, J-7-53, J-7-78 and J-576 were found moderately resistant.

Evaluation of advanced stage hybrids for late blight resistance at Modipuram: Thirty nine advanced stage potato hybrids along with six varieties were evaluated for late blight. All hybrids showed less AUDPC than K. Bahar (1056), however minimum AUDPC was recorded in MS/9-723 (52). Advanced hybrids namely MP/4-578 (82), MS/5-1543 (130), MS/06-1947 (150) MS/9-749(168) MS/8-228 (170) and MS/8-215 (217) were found moderately resistant.

Breeding for processing and export quality

Hybridization A total of 80,220 TPS of 41 crosses were produced and at harvest 582 clones were selected from the 20,000 seedlings at Modipuram.

Preliminary yield trial: A total 151 clones were selected from 949 clones in initial clonal stages (F_1C_1 to F_1C_3). In F_1C_4 stage, 11 hybrids were selected out of 18 hybrids tested at 75 and 90 DAP.

Confirmatory yield trial: Five advanced hybrids namely, MP/04-578 (for French fry), MP/04-816, MP/06-595, MP/06-86 and MP/07-214 (for chips) were selected on the basis of total tuber yield, processing grade yield, chip colour & dry matter from the eight hybrids evaluated at 75 and 90 DAP.

Regional evaluation of advanced processing hybrids: Four advanced processing hybrids, viz. MP/04-578 (for French fry), MP/04-816, MP/06-39 and MP/05-1009 (for chips) were evaluated at 3 locations viz., Amirgarh (Gujarat), Burdwan (West Bengal) and Indore (MP) at 90 DAP for yield and processing traits (Table 3). At Jalandhar besides above hybrids, 3 other hybrids viz. MP/02-204, MP06-26 and MP/06-86 were also evaluated

Amirgarh (Gujarat): MP/04-578 recorded maximum processing and total tuber yield (52.1 and 57.6 t/ha) as against Kufri Frysona (42.4 and 50.6 t/ha). MP/4-816 was found to be superior in yield as well as quality over best control K. Chipsona-3.

Burdwan (West Bengal): MP/04-816 (49.26 t/ha) for chips and MP/04-578 (46.46 t/ha) for French Fries were found superior than their respective controls.

Indore (MP): MP/04-816 recorded 35.81 t/ha yield, whereas MP/04-578 (for French fry) recorded maximum yield of 32.04 t/ha with acceptable processing attributes.

Jalandhar (Punjab): MP/06-86 recorded maximum processing and total tuber yield (45.1 and 51.0 t/ha) followed by MP/06-39 (43.82 and 48.4 t/ha). All genotypes recorded more than 20% dry matter except MP/06-39 (19.16%). All genotypes could make acceptable colour fries at harvest. An acceptable colour chip was found in all the genotypes at harvest except in MP/04-578, MP/02-204 and MP/06-26 (Table 4)

Screening of parental lines for late blight resistance: Forty-eight and thirty-six parental lines were assessed for yield and late blight at Shimla and Kufri. The best parents both at Kufri and Shimla were CP 4045, CP 3771, CP 2350, CP 4082, CP 1971 and CP 4044.

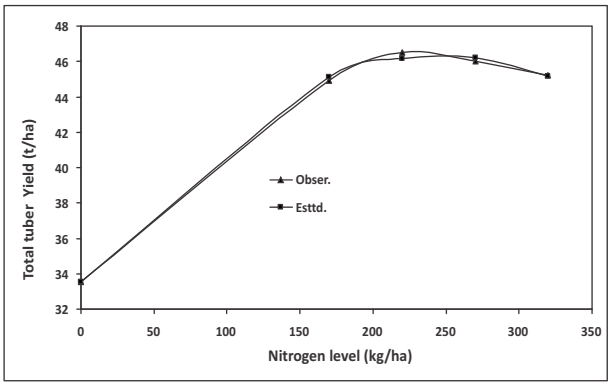
Performance of advanced processing hybrids at Shimla: MP/2K-424 (19.54) produced significantly high tuber yield than the best control K. Himsona (16.59) among the 10 advanced processing hybrids evaluated at 120 DAP during summer.

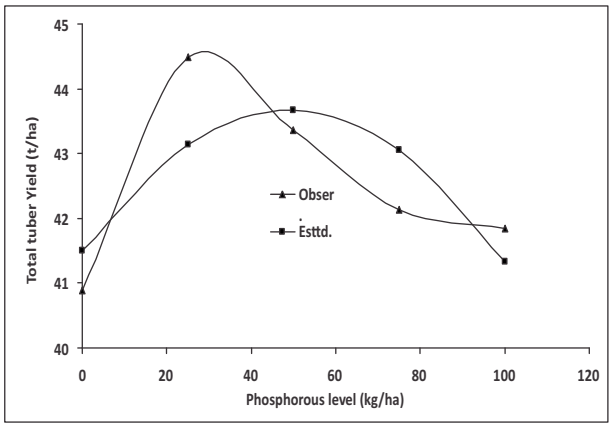
Processing hybrid introduced in AICRP: Based on superior performance, MP/04-578 (Kufri Chipsona-1 x MP/92-35) was introduced in AICRP for multi-location testing. It produces white cream, oblong tubers with shallow eyes and cream flesh and is suitable for French fries (Fig. 9). The hybrid produced 27 and 38 t/ha tuber yield as against controls K. Frysona (25 and 33t/ha) at 75 and 90 days respectively). The hybrid produced 9 %, 16% and 7% (at 75 days) and 14 %, 14% and 9% (at 90 days) higher processing, French fry grade and total tuber yields, respectively over best control Kufri Frysona. Hybrid MP/4-578 possesses high tuber yield and acceptable processing attributes for French fries, resistance against late blight and PVY which can be helpful in expanding the potato production and its utilization for processing.

Fig. 9. Tuber, flower, leaf and sprout of MP/04-578

Optimization of crop geometry of cv. Kufri Himsona: A field trial was initiated during 2012-13 for optimizing the crop geometry of cv. Kufri Himsona under flood irrigation for achieving highest chip grade tuber productivity. Chip grade tuber yield was highest with 66 cm row spacing (31.8 t ha^{-1}) remaining significantly better over 60 cm (25.6 t ha^{-1}) and comparable to 72 cm (31.7 t ha^{-1}). The productivity was not influenced by plant to plant spacing and crop geometry of 66 X 35 cm achieved highest chip grade (32.8 t ha^{-1}) and total tuber yield (46.8 t ha^{-1}) remaining comparable to 66 X 20 cm. Quality parameters viz., specific gravity and chip colour were not influenced by combinations of row and plant spacing.

Optimization of macro- nutrient requirement of cv. Kufri Frysona under drip and sprinkler irrigation: Optimum N- P- K doses were calculated based upon yield trials conducted during 2010-12. Response of Kufri Frysona for macro-nutrition was similar under drip and sprinkler irrigation. Economic optimum dose of nitrogen, phosphorous and potassium for cv. Kufri Frysona were 241.8, 45.9 and 120.7 kg ha^{-1}, respectively. Further, quality traits like specific gravity and fry colour were not influenced significantly with varied levels of fertilizers.





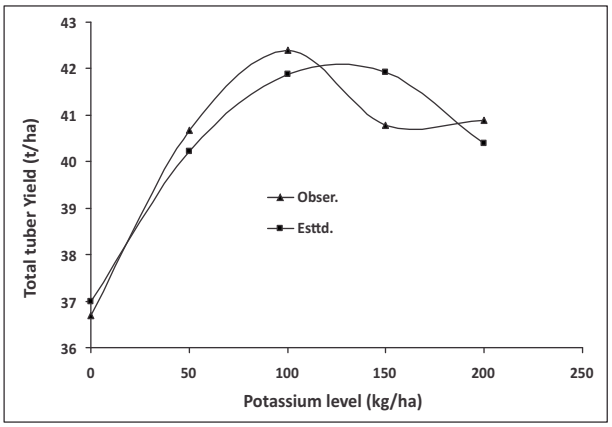


Fig. 10. Response curve of expected and observed total tuber yield of Kufri Frysona for Nitrogen, Phosporus and Potash

Table 3. Performance of advanced processing hybrids at Amirgarh (Gujarat), Burdwan (West Bengal) and Indore (Madhaya Pradesh) at 90 DAP

Variety/ hybrids	Processing Grade yield (t/ha)			French fry grade yield (t/ha)		Total tuber yield (t/ha)		
	Gujarat	WB	MP	Gujarat	WB	Gujarat	WB	MP
MP/04578	52.10	39.22	30.07	38.01	26.32	57.60	46.46	32.04
MP/04816	58.12	43.98	32.43	0.00	0.00	63.56	49.26	35.81
MP/0639	59.01	46.30	29.84	0.00	28.53	64.63	55.46	33.10
MP/051009	51.83	38.24	24.26	0.00	0.00	62.53	47.23	29.21
K Chip -1	-	-	21.09	-	-	-	-	24.10
K Chip -3	49.57	33.56	-	0.00	14.24	62.23	43.14	-
K Chip -4	50.31	32.54	19.68	0.00	0.00	58.98	37.74	21.8
K Frysona	42.41	34.13	24.33	30.79	21.41	50.56	44.00	22.2
Atlantic	54.64	35.17	20.21	0.00	0.00	59.23	41.01	22.4
K Jyoti	-	46.40	28.43	-	0.00	-	53.80	30.97
CD (0.05)	2.49	2.71	2.95	2.29	1.89	2.74	2.77	2.75

Variety/ hybrids	Chip / French fry colour (Visual)			Tuber Dry matter content (%)		
	Gujarat	WB	MP	Gujarat	WB	MP
MP/4-578	1.5	2.0	1.5	20.60	21.07	22.0
MP/4-816	2.0	2.0	1.5	19.80	20.66	22.0
MP/6-39	1.5	3.5	3.8	18.50	18.24	21.3
MP/5-1009	5.0	6.0	2.0	20.60	20.48	21.0
K Chip-1	-	-	2.5	-	-	22.8
K Chip-3	1.0	4.0	-	22.50	22.27	-
K Chip-4	1.5	4.0	2.2	20.40	20.55	21.8
K Frysona	1.5	2.5	1.8	21.30	22.77	22.2
Atlantic	1.5	3.0	2.5	20.00	20.24	22.4
K Jyoti	-	4.5	3.5	-	17.4	19.6

Table 4. Processing quality of advanced processing hybrids/varieties (90 DAP+ 20 days of skin curing

Variety	Dry matter (%)	Reducing sugar	Sucrose	Chip colour	Fry colour
MP/02-204	22.17	114.6	275.9	4.87	1.75
MP/04-578	20.18	244.1	233.8	5.25	4.25
MP/04-816	20.45	124.2	224.5	2.0	1.50
MP/06-26	20.15	153.8	259.8	5.0	3.62
MP/06-39	19.16	85.4	239.7	3.25	3.13
MP/05-1009	20.95	363.9	235.4	3.75	1.87
MP/06-1009	22.28	85.4	226.2	3.50	2.87
K. Chipsona -1	21.58	29.2	221.2	2.25	2.13
K. Chipsona -3	21.58	84.6	236.5	2.5	3.62
K. Chipsona - 4	22.46	87.6	224.4	3.62	1.62
K. Frysona	22.18	135.1	219.6	3.37	1.50
K. Himsona	21.85	174.7	280.7	3.25	1.50
K. Surya	20.46	129.4	280.7	3.25	2.25
Atlantic	22.18	37.0	189.8	2.25	1.50

Development of TPS population

1. **Production of TPS:** A total of 439 gm TPS from 13 crosses were generated for population development while 12 g TPS were produced from 10 crosses involving 36 female and 3 pollen parent for potential line development under natural photoperiod condition. 2-3g of TPS 92 PT-27 was produced for sale purpose.

2. **Screening of parental lines for flowering and berry setting:** TPS population KP-15C3 flowered profusely at Patna during winter conditions evaluated for flowering and berries setting. The features of TPS parental line KP 15C3 (Parentage: MF-II x D-150) which profusely flowered under natural condition are given below-

Table 5 : Details of TPS line KP15C3

Pollen fertility (%)	5	No. of flowers /bunch	15.6
Days to flower initiation	39	No. of berries /bunch	14.2
No. of bunch/ plant	5.8	Yield of TPS /Plant (g)	7.1

Fig. 11. Parental line KP15C3 flowered under natural condition (below 8°C) at CPRS Patna

3. **Evaluation of TPS populations as Transplanted crop**

Yield Trial at Patna: Among the 14 red x red populations evaluated at 90DAP, populations PT/12-38 and PT/12-40 gave significantly higher total tuber yield than the control 92PT-27; while among 15 white x white crosses populations viz. PT/12-01, PT/12-16 and PT/12-18 gave significantly higher total tuber yield than the control 92PT-27. The population PT/12-29 gave highest red tuber per cent (73.56 %).

Yield Trial at Shillong: Among the 34 TPS populations evaluated during summer season, TPS populations PS8/107-1 x 97-1 (8.77 t/ha), PS9303 x D-150 (8.28 t/ha), PS6/39-8 x 97-1 (7.67 t/ha), PRT-16 x 97-1 (7.66 t/ha) and RS8/63-2 x 2002P32 (7.05 t/ha) gave significantly higher tuber yield than the control 92-PT-27 (5.25 t/ha) as transplanted crop under rain-fed conditions. None of the TPS populations showed resistance to late blight leading to 100% disease incidence 65 days after transplanting.

2. **Yield Trial with Seedling tubers (F_1C_1) at CPRS, Patna:** Among the 15 red skinned populations, five populations namely PT/11-68, PT/11-69, PT/11-70, PT/11-71 & PT/11-72 yielded significantly higher than control K. Kanchan at 90 days harvest, however among the 13 white skinned populations evaluated at 90 DAP, two populations viz PT/11-63 and PT/11-59 gave significantly higher total tuber yield than the control 92PT-27.

3. **Anther culture of parents of TPS population at Shimla:** The TPS parents viz., 83P47 and D-150 were used for regeneration of dihaploid via anther culture but none of the parents were responded to regeneration of androgenesis. This may be due to poor genetic potential of the genotype towards anther-culture.

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 reduction of cold-induced sweetening; gene expression for potato tuberization and late blight resistance; and production of interspecific potato somatic hybrids using wild *Solanum* species.

Whole genome sequencing of *Phytophthora* infestans (A2 mating type)

Late blight caused by the oomycete, *Phytophthora infestans*, is the decimator of potato cultivation costing over $5-6 billion worldwide in crop losses and control measures. Yield losses due to late blight in India vary from year to year and range from 20-75%. CPRI has initiated the whole genome sequencing of A2 mating type of Indian *Phytophthora* strain. So far the sequencing has been completed covering around 14X of its genome size (appx. 240 Mb) after the seven (I to VII) runs which generated in total 3564.93 MB varied from 361.75 to 625.75 MB data with an average read length of 340.58 ranging from 285.98 to 375.49. Presently gene prediction, annotation and comparative genomics is being carried out.

Whole genome sequencing of Indian strains of *Ralstonia solanacearum*

Ralstonia solanacearum is a major phytopathogen that attacks many crops including potato over a broad geographical range. The extensive genetic diversity of strains responsible for the various bacterial wilt diseases has in recent years led to the concept of an *R. solanacearum* species complex. If not all but major *Rs* complex exist in India causing wilt in many of the vegetable crops. To understand the species complex and the strainal variations existing in nature we initiated and completed the whole genome sequencing of 3 phylotypes of *R. solanacearum* covering 25X depth of each phylotype having 5.8 Mb genomic sizes. Preliminary studies revealed that the genome is known to poses a core chromosomal element of 2,543 bp and an extra chromosomal element of 3,538 bp.

Transgenic potatoes for reduction of cold induced sweetening

A total of 90 transgenic RNAi lines were multiplied *in vitro* and about 900 plantlets were planted in the glasshouse of Central Potato Research Institute, Shimla for evaluation of cold-chipping attributes. Transgenic lines (18 for *UGPase* amiRNA, 20 for *INV* amiRNA and 16 for both *UGPase* and *INV* combined amiRNAs, 18 *UGPase*-TGS and 18 tubers of Marker free transgenics) were developed. These lines were cold stored at 5°C for 45 days at Shimla and after this cold storage some of the lines showed improvement in chip colour. As the studies taken are for single generation where stability of transgenic traits remains doubtful, these 90 lines will be tested for one more season both at Shimla and Jalandhar under glass house conditions.

Role of heat shock proteins (HSP's) for potato tuberisation

To address the issue of effect of heat on potato tuberization, we analyzed transcriptional response profiles of heat shock proteins in heat tolerant (Kufri Surya) and heat susceptible (Kufri Chandramukhi) potato cultivars to a range of 24^{0}C heat stress in plant leaf tissues. Gene expression levels were assessed from total RNA isolated from leaf tissues by Real Time PCR analysis based on the number of amplification cycles needed to reach a common fixed threshold (cycle threshold - Ct) in the exponential phase of PCR. K. Surya showed 30 fold higher expression (RQ value 32.33) of four HSPs gene namely17.6 KDa small HSP class-I, HSP 70, HSP 40 and HSP DnaJ during tuberisation period at 24C as compared to K. Chandramukhi (RQ Value 1.87 to 0.863) and non stress condition (0th days RQ value 1.0), this correlates with non tuberisation state also in later cultivar (Fig 12).

Overexpression of 17.6 HSP gene in potato cv. Kufri Chandramukhi for heat stress tolerance

Real time PCR analysis of heat shock protein genes i.e. HSP 17.6 KDa small HSP class-I, chloroplast small HSP class-1, chloroplast small HSP class-II, HSP DnaJ, HSP 40, HSP 70 and 101 KDa HSP) at regular intervals till 21 days (tuberisation period) at 24°C temperature, in Kufri Surya, the expression of small HSP namely17.6 KDa small HSP class-I, HSP DnaJ, HSP 40, HSP 70 were found to be 30 fold higher during the tuberisation period (i.e. 21 at days after planting) as compared to Kufri Chandramukhi and non stress condition. Based on this expression data, we are targeting to enhance the tuberisation conditions in heat susceptible cultivar by over

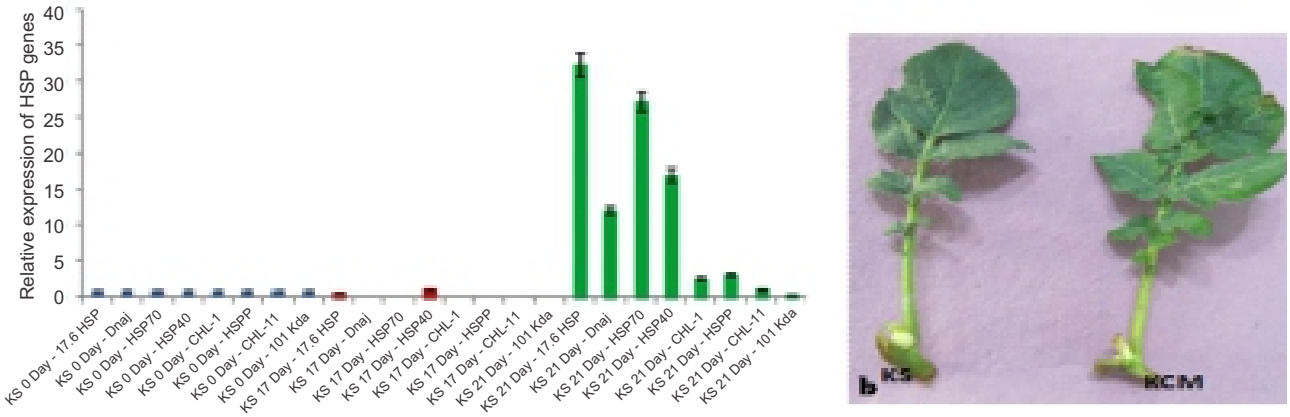


Fig. 12. Relative real time gene expression analyses in response to 24°C temperature condition in potato cultivar a) K. Surya and b) impact of heat stress (24°C) on potato tuberisation

expressing the 17.6 HSP gene. 476bp bp cDNA fragment was isolated from Heat stress tolerant K.Surya and cloned in pBI121 binary vector driven by CamV35S promoter (Fig. 13 and 14) for *Agrobacterium* mediated transformation of K. Chandramukhi.

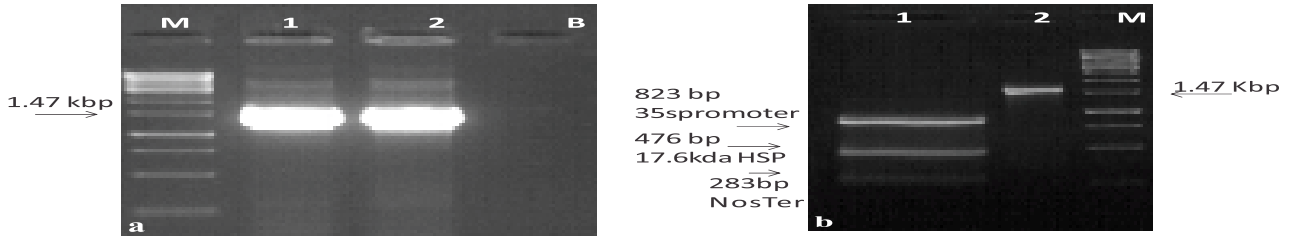


Fig 13. PCR amplification of EHA105 plasmid confirming the Integration of 35SPromoter-17.6 Kda HSP-Terminator Cassette in pBI121 binary vector; b) Restriction analysis of PCR amplicon of EHA 105 plasmid With XbaI-SacI enzyme confirming the integration of promoter-gene-terminator cassette in pBI121 binary vector

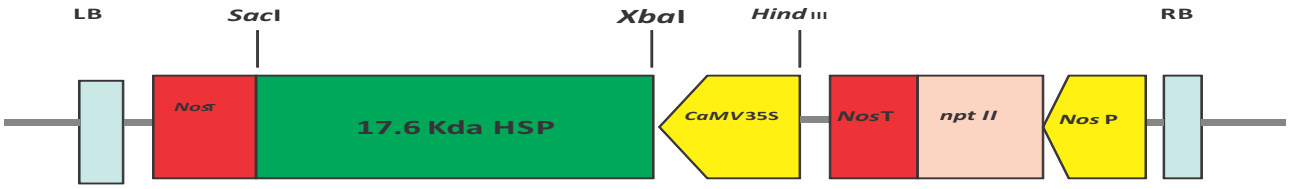


Fig. 14. Map of the T-DNA region of the binary vector cassette, pBI121:17.6KDa HSP

Functional Validation of microarray based expression of 22.7HSP gene through transgenic approach

Microarray analysis of genes involved in late blight resistance in Kufri Girdhari revealed that 22.7HSP gene expressed 132 fold over before interaction of the *P.infestans*. 22.7HSP genes was isolated from the *P.infestans* challenged tissues and cloned 576bp full length cDNA in the binary vector Pbi121 under the control of CamV35S promoter (Fig. 15 & 16.)

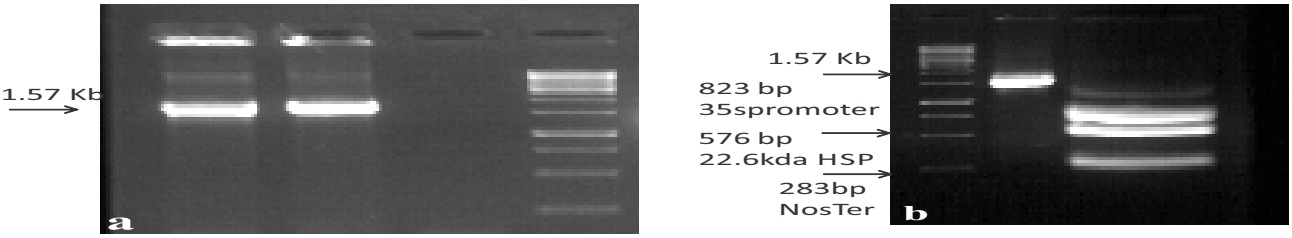


Fig 15. PCR amplification of EHA105 plasmid confirming the Integration of 35SPromoter-22.7 Kda HSP-Terminator Cassette in Pbi121 binary vector; b) Restriction analysis of PCR amplicon of EHA 105 plasmid With XbaI-SacI enzyme confirming the integration of promoter-gene-terminator cassette in pBI121 binary vector

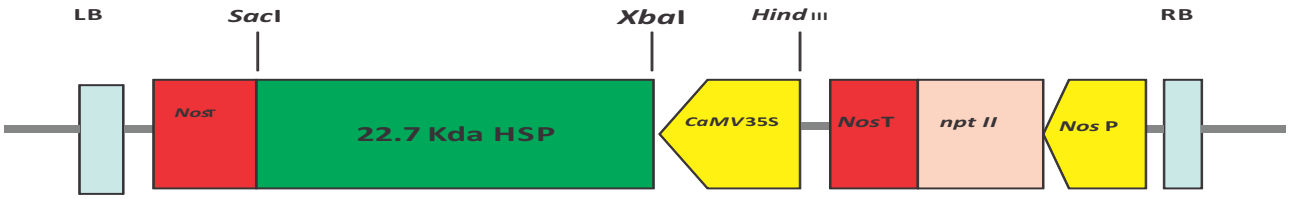


Fig. 16. Map of the T-DNA region of the binary vector cassette, pBI121:22.7KDa HSP

SNPs discovery for late blight resistance in potato

Thirteen SNPs at varying position were found in 129 genotypes for *Allene Oxide Synthase 2* Gene. *In-silico* analysis revealed significant role of these SNP's against late blight resistance. MSA depicted 3 important SNPs positions i.e. 866, 875 and 982 are responsible for late blight resistance correlating with phenotypic data. Nucleotides G at position 866, C at positions 875 & 982 results in the translation of Ser, Ala and Leu, respectively that contributes for late blight resistance. Whereas nucleotides A at positions 866 & 982 and T at position 875 results in the translation of Asp & Met and Val respectively which is responsible for late blight susceptibility.

Allele mining for late blight resistance *R* gene homologues in the wild *Solanum* species

A total of 44 wild *Solanum* species were screened against late blight infection by *in vitro* assay in the environment controlled chamber. The *in vitro* chamber maintained at 23 and 15C during day and night, respectively. The *P. infestans* races 1.2.3.4.5.6.7.8.9.10 were mass cultured on tuber slices of susceptible potato cv. Kufri Chandramukhi. Plants were sprayed till run off with zoospore solution and throughout the screening period, relative humidity in the chamber was maintained 90% using mist generation system. Percent foliar necrosis was recorded two times i.e. at 7 and 9 days after inoculation (DAI) during the late blight progression. Out of 44 wild species accessions, 17 accessions of the 14 wild *Solanum* species viz., *S. berthaultii*, *S. cardiophyllum*, *S. hougasii*, *S. huancabambense*, *S. iopetalum*, *S. jamesii*, *S. lesteri*, *S. microdontum*, *S. pinnatisectum*, *S. polyadenium*, *S. polytrichon*, *S. stoloniferum*, *S. trifidum* and *S. verrucosum* were scored 0-20 % late blight infection and classified into very high level of resistance. Fig. 17 shows PCR amplification of R genes conferring late blight resistance in the wild species.

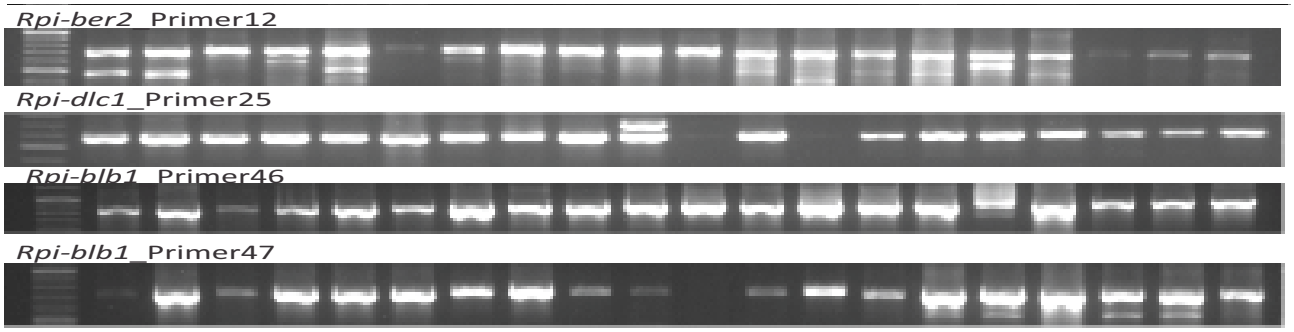


Fig. 17. PCR amplification of late blight resistance R genes-specific primers in the wild species.

Protoplast isolation, electrofusion and regeneration of putative somatic hybrids

Interspecific symmetric somatic hybridization was carried out between the androgenic dihaploid (C-13) of common potato *S. tuberosum* (2*n*=4*x*=48; 4 EBN) and the wild *Solanum* species. In total, 720 protoplast isolation and electrofusions of C-13 (+) *S. cardiophyllum*, C-13 (+) *S. microdontum*, C-13 (+) *S. acaule*, C-13 (+) *S. lesteri*, C-13 (+) *S. jamesii*, C-13 (+) *S. trifidum*, C-13 (+) *S. stoloniferum*, C-13 (+) *S. capsibaccatum* were attempted. 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 wild *Solanum* species into the cultivated potato *S. tuberosum*. Out of total fusions, based on culture of first shoot per callus, 50 microshoots of C-13 (+) *S. cardiophyllum* were regenerated from calli and multiplied on MS medium for molecular and phenotypic characterization (Fig. 18).

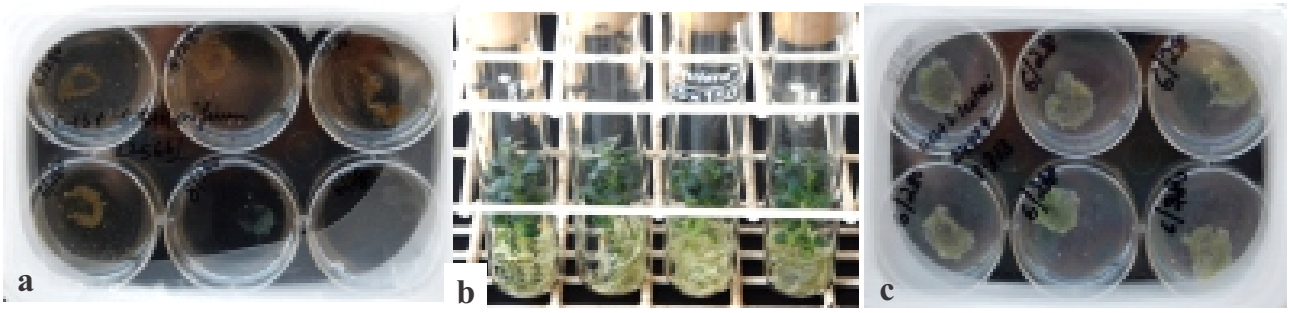


Fig. 18. Protoplast isolation, electrofusion, regeneration of microcalli and in vitro plants of C-13 (+) S. cardiophyllum (a & b), and C-13 (+) S. lesteri (c)

Analysis of genetic and epigenetic variation of potato somatic hybrids

Somatic hybrids *Solanum tuberosum* dihaploid C-13 (+) *S. pinnatisectum* mother plant and 30th cycles sub-cultured somatic hybrids were used to detect the genetic and epigenetic changes. To detect genetic changes, eight AFLP primer pair combinations yielded 49 polymorphic bands out of 329 scorable bands. Eight MSAP primer pair combination detected total DNA merthylation variation in the regenerants was ranged from 3.2 to 8.5%. Whereas, total methylation levels in the regenerants was detected from 0.7 to 4.2%, and 0.0 to 3.8%, by MS-ISSR and MS-RAPD markers, respectively. The study concluded that genetic and epigenetic variations are induced in the somatic hybrids mother plant and the regenerants over a period of time during the tissue culture process (Fig. 19).

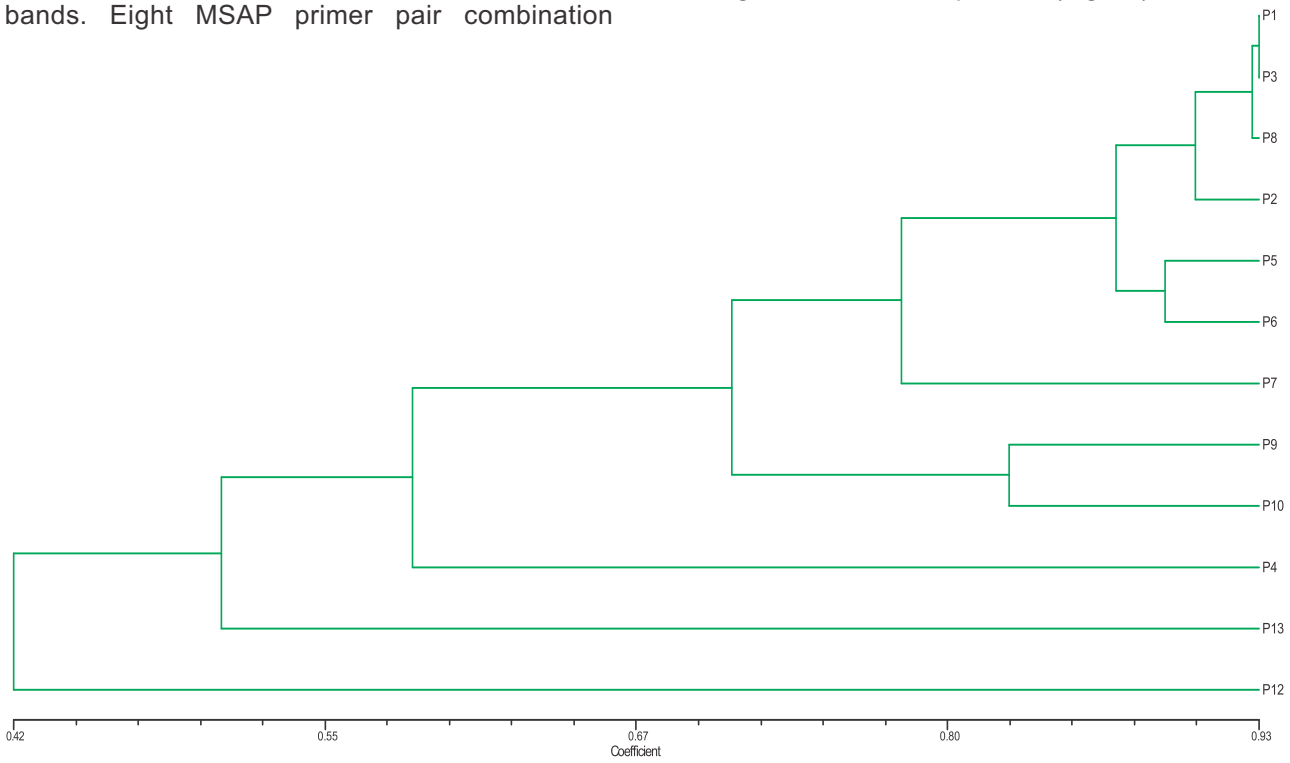


Fig. 19. Cluster analysis based on Jaccard similarity coefficient of potato somatic hybrids by AFLP markers

Evaluation of somatic hybrids under field conditions

Ten somatic hybrids of C-13 + *S. pinnatisectum* along with one parent C13 and five control varieties were evaluated in replicated trial at 90 days and 105 days after planting. None of the somatic hybrids of *S. pinnatisectum* and parent C13 produced tuber yield higher or at par with control varieties. Somatic hybrids P1, P3, P4, P6, P8 and P10 produced significantly higher total tuber yield at 90 days after planting than the parent C13. However at 105 days somatic hybrids P1, P4, P6, P8, P9 and P10 produced significantly higher total tuber yield than

parent C13. Highest total tubers/plant were recorded in P1, P4 (13 tubers), followed by P10 (12), P8 (11), P2, P3, P6, C13 (10), P5 (9) than Kufri Pukhraj (9) and Kufri Bahar (8). All the somatic hybrids exhibited change of skin colour from white/yellow (Fig. 20) to light purple/purple on exposure to sunlight, however no such change of colour was observed in parent C13 and control varieties.

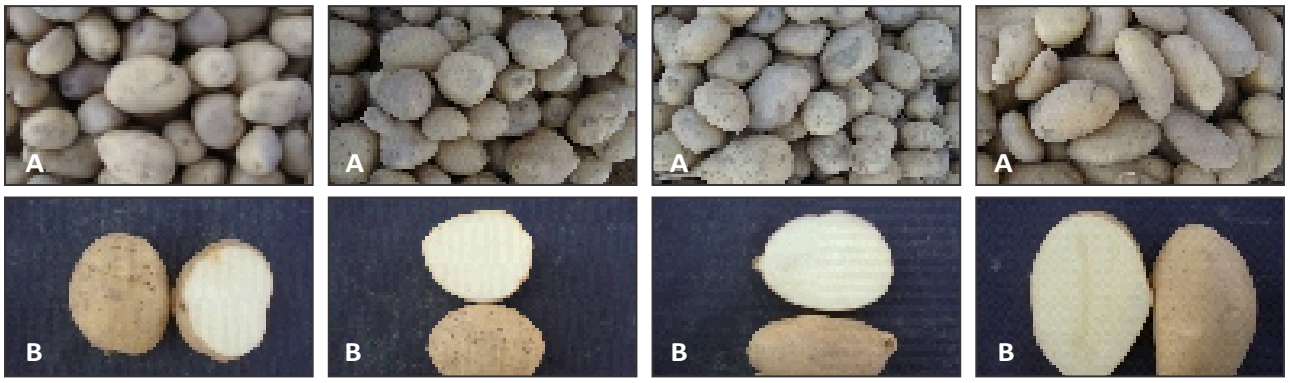


Fig. 20. Tuber characters of somatic hybrids of C-13+S. pinnatisectum at harvest

Evaluation of potato somatic hybrids for late blight resistance

Potato somatic hybrids of the dihaploid *S. tuberosum* 'C-13' (+) *S. pinnatisectum* namely P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P12 and P13; parents dihaploid *S. tuberosum* C-13 and wild *S. pinnatisectum*, control varieties Kufri Jyoti (susceptible), K. Girdhari and K. Himalini (resistant) were used in the study. All the somatic hybrids (P1, P2, P3, P6, P7, P8, P9, P10, P11, P12 and P13) were high resistant (HR) with AUDPC value ranged from 11.67 to 39.17 except P4 (58.33) and P5 (61.67) were resistant (R). However, in the *in vitro* assay in the environment closed chamber, only P7 (45.83), P9 (5.83) and P13 (5.83) were high resistant (HR). Other somatic hybrids were in the category of resistant (R) to moderate resistant (MR) with AUDPC values ranged between 65.83 to 131.67. Pictorial representation of late blight reactions on the somatic hybrids and the control cultivar is shown in (Fig. 21).

Fig. 21. Evaluation of the somatic hybrids for late blight resistance

Gene expression analysis for nitrogen use efficiency in potato cultivars by real-time PCR

The real time gene expression of ammonium transporter (AMT), cytochrome oxidase (COX1), asparagine synthetase (AS), nitrate reductase (NR) and nitrite reductase (NIR) genes was analyzed in leaf tissue of potato cultivars under N stress and sufficient field grown conditions. Results showed that gene expression of AMT, AS and COXI in leaf tissues particularly under N stress successfully explained the variation of N efficieny in three cultivars Kufri Gaurav, Kufri Pukhraj and Kufri Jyoti which differ widely in N efficiency. The higher expressions of AMT, COX1 and AS in leaves can be used as parametres to screen potato genotypes for high utilization, transport and storage of N (Fig. 22).

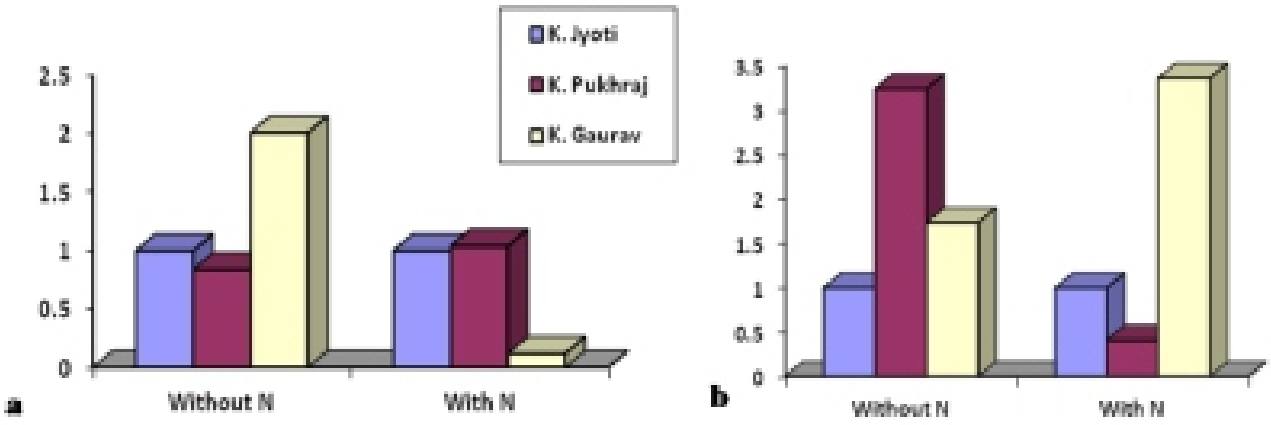
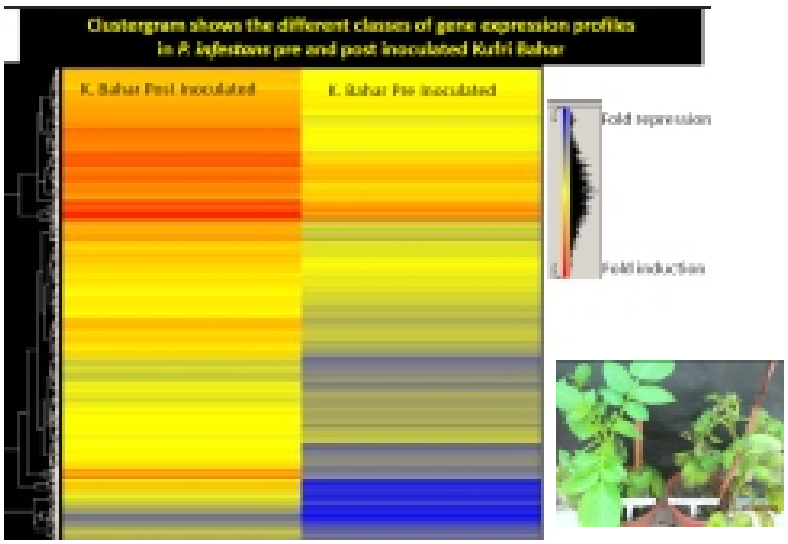


Fig. 22. Real time gene expression analysis in leaf tissues of potato cultivar in response to without and with N application for the genes a) Ammonium transporter (AMT) and b) Asparagine synthetase (AS)

Development of "Genome Specific Markers" for potato diversity studies

In this study, adding to the list of various molecular markers, a new set of markers called "Genome Specific Markers (GSMs)" study was carried out in potato for the genetic profiling. Markers were tested for 20 different potato species for the diversity analysis (Fig 23). This is the first report of using the genome specific primers in potato. Study indicates that use of these markers can clearly distinguish among different cultivated, semi-cultivated and wild species. Generation of the genetic profiles using the genome specific primers helps in documentation of ownership and protection of intellectual property rights along with the other molecular marker system.

Fig. 23. Genome specific marker DM7 screening on 2.5% agarose gel



Division of Crop Production

Resource management strategies and information technology tools for potato based cropping systems

Multiple cropping using short duration crop cultivars and intensive input management is practiced to enhance production and increase land use efficiency. In India, potato based cropping systems play an important role in improving the productivity of the region due to the fact that potato being a short duration crop and can be harvested early or late to meet the demand of cropping system where it is grown. Hence, the programme aims to develop resource management strategies for potato based cropping systems under different agro climatic conditions and develop information technology tools for potato production.

Resource management strategies in potato based cropping systems

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

Associative effect of intercrops on potato growth, yield and the total productivity and economics of the vegetable based relay inter cropping systems was evaluated at Patna. The highest tuber yield of 24.4 t/ha was recorded in potato+onion (1:1) followed by 22.7 t/ha in potato+onion (1:2) intercropping. All the intercropping systems produced higher potato equivalent yield (PEY) as compared to sole potato crop. The highest PEY (36.3 t/ha) was recorded in potato+onion (1:2) followed by potato+radish+onion (1:1:1) intercropping.

In the relay crop of vegetables, the highest PEY (76.8 t/ha) was recorded in potato+onion (1:2)-bottle guard system followed by potato+onion (1:1)-bottle guard system (64.6 t/ha). Based on net return, the best system was potato+onion (1:1)–bottle gourd closely followed by potato+onion (1:2)–bottle gourd, potato+onion(1:1)–sponge gourd and potato+onion (1:1)–tomato system.

Evaluation of potato based cropping systems for sustainability under Eastern Indo-Gangetic plains of Bihar

Productive, resource use efficient and remunerative potato based crop sequences were evaluated at Patna. The cropping systems started with potato crop. In four cropping systems, average yield of early planted Kufri Surya was in the range of 19.0 t/ha to 20.3 t/ha while of Kufri Ashoka was 25.7 t/ha to 27.6 t/ha. Second crops of sequence *i.e.* wheat, oats, potato and bengal gram are yet to be harvested.

Evaluation of peas and radish as intercrops in potato in Nilgiri hills

Peas and radish were tried as intercrops in potato cv. Kufri Jyoti and Kufri Neelima in different row combinations to find out the most suitable one for Nilgiris. Due to delay in onset of monsoon, germination of pea crop was poor. Radish being a hard crop, withstood high temperature and germinated well after rains. The yield of Kufri Neelima was better (21% higher) both in sole stand as well as intercrops. The intercrop combination of Kufri Neelima with radish in 3:1 row proportion recorded higher PEY of 29.6 t/ha when compared with sole stand of Kufri Neelima.

Evaluation of drip irrigation in spring season potato at Ooty

Three methods of planting, (raised flat bed, paired row and normal planting) were compared with three methods of irrigation (furrow, drip in every line, drip in alternate line) in two potato varieties (Kufri Himalini and Kufri Girdhari) during spring season in Nilgiris. In both the varieties, raised flat bed with every furrow irrigation was most effective which produced 12% higher yield than normal planting with every furrow irrigation (Fig. 1). Drip system was better than furrow irrigation under all methods of planting.

Evaluation of potato based crop sequences and intercropping systems in NEH region

Seven potato based cropping systems were evaluated during 2012 at Shillong, Meghalaya. The potato was the main crop during summer while succeeding crops were taken during autumn as per the treatments. The highest PEY (52.0 t/ha) was recorded in potato-cabbage crop sequence. In another study at Shillong potato+radish (1:1) intercropping system recorded highest land equivalent ratio (1.21) and PEY (30.7 t/ha) which indicates that planting of radish as an intercrop with potato in the ratio of 1:1 is more remunerative for the hilly region of Meghalaya.

Nutrient economy in cropping systems through use of residual fertility of potato in NEH region

In a field experiment at Shillong, potato-cabbage recorded the highest potato equivalent yield (45.8 t/ha). Application of 50% recommended dose of

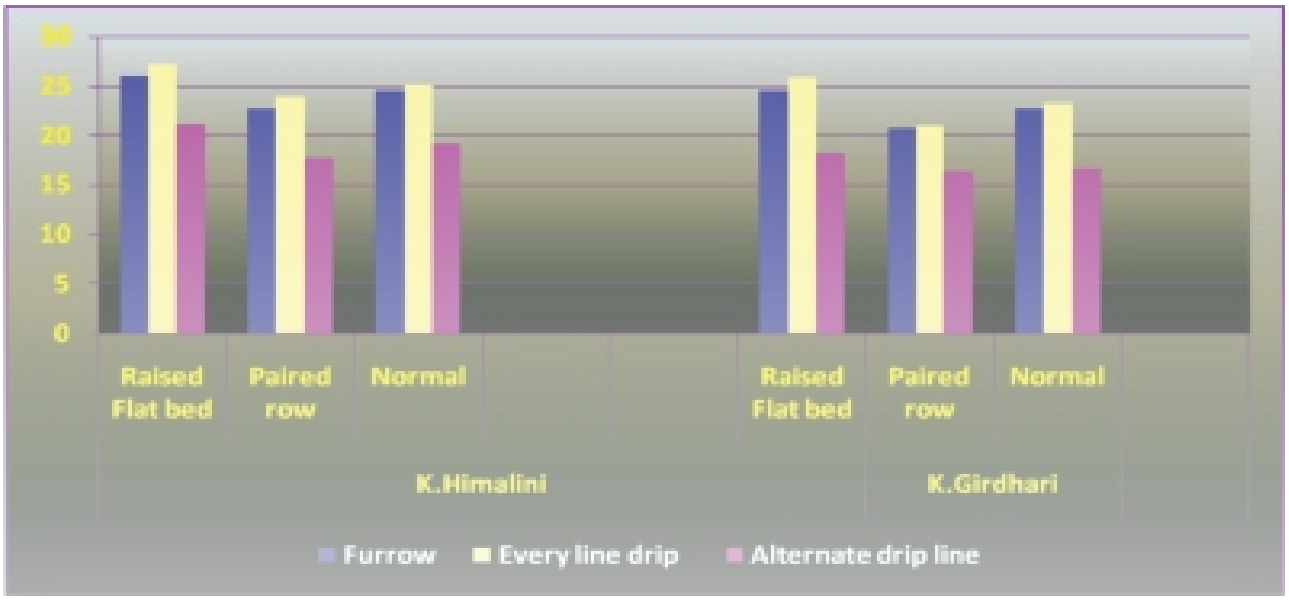


Fig. 1. Evaluation of different methods of irrigation in potato at Ooty

fertilizers (RDF) to potato and 50% N through FYM and 100% RDF to subsequent crop brought about significant improvement in potato equivalent yield (42.5 t/ha).

Yield gap study of potato production– farmers' practice vis-à-vis recommen-ded practices in the north-western hills

At Shimla the yield gap between the farmers' practices and with recommended practices of CPRI was studied. The highest tuber yield (17.9 t/ha) was obtained with improved production technology. The results indicated that potato tuber yield was 64% higher over control when recommended production technologies were followed. Application of NPK alone increased the tuber yield by 43% over control while the farmers' practices gave only 16.8% higher yields over control. Thus the primary reason of low productivity at farmers' field can be attributed to lesser application of NPK fertilizer. It is further indicated that adoption of production technology developed by CPRI for hill farmers can increase the productivity by around 40%, which is the current gap between farmers' and research farm yields.

Resource management strategies for *kharif* potato in plateau areas

The work on *Kharif* potato in plateau areas was carried out by acquiring the land at the farm of Agricultural Research Station, Madenur, Hassan, Karnataka (University of Agricultural Sciences, Bengaluru) during summer, 2012.

Identification of suitable potato hybrid with combined resistance to late blight and viruses for *Kharif* crop

The trial was planted on 5th June, 2012. Due to the prevailed drought situation, the emergence was slow. Kufri Himalini was the top yielder with 18.2 t/ha, whereas, the top yielder among hybrid were SM/92-338 and LB-17 yielding 11.4 t/ha and 11.0 t/ha, respectively.

Identification of suitable processing hybrid for kharif crop in plateau region

Four processing hybrids along with 4 controls were evaluated at Madenur, Hassan. In general the yields were very low in the hybrids and control varieties due to the drought conditions and also all the genotypes were susceptible to late blight. The top yielder was hybrid MP/04-578 (6.3 t/ha) followed by MP/04-816 (5.8 t/ha) and Kufri Chipsona-4 (5.2 t/ha).

Evaluation of suitable variety and standardization of optimal planting date for *kharif* potato

This trial was initiated during *kharif* 2011 and repeated during 2012. In general yields were low as monsoon was delayed by more than a month and the rainfall received was 25% less than normal. Potato variety Kufri Surya followed by Kufri Himalini performed well in Hassan area of Karnataka and under delayed onset conditions, the optimum time of planting was found to be 30th May to 10th June (Fig. 2). However, potato variety Kufri Pukharaj is suitable for early planting *i.e.* in the first fortnight of May.

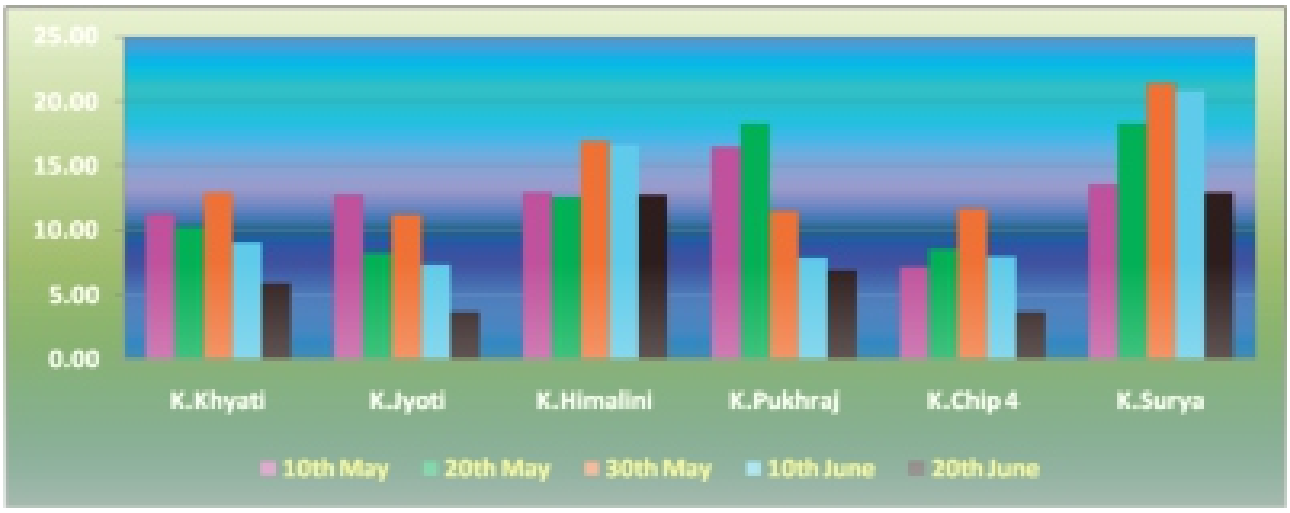


Fig. 2. Performance of potato varieties (yield t/ha) under different planting dates at Hassan, Karnataka

Optimization of nutrient requirement for *kharif* potato

Nutrient requirements of Kufri Surya, Kufri Himalini and Kufri Jyoti were worked out. All the varieties performed better at 20 tonnes of FYM/ha (14% increase in yield over 10 t FYM). Kufri Jyoti required 20 t FYM/ha along with 125% recommended dose of NPK while Kufri Surya and Kufri Himalini performed better at 20 t FYM/ha with 100% recommended dose of NPK.

Intercropping studies in *kharif* potato

An intercropping study was conducted at Madenur, Hassan in 2012. Due to delay in onset of monsoon and lack of enough irrigation facility, in general, the performance of intercrops was poor. Among the three varieties tested, Kufri Surya performed better in intercrop combinations.

Documenting problematic weeds of potato crop in Karnataka

A survey was conducted in 30 different locations of Hassan district and based upon relative frequency and dominance, the three most important weed species of the district were identified as *Nicandra physalodes, Parthenium hysterophorus* and *Cyperus rotundus. Dinebra retroflexa, Abutilon indicum, Acanthospermum hispidium, Ageratum conyzoides, Alternanthera sessilis, Amaranthus viridis, Commelina benghalensis, Desmodium diffusum, Digeria arvensis,* and *Phyllanthus niruri, Cynodon dactylon* were also observed in lesser intensity.

Management of late blight

A trial was conducted at Madenur, Hassan for evaluation of five different chemical fungicides for management of late blight along with untreated control in potato cv. Kufri Jyoti. First appearance of late blight was recorded on 20th July, 2012. The results revealed that all the treatments were effective and recorded significantly low intensity of late blight compared to untreated control. Among the treatments, prophylactic spray (just at the time of canopy closure) with mancozeb @ 0.2% followed by two more sprays at weekly intervals recorded minimum intensity of late blight (12.5%) followed by dimethormoph (13.25%), fenamidon (13.75%), cymoxanil (17.25%) and azoxystrobin (18.25%). Maximum yield (20.86 t/ha) was recorded in prophylactic spray (just at the time of canopy closure) with mancozeb @ 0.2% followed by two more sprays at weekly intervals which was at par with dimethomorph treatment.

Varietal screening for late blight in *Kharif* potato

Six varieties of potato were screened against late blight by planting the trial on 21st June, 2012. Late blight appeared on 20th July, 2012. Kufri Girdhari recorded the minimum incidence of late blight (21.3%) followed by Kufri Shailaja (26.25%), Kufri Himalini (27.5%), Kufri Pukhraj (40%), Kufri Surya (55%) and Kufri Jyoti (55%). However, Kufri Himalini was the top yielder (14.3 t/ha) followed by Kufri Surya (14.2 t/ha).

Exploring the possibilities of seed potato production in *Kharif* areas of Karnataka

A survey was conducted in *Kharif* areas of Karnataka in Hassan (on 26th July, 2012) and Chikmagalur district (on 27th July, 2012) to monitor the aphid build-up to explore the possibilities of seed potato production. Incidence and intensity of major diseases (late blight, virus, wilt *etc.*) and appearance and build-up of other pests (white flies, tuber moth and mites) were also recorded.

Out of the 6 locations surveyed in Chikmagalur district, aphids were noticed only in one location (Ambale), but in Hassan district aphid build up ranged between 5 to 40 per 100 compound leaves in different locations. The other pests recorded were mites (2 to 10%), green leaf hoppers, leaf eating caterpillars (*Spodoptera*, *Helicoverpa*), white grubs, stem borers, potato tuber moth and *Epilachna* beetle.

Late blight incidence was not much severe and it ranged from 10 to 40% due to dry weather. Other diseases like leaf spots/early blight (5 to 25%), bacterial wilt (3% to 30%) and several viral diseases (5 to 60%) were spotted.

Monitoring of major diseases and pests of *kharif* potato

An experiment was conducted to monitor the major diseases and pests of *Kharif* potato at Madenur in 3 varieties (Kufri Jyoti, Kufri Himalini and Kufri Surya). The incidence of late blight was first observed on 20th July, 2012 and the peak incidence was observed at 85 DAP. Intensity of late blight was high in Kufri Jyoti in untreated control plots (71.7%) followed by Kufri Surya (66.7%) and Kufri Himalini (62.5%). Virus incidence was 2 to 10%. Aphids (5 to 33.3 per 100 compound leaves) and white flies (2 to 18.7 per 100 compound leaves) were recorded in standing crop of potato.

Evaluation of herbicides for weed management in potato crop

Controlled release formulations of metribuzin herbicide (CMC- metribuzin 2G and CMC+ Kaolin-metribuzin 2G) were evaluated in a field experiment with potato cv. Kufri Surya at Modipuram. Results revealed that CMC- metribuzin 2G and CMC+ Kaolin- metribuzin 2G had comparable tuber yields of 24.9 and 25.2 t/ha, respectively over metribuzin (24.1 t/ha) and weed free plots (24.5 t/ha). In another experiment, post emergence application of herbicide bentazone (1.5 kg/ha) reduced total weed dry weight by 89.8 % over weedy check. While at Gwalior, bentazone (1.0 kg/ha) reduced weed dry weight by 79.6 % over weedy check, and recorded comparable tuber yield (11.1 t/ha) as obtained in weed free plots (12.4 t/ha).

At Modipuram, sulfosulfuron @ 50 g/ha was more effective in controlling weeds and also produced highest tuber yield among different doses tried.

At Shillong (NEH region), although the highest potato tuber yield (27.4 t/ha) was recorded in weed free check, but economically metribuzin @ 1.0 kg/ha as pre-emergence was more effective.

Develop database and web enabling of Decision Support Systems/tools

The decision support systems, Potato Pest Manager (PPM) and Computer Aided Advisory System for Potato Crop Scheduling (CAASPS) were web enabled and are hosted on application server. The IP of application server is 14.139.61.86/ ppm_test/ default.aspx and 14.139.61.86/caasps/ login.aspx, respectively which is also linked to CPRI web site (http://cpri.ernet.in). The DSS is designed such that only the authorized user can get access to the above DSS. The user id and password can be requested from CPRI, Shimla. The photographs of problematic weeds of potato in plains and hills were obtained for use in a decision support system on potato weed management.

Climate change impact and adaptation strategies for potato crop

Climate change no longer remains the future challenge. It is now perceived as an immediate threat which needs to be challenged for once and for all. Although 2007 IPCC (Intergovernmental Panel for Climate Change) report had predicted that a 1.5ºC increase in temperature would increase yields, average global yields of major food crops are now more than one percent lower than what they would have been without warming. Keeping up with the pace of change would not be easy unless we keep ourselves prepared for the change, for the challenges. In order to meet these challenges, the present programme was initiated to assess climate change impact on potato in different states/potato growing pockets with respect to production and biotic and abiotic stresses and to develop suitable management strategies to combat climate change threat on potato production.

Calibration of WOFOST model

WOFOST (World Food Studies) estimates the growth of an annual crop under a particular set of specific soil and weather conditions. The simulation of crop growth in this model is based on eco-physiological processes. This model is being used for potential production of potato crop under Indian conditions for impact studies of climate change and also for development of suitable adaptation strategies. The model was already calibrated and validated for potato cultivars Kufri Badshah, Kufri Jyoti and Kufri Bahar during last year and this year it was calibrated for potential situations for short duration potato cultivar Kufri Pukhraj. 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), TSUM2 (Thermal time from anthesis to tuber initiation). A close match was observed between simulated and measured values for total dry matter production and tuber dry matter yield (Fig. 3 & 4).

Climate change impact on potato productivity in Punjab

Impact assessment of climate change was carried out for potato productivity in Punjab state for three potato cultivars belonging to late (Kufri Badshah), medium (Kufri Jyoti) and early (Kufri Pukhraj) maturity groups, using A1FI scenario of temperature (SRES A1FI pathway) and atmospheric CO_2 (based

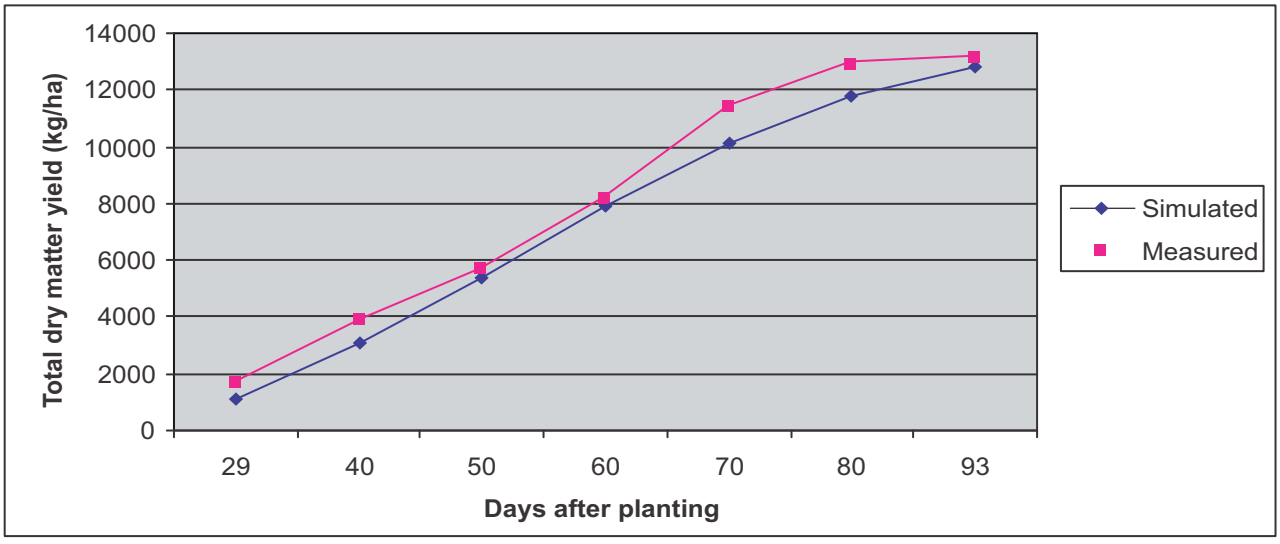


Fig. 3. Validation results of WOFOST crop growth model on total dry matter yield of Kufri Pukhraj

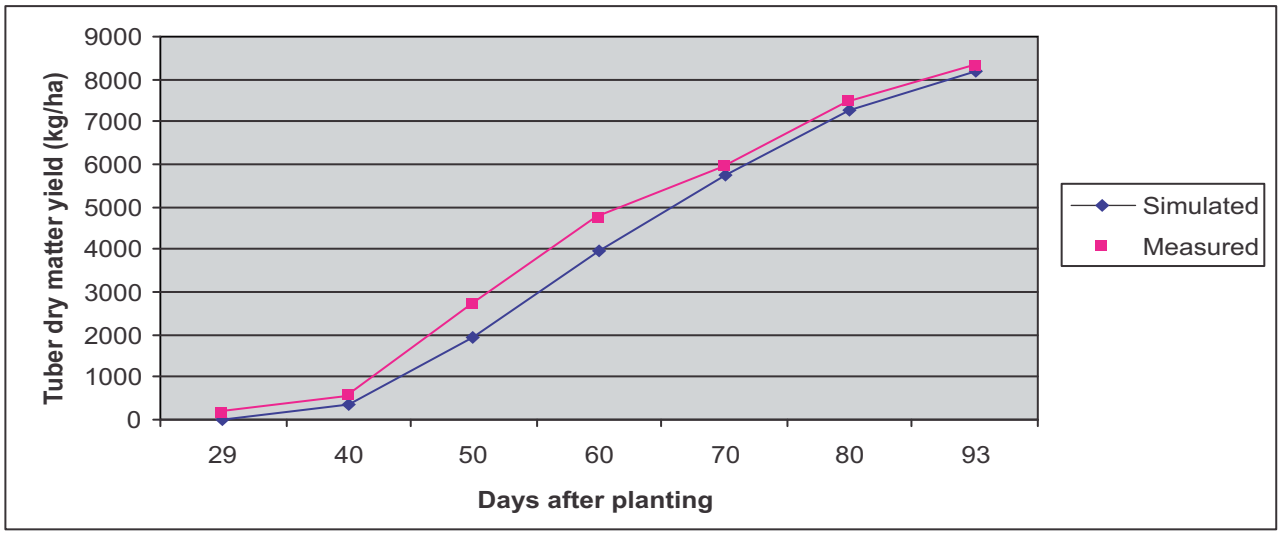


Fig. 4.Validation results of WOFOST crop growth model on tuber dry matter yield of Kufri Pukhraj

on the Bern-CC model for A1FI scenario) for the years 2020 and 2055 (Fig. 5). The simulation study was done using WOFOST crop growth model, which was run for potential production of potato cultivars at 13 different stations located across Punjab. The results from simulation study were interpolated using kriging technique in a GIS software to generate maps of potential productivity and the changes thereon. It was estimated that rise in temperature alone will result in change in productivity of Kufri Badshah from +11.6 (Amritsar) to -10% (Fatehgarh) in 2020, while the change in productivity of Kufri Jyoti will be in the range of +11.6 (Amritsar) to -11.6% (Fatehgarh) and of Kufri Pukhraj from +12 (Amritsar) to -11.5% (Mansa).

In 2020, CO_2 fertilisation alone is expected to increase tuber productivity from +3.9 to +4.5%, depending upon cultivar and location. However, in 2055, a mean decrease of 17.9% (Kufri Badshah), 21.1% (Kufri Jyoti) and 22% (Kufri Pukhraj) is likely in the productivity of potato cultivars due to rise in temperature, when effect of CO_2 fertilisation is not considered, while the expected rise in CO_2 is likely to bring about 17.3 (Kufri Badshah) to 18.5% (Kufri Jyoti) increase in potato productivity when the change in temperature is not considered. It is further estimated that under the combined influence of change in temperature and CO_2, the productivity of potato cultivars will not be affected in 2020 over the baseline scenario (Kufri Badshah -0.08%; Kufri Jyoti +0.4% and Kufri Pukhraj +0.7%) but will decline in 2055 (Kufri Badshah -2.62%; Kufri Jyoti -4.6% and Kufri Pukhraj -5.3%), when the total geographical area of Punjab is considered. It is further shown that if the present distribution of potato acreage within Punjab remains unaltered in future, there will be benefits from climate change as the potential productivity of Kufri Badshah, Kufri Jyoti and Kufri Pukhraj will increase by 3.3, 3.1 and 3.6% in 2020, although the potential productivity will again decline to baseline values in 2055 (Kufri Badshah +0.1%; Kufri Jyoti -1.5% and Kufri Pukhraj -1.9%).

Genetic coefficients of potato varieties

Field experiments were conducted at Modipuram, Gwalior and Patna to work out the genetic coefficients of Indian potato cultivars (Kufri Sadabahar and Kufri Khyati at Modipuram, Kufri Surya at Gwalior and Kufri Arun and Kufri Kanchan at Patna). The crops were planted at different dates and data on phenological growth were recorded at 10 days interval started from emergence 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.

Effect of different temperature on growth of *P. infestans* and late blight development under lab conditions

At Shimla, effect of different temperature regimes was studied on growth of eleven isolates of *Phytophthora infestans* and development of late blight on detached leaves. The temperature within the range of 15-22ºC greatly influenced the *in vitro* mycelial growth of each isolate but the optimum growth was observed at 18°C. At 25ºC, the growth of some of the isolates was fairly well. Similar trend was observed at 28ºC but the rate of growth was slow.

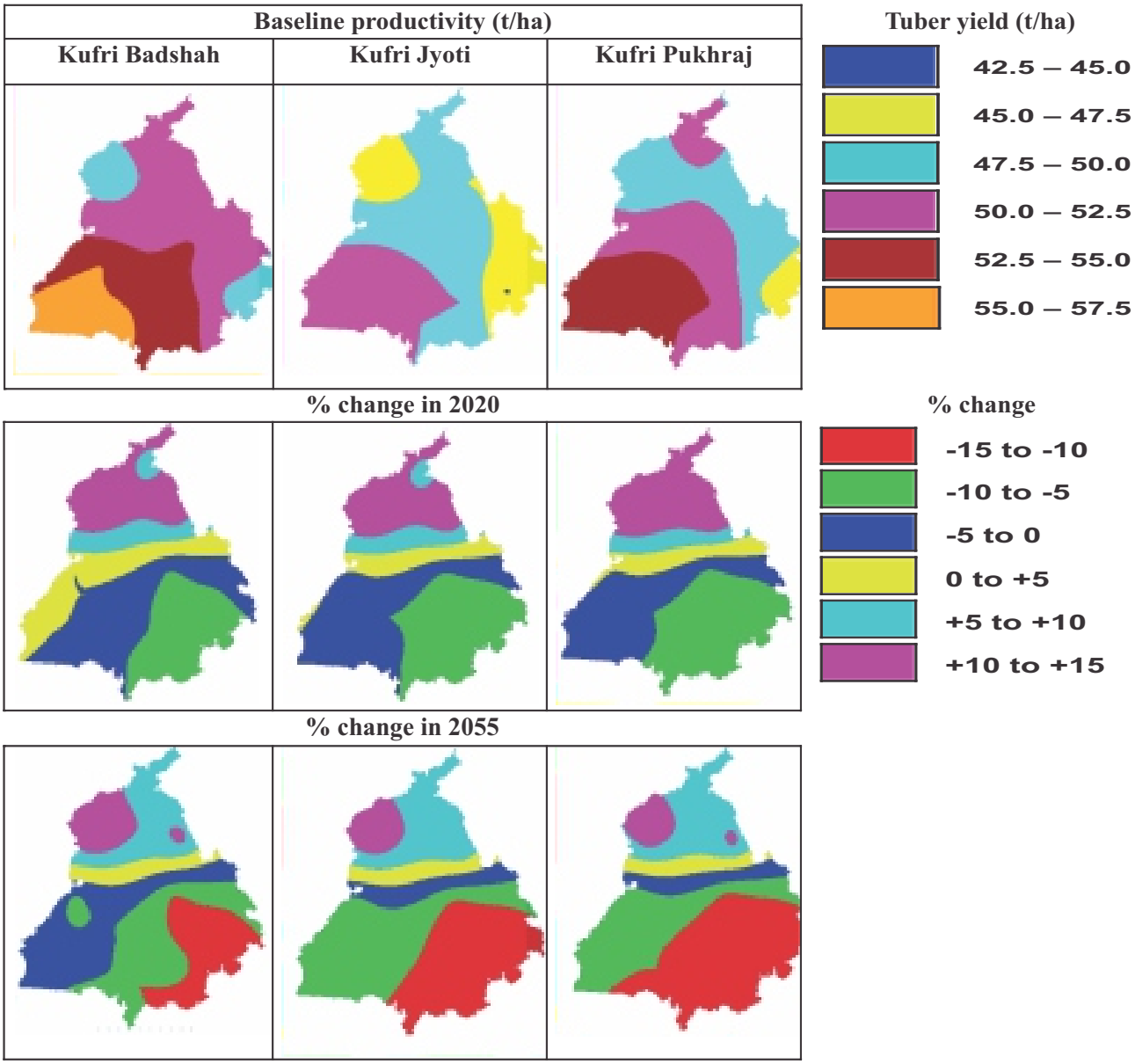


Fig. 5. Potential productivity of different potato cultivars under baseline and changes in future climatic scenario

Further increase in temperature (30 and 32°C) restricted the growth of mycelium and no growth was observed at 30 and 32°C. In general the sporangial germination decreased with increase in temperature but few isolates showed good germination at 22ºC too. At 28ºC, germination percentage ranged from 7-23% and at higher temperature (30 & 32ºC) sporangia could not germinate. Irrespective of the isolates and cultivars, minimum incubation period (72 hrs) was recorded at 18 and 20ºC. The incubation period ranged from 72-96 hrs at 22-28 ºC. At higher temperature (30 & 32ºC), the range of incubation period was wide (72-120 hrs). Maximum lesion area was observed at 18 and 20ºC and thereafter it showed declining trend with increase in temperature. At high temperature (30 and 32ºC), the isolates could produce lesions though the lesion size was very less. The range of latent period was from 96-144 hrs but minimum latent period was observed at 20ºC. At high temperature (30 and 32ºC), only a few isolates could sporulate after a latency period of 144 hrs.

In the similar experiment conducted at Modipuram, it was observed that up to 15ºC temperature, incubation period was high and lesion area was less while from 18 to 25ºC incubation period was less and lesion area was more and thereafter with subsequent increase in temperature, incubation period increased with decreased lesion area (Fig. 6).

Yield loss due to late blight

In an experiment conducted at Modipuram to assess yield loss due to late blight, it was observed that due to heavy rains (>50 mm) received during the third week of February 2013, late blight severity ranged from 5-40%. Heavy rains along with late blight caused up to 75% of yield loss.

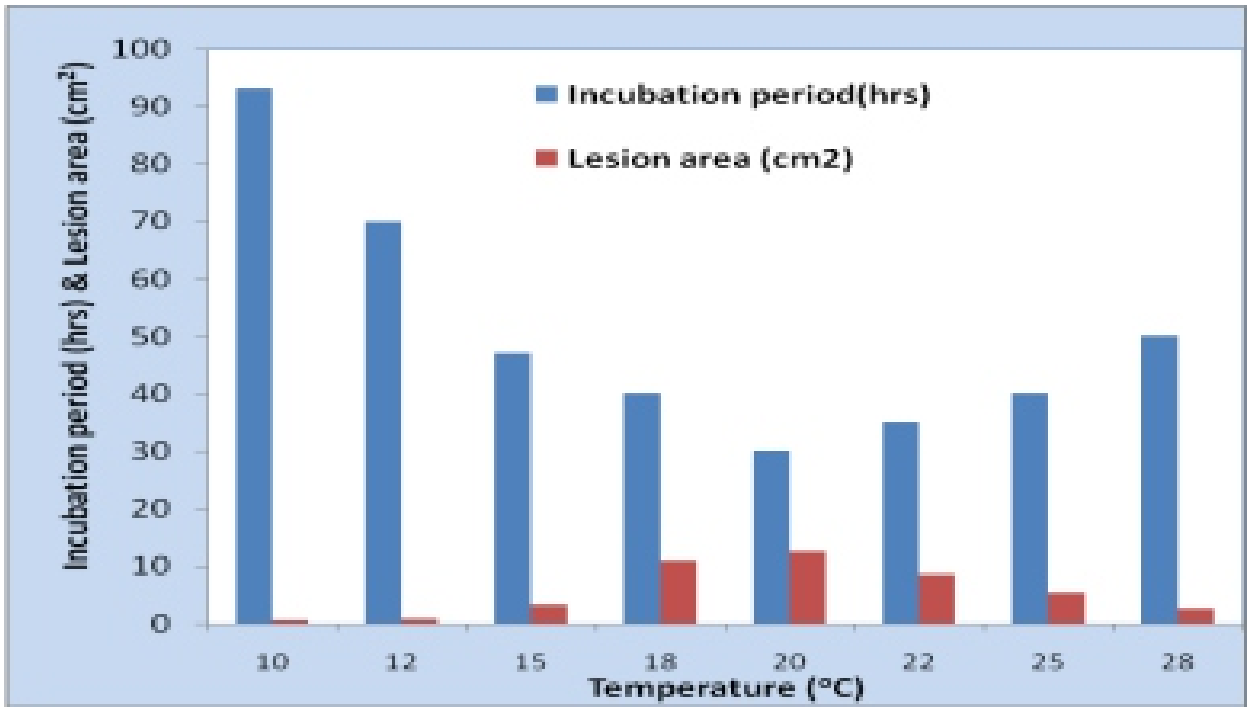


Fig. 6. Effect of temperature on the incubation period and lesion area development

In-vitro studies on survival of *Ralstonia solanacearum* under different temperature regimes

At Shimla, survival of four different *R. solanacearum* strains was studied *in-vitro* at varied temperature regimes for six months. All strains (r1bv3, r1bv4, r1bv2T, r3bv2) survived better at 20-28ºC. The strains, r3bv2 (potato race) and r1bv2T (tropical race) were able to survive at 32ºC even after five months of incubation while r1bv4 and r1bv3 could survive only up to 3 and 2 months, respectively at this temperature. However, none of the strains survived beyond one month of incubation at 37ºC or higher temperature.

Weather effect on potato pests

At Gwalior, the highest thrips population was observed in September planted crop with (7%) incidence of stem necrosis disease. Similarly high incidence of white fly population was also recorded in early planted crop (September planted crop). A direct relationship was found between planting date and activity of viruliferus thrips with % incidence of stem necrosis disease. The high temperature (30-35^{0}C) and dry weather during early October was found favorable for the development of stem necrosis disease. Similarly, white fly activity also triggered on early crop due to high temperature (30-35^{0}C) and humidity (65-70%). More than 50 mm rains were recorded during first fortnight of September 2012, resulting in low incidence of stem necrosis and sucking insects on crop as compared to 2011, when no rains were received during September. The highest total tuber yield (23.2 t/ha) and marketable tuber yield (20.5 t/ha) was recorded in potato crop planted on 15th of October with no incidence of stem necrosis and low incidence of thrips, leafhopper and white fly population. The incidence of stem necrosis, total tuber yield and marketable tuber yield showed significant difference among the different dates of planting.

At Modipuram, the maximum, minimum temperatures, evening and morning RH and soil temperatures were lower and rainfall was higher in September 2012 compared to 2011, which resulted in more burning due to mite (16-63%). However, these weather conditions led to lesser burning due to leafhopper (9-16%) in 2012 compared to 2011, thus yield losses were lesser.

Nutrients and water management in potato

The challenge for agriculture over the coming decades will be to meet the world's increasing demand for food in a sustainable way. Declining soil productivity, less availability of irrigation water and inefficient management of plant nutrients and water have made this task more difficult. The aim of this programme is efficient and economic use of two major inputs of potato production *viz*, nutrients and water for sustainable crop production and also to identify nutrients and water efficient potato varieties/hybrids to economize on these inputs.

Development of site-specific nutrient management techniques

Site specific nutrient management (SSNM) tested at Modipuram, Meerut with omission plot technique and over fertilized reference (OFR) in potato cultivar Kufri Khyati indicated that the highest tuber yield was reduced by 25 t/ha in N omission plot as compared to OFR plot. After N omission plot, the greatest effect was recorded in K omission plot (6.45 t/ha) followed by Zn (4.41 t/ha) and P (2.39 t/ha).

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

At Patna, as the growth advanced the chlorophyll index (SPAD Index) decreased however, soon after top dressing the index improved. There was differential response of recovery of index in different cultivars after top dressing. All cultivars showed lowest value for SPAD index at zero application of N throughout the growth period, however, there was some improvement as irrigation was applied at around 30 days after planting (DAP). The cultivar Kufri Jyoti showed wide variation in the index for different N levels whereas in Kufri Gaurav and Kufri Khyati, the differences in the SPAD value was not wider at 160 and 240 kg N/ha making it clear that increasing N level significantly increased the SPAD index in Kufri Jyoti even up to the highest level of N, whereas same was not the case in Kufri Gaurav and Kufri Khyati. The results showed that SPAD index is a good index and can be used to work out supplementary N requirement of potato crop.

Optimising nitrogen requirement of potato using relative CCI (Chlorophyll content index)

The experiment was initiated at Shimla to find out the nitrogen requirement of potato using RCI (relative Chlorophyll Index=CCI in a plot/CCI in control X 100) for optimum yield. RCI was worked out by measuring CCI with hand-held chlorophyll content meter, at an interval of 3- 4 days, starting from emergence and the nitrogen was applied when the RCI reached at or below threshold level. The results from the first year of study indicated that N in potato should be applied @ 25 kg/ha when RCI reaches to 90%.

Quantification of contribution of PSB in reducing the requirement of P fertilizer in potato production in mid hill of Himachal Pradesh

In a field experiment at Shimla, tuber yield of potato with 100% P (20.6 t/ha) was statistically at par with that of 75% P + PSB (20.3 t/ha). The results indicated that combined application of P along with tuber inoculation with PSB was effective in reducing the inorganic P dose by approximately 18% and increasing phosphorus use efficiency.

Best nutrient management practice at farmer's field

Best nutrient management practices (BMP) consisting of nutrient application based on soil test, suitable sources of NPK fertilizer (CAN, SSP and MOP for N, P and K, respectively), applied correctly (half nitrogen and full PK at the time of planting and remaining half N at the of earthing up), at proper time and mulching were compared with other treatments at shimla. BMP treatment gave 44.8% higher yield followed by 100% RDF of fertilizers (37.9%) and farmer's practices (15.5%) as compared to absolute control *i.e.* where no fertilizer and no FYM were applied (Fig. 7).

Effect of integrated nutrient management in potato in NEH region

Use of organic manures, inorganic fertilizers and bio-fertilizers showed significant impact on yield of tubers in a field experiment at Shillong. Highest tuber yield (19.05 t/ha) was recorded by application of 75% recommended dose of fertilizers (RDF) and 25% N through FYM+ inoculation with bio-fertilizers (*Azotobacter* + PSB).

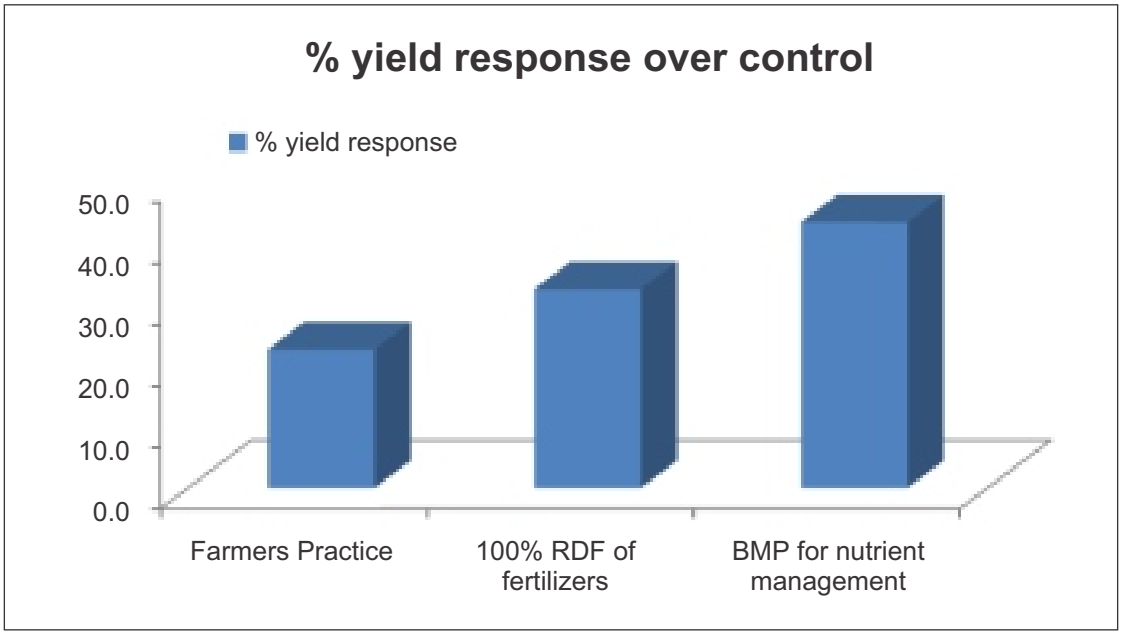


Fig. 7. Effect of best nutrient management practice (BMP) on tuber yield response at farmer's field

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

Breeding programme

Hybridization: A total of 32,421 seeds of 42 crosses were obtained at Kufri. A total of 19,124 seeds of 13 crosses were obtained from hybridization work at Jalandhar.

Raising of seedlings: A total of 20,254 F_1 seedlings obtained from germination of 57,326 seeds, were transplanted in field with no additional nutrient supplied and 3,618 selections were made on the basis of tuber characters such as colour, shape and eye depth.

Evaluation in clonal generations: 3,543 F_1C_1 clones were planted. Based on tuber characters, such as shape, skin colour and eye depths, 356 clones were selected. Out of 837 F_1C_2 clones planted, 152 were selected. The yield range of the selected clones was 520 to 1200 g/plant as compared to 500 g/plant of control Kufri Gaurav. Out of 331 F_1C_3 clones planted, 19 were selected. The yield range of the selected clones was 587 to 720 g/plant as compared to 567 g/plant of control Kufri Gaurav.

Screening of hybrids/cultivars for water and nitrogen use efficiency

Patna: Different cultivars differed in their efficiency to utilize applied N as evidenced by agronomic efficiency, highest being for Kufri Gaurav. At lowest N level (80 kg/ha) also Kufri Gaurav was the highest in agronomic efficiency followed by Kufri Pukhraj, Kufri Khyati and Kufri Arun.

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 cultivars Kufri Giriraj, Kufri Megha and Kufri Jyoti.

Modipuram: 35 hybrids/genotypes selected last year were planted along with one popular variety Kufri Pukhraj at three soil moisture regimes *i.e.* wet, moist & semi-dry moisture regimes (0.20-0.25, 0.40-0.45 and 0.60-0.65 bars) at 15 cm soil depth. The 19 hybrids/genotypes produced equal/or higher yield than popular variety Kufri Pukhraj at all soil moisture levels and have been selected for conducting IInd year replicated trial during next crop season.

Jalandhar: Out of 6 germplasm tested in third year replicated field trial, 4 having N efficiency (in terms of yield at different N doses) equal or close to that of Kufri Gaurav, were selected for further

testing under confirmatory trial. Out of 12 germplasm, 5 germplasm having highest tuber yield close to those obtained by Kufri Gaurav and Kufri Pukhraj, have been selected for further testing under replicated trial.

Germplasm J-93-58 has an edge over Kufri Gaurav in N efficiency

One hundred germplasm were tested under nitrogen deficient and sufficient conditions in a single row, 2.4 m long without replication during 2009-10 at Jalandhar. The tuber yields of different germplasm varied between 7.8 and 39.8 t/ha under N stress (No nitrogen) with a mean of 19.3 t/ha. The 46 germplasm having yield under N stress more than 19.3 t/ha (mean yield of all germplasm) were selected and further tested during 2010-11 in a plot wise trial. The tuber yield of 46 germplasm varied between 6.0 to 26.2 t/ha under N stress with a mean of 12.3 t/ha whereas tuber yields varied between 17.5 to 45.0 t/ha under 240 kg N/ha with a mean of 33.5 t/ha. The 27 germplasm, having tuber yield higher than either mean tuber yield without or with nitrogen application, were selected and further tested during 2011-12 in a replicated trial using randomised block design with 4 replicates, 4 N rates of 0, 80, 160 and 240 kg N/ha and five control potato cultivars. The germplasm, J-93-58 appear to be more N efficient than previously identified most N efficient cultivar Kufri Gaurav based on nitrogen requirement for getting equivalent yield. It produced yield of 36.3 t/ha at 160 kg N/ha whereas Kufri Gaurav needed 240 kg N/ha to produce tuber yield of 35.16 t/ha. Field experiment conducted during 2012-13 confirmed that germplasm J-93-58 has an edge over Kufri Gaurav.

Root parameters as related with N efficiency of potato cultivars

At Patna, different root parameters *viz.*, fresh root weight, root length, surface area and volume in general increased with increasing N level, though the significant increase was in root weight and root length only. Among different cultivars Kufri Arun produced highest secondary root fresh weight and secondary root length while Kufri Gaurav produced the highest total root fresh weight, secondary root/shoot ratio and secondary root volume at 30 days after planting under field conditions. In a sand culture at Patna, efficient cultivars like Kufri Gaurav, Kufri Pukhraj and Kufri Khyati, had higher root surface area and fresh root weight of secondary roots as compared to old cultivars like Kufri Jyoti (Fig. 8).

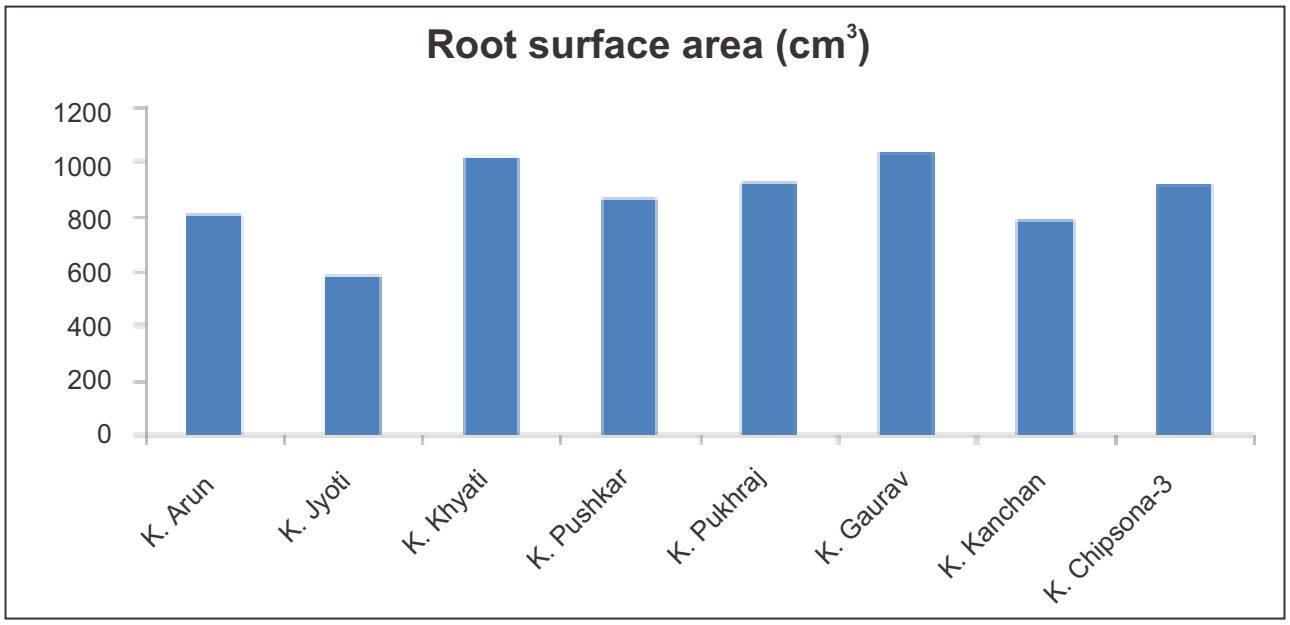


Fig. 8. Root surface area of 25 days old plants of different cultivars grown in sand culture

Improving water use efficiency through micro-irrigation

Phasic water need of potato crop

The irrigation at 1.00 time of cumulative pan evaporation (CPE) up to stolen formation, 1.50 times CPE from stolen formation to early tuber bulking stage and 1.25 times CPE applied up to maturity produced significantly higher total yield (36.0 t/ha) under drip irrigation at Modipuram. Similarly, the irrigation at 1.25 time of CPE up to stolen formation, 1.50 times CPE from stolen formation to early tuber bulking stage and 1.25 times CPE applied up to maturity gave maximum yield (36.7 t/ha) under sprinkler irrigation than other treatments. While in case of furrow method of irrigation, the potato yield was significantly higher (33.8 t/ha) when irrigations applied at 20 mm CPE water level as compared to 25 and 30 mm CPE.

Data confirmed last year results that the yields of all potato cultivars were significantly higher, when crop raised under mini-sprinklers (170-350 lph discharge) placed at 7x7 m distance in comparison to mini-sprinklers, placed at 8x8 m distance. While, the Metal Impact/Impact Plastic sprinklers with water discharge 360-720 lph, placed at 10x10 m distance produced significantly higher yield than 12x12 m distance. However, it was statistically at par with the produce of THMV mini-sprinklers (170-350 lph discharge), placed at 7x7 m distance. The similar trend was also observed in case of water use efficiency. Results confirmed last year observation that the drippers with 2 lph water discharges placed at 20 or 30 cm distance produced significantly higher yield in comparison to other treatments.

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 (31.2 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 at Modipuram. Similarly, under sprinkler irrigation method, the nitrogen applied in two splits 50% at planting+50% at earthing-up/or stolen formation stage gave higher yield (31.3 t/ha) followed by three splits (1/3 at planting+1/3 at earthing-up/or stolen formation +1/3 at 15 days after earthing-up/ or tuber initiation stage) as compared to other treatments tried. The similar trend was also noticed in case of water and nutrient use efficiency under drip and sprinkler irrigation methods.

Role of potassium in modifying drought effect in potato

Field trial was conducted at Shimla to find the role of potassium in modifying drought effect in potato. The highest level of K along with 80% of available water was found to give highest dry matter content and tuber yield at harvest.

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

At Shimla, soil moisture contents remained 12 -15% higher in poly-mulch and pine needle mulch in comparison to no mulch condition during drought periods. Soil temperature varied differently under different poly-mulch. Black polythene mulch 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 bare soil condition. On the other hand silver poly-mulch and pine needle 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 and 1.2-2.2°C at 5 cm depth and 0.9 -1.1°C at 10 cm depth, respectively relative to no mulch condition. 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 75.2%, 42.9 % and 3.0% under silver poly mulch, pine needle mulch and black poly-mulch, respectively in comparison to no mulch condition. Surface configuration did not show much variation in tuber yield.

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

Introduction of high yielding varieties, irrigation and high analysis fertilizers accelerated the mining of nutrients from the soil. Since large amount of nutrients has to be applied to soil in chemical form to obtain higher yields, these may have adverse impact on soil productivity in long run. The aim of conducting this long term manurial and fertilizer experiment at fixed site at Modipuram, Meerut with important cropping systems of the area is to monitor the changes in soil properties, productivity, pest dynamics and quality of produce for sustainable crop production on long run.

Long term manurial and fertilizer experiment in potato based cropping systems

To study the long term effect of application of organic manure, crop residue and inorganic fertilizers, three promising potato based cropping systems *viz.* potato–wheat–paddy, potato–onion–maize and potato–green gram–sesamum being evaluated since 2006-07 on the same site at Modipuram, Meerut. The results revealed that among the seven treatments applied, all the crops yielded maximum, when 100% recommended N, P and K were applied through inorganic fertilizers. However, yield of paddy, sesamum and green gram was at par, when the nutrients were applied through organic or inorganic sources.

The highest yield of wheat (4.4 t/ha) and groundnut (2.3 t/ha) during 2012 was recorded in treatment where 100% NPK was applied through fertilizer along with crop residues of previous crop. However, in contrast onion (26.9 t/ha), paddy (5.56 t/ha) and maize (5.9 t/ha) yielded highest, when in addition to 100% NPK through fertilizer, secondary and micronutrients were also applied. In green gram, highest yield (0.28 t/ha) was recorded, when nutrients were applied through organic source.

The highest potato equivalent yield (PEY) of 91.3 t/ha was recorded in maize-potato-onion followed by paddy-potato-wheat (67.6 t/ha) and sesamum-potato–green gram (60.8 t/ha) cropping system during 2011-12 (Fig. 9). Similar trend in PEY was also observed for the mean yield of five years (2007-08 to 2011-12).

The incorporation of residue of preceding crop improved the tuber yield in all the three cropping systems, though it was not significant. The marketable tubers number and weight were more in inorganically raised crop of potato. Depending upon the source of nutrients supply, the grain/straw ratio in paddy, wheat and maize varied from 0.84-1.07, 0.71–0.89 and 0.33–0.58, respectively. In general, the organic source of nutrients produced more straw and in absolute control, the ratio was 0.73, 0.89 and 0.58 in wheat, paddy and maize, respectively. Among the cropping systems, paddy-potato-wheat and maize-potato-onion showed higher carbon stocks in soil than groundnut-potato-green gram cropping system.

Like previous year, to improve PEY of oilseed based cropping system (potato-green gram-sesamum), more trials were conducted to know the scope of raising groundnut at Modipuram. The pod yields varied in different entries and INS-1-2010-12 and INS-1-2010-13 produced 6.34 and 6.30 t/ha, respectively.

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

For nutrient dynamics studies, after six complete cycles, treatment wise soil was analyzed before and after potato harvest. In potato-wheat-paddy cropping system, except control, there was increase in soil conductivity in all treatments after potato. The organically treated plots had more conductivity than conventionally fertilized plots. The treatment-wise effect of different nutrients supply options on soil properties, before nutrient application and after potato harvest reveals that among the seven treatments, the soil organic carbon was more, both before and after potato harvest and thus indicating its build up in soil, due to nutrient supply through organic manure to all crops of the rotation, since 2006. The average organic carbon in organic, inorganic and integrated nutrients supply treatments was 0.83, 0.46 and 0.70%, respectively.

The soil pH decreased significantly in control after harvest, while no definite trend was recorded in treatments involving different sources of nutrient

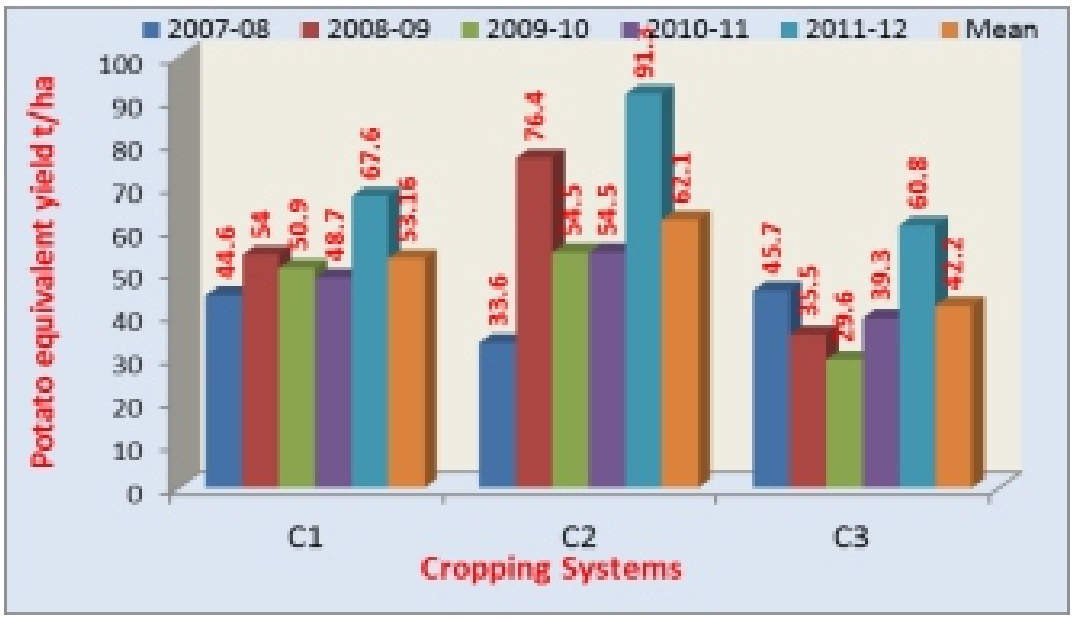


Fig.9. Year-wise PEY of promising potato based cropping systems
(C_1 = Potato–Wheat–Paddy, C_2 = Potato–Onion–Maize, C_3 = Potato–Green gram–Sesamum)

supply. The percent soil organic carbon and available N, irrespective of treatments, 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 absolute control where no fertilizer was applied since 2006 and potato-wheat-paddy cropping system was followed each year, the respective increase in available P and K was 18.2 and 29.2%. 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%. Soil manganese decreased in control and recorded 4.2–17.5% increase in all other treatments.

The micronutrient analysis of crops revealed that irrespective of treatment, zinc content in potato, wheat, paddy, maize and green gram was negligible, while in sesamum and groundnut, the content varied from 17–53 and 13–39 ppm, respectively. In case of copper, its content in potato, wheat, paddy, maize, green gram, sesamum and groundnut varied from 2.0–6.17, 2.0-3.5, 1.7-2.8, 1.8-3.5, 3.2-4.0, 11.0-14.0 and 6.0-12.5 ppm, respectively. Similarly the iron and manganese contents also varied in different crops.

The carbon 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 (vermicompost/crop residue) resulted in higher stock of C as well as C sequestration rate in all the cropping systems. In contrast, application of secondary and micronutrients alongwith 100% N, P and K produced similar or lesser C stocks than 100% N, P and K. The integrated application of organic amendments along with fertilizers worked out to be the best management option for enhancing C sequestration in soil for sustainable crop productivity.

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

The nutrient budgeting revealed that irrespective of nutrient supply options, available soil nitrogen and phosphorous improved, while available potassium decreased after wheat harvest.

Organic farming in potato production

With the aim to develop agro-techniques for organic potato production, field experiments were conducted at Modipuram, Meerut to study the effect of organic

and inorganic sources of nutrients on soil fertility and on the quality of crop produce. Application of variable ratio of fertilizers and vermicompost to supply nutrient equivalent of 180, 80 and 100 kg (approximately) of N, P_2O_5 and K_2O/ha on two potato cultivars, Kufri Anand and Kufri Gaurav, showed that vermicompost (100%) gave 24.9% higher yield in Kufri Gaurav and Kufri Anand. This was primarily due to 55.4% more yield of large sized tubers in Kufri Gaurav than Kufri Anand. On the contrary, the medium and small sized tuber yield was 7.1 and 28.3 percent, respectively more in Kufri Anand. Tuber yield was maximised in both the cultivars with the application of vermicompost (25%) + NPK fertilizers (75%). Thus the new cultivar Kufri Gaurav performed better than previously years best Kufri Anand.

Unlike previous years, the tuber yields from 100% vermicompost were at par with 100% fertilizers, after being raised on same plots for eight consecutive years. Kufri Gaurav gave higher tuber production than Kufri Chipsona-1. The organic, inorganic and integrated nutrient supply options were at par in tuber production in Kufri Chipsona-1. In Kufri Gaurav, the highest tuber yield was obtained through fertilizers application and was significantly more than 100% NPK through organic manure. Application of bio-fertilizer B5 with fertilizers increased the tuber yield in Kufri Gaurav, Kufri Pukhraj and Kufri Chipsona-3. In contrast, use of B5 with organic manure improved the tuber yield only in Kufri Chipsona-1, though the difference was non-significant.

The use of bio-fertilizers B-5, both with organic manure (vermicompost) and conventional fertilizers, on tuber yield revealed that tuber yield increased significantly only in Kufri Khyati, when raised organically. The tuber yields obtained with organic manure were 37.5, 34.1 and 38 t/ha in Kufri Chipsona–3, Kufri Sadabhar and Kufri Khyati, respectively. The corresponding yields with conventionaly fertilizers were 36.8, 38.1 and 47.9 t/ha, respectively. In general, the three nutrients supply options *viz.* organic, inorganic and integrated (in different ratio of organic and inorganic sources), did not vary in their response to virus infection in potato cv. Kufri Gaurav.

In field studies conducted at Shimla, the results revealed that organic potato can be produced successfully with combined use of organic manure supplemented with bio-cultures (viz. *Azotobactor* and Phosphobacteria). The nutrients application through organic manure also improved soil health and productivity.

Farm machines for potato cultivation

Farm mechanization plays an important role in timely completion of various cultural operations in potato production. Keeping this in view, the objectives of this research programme are to develop potato grader, a tractor operated potato combine harvester, aeroponic a high tech system for seed potato production and the potato handling and treatment devices/aids.

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

Design and development of tractor operated potato combine harvester

On the basis of performance and observations made during evaluation in the actual field conditions, the prototype combine harvester (Prototype-I) developed during the last year was improved to achieve better performance through reduction of soil and trash and minimize tuber bruising in the final collection. The following modifications and provisions were made.

1. Elimination of agitation or vibrations at the rear end of the primary chain by replacing the second agitator system with plain rollers with an aim to support the chain only without any vibrations.
2. Reducing the rear end height of rod chain conveyor hence the inclination of the chain to check back flow of tubers.
3. Design and fabrication of new primary chain conveyor with PVC cover on rods.
4. Providing an anti-clodding system to check clod formation during harvesting.
5. Development and providing of clod crushing roller.
6. Development and providing of trash separator in the prototype harvester.

The experimental prototype was improved to facilitate smooth forward flow and check back flow of tubers with the aim to reduce/eliminate the tuber bruising over the primary elevator chain. The second rear vibratory shaft was removed and was replaced with a shaft supporting four plain wooden rollers having 60 mm dia, and spaced 250 mm apart provided only to support the chain without imparting any vibration to the rear side of the chain. The position of shaft was kept adjustable to change the inclination of the upper side of the primary rod-chain during operation to avoid back flow of tubers and ensure its quick forward motion without hindrance, and thereby reduce bruising. The rear height and thereby the slope of the chain was also reduced to achieve this purpose. New drive sprockets were designed and fabricated. The sprockets consisted of 14 teeth, with teeth width and dia of sprockets as 30 mm and 180 mm, respectively and were used to replace the conventional split type 250 mm dia and 25 mm wide 18 teeth sprockets. The rear height of chain was thus lowered by 70 mm over the previous design. A new 135 rod chain conveyor with PVC cover on rods was also designed and fabricated and provided to the prototype replacing the conventional chain, to provide protection and desired cushioning effect to reduce or eliminate the tuber bruising during operation.

To check clod formation during harvesting, two dicone diabolo rollers were provided at the front side of the experimental prototype one each above the lifter share or digger blade. The position of rollers can be adjusted with respect to blade to vary the pressure on the ridge. More the roller pressure, better the fragmentation of the ridge soil. The reduced size of the clods help them to sieve down from the gap in rod chain. This may lead to better separation of soil from the potato tubers and helps to get the clean tubers in the final collection. To break soft clods at the primary chain conveyor itself and help to sieve it down, a system consisting of a rubber roller on a shaft was developed, fabricated and provided above the rear side of the rod chain conveyor. The rubber roller of dia 300 mm and 1160 mm length was used to crush the soft clods passing below it. The provision was made to provide rotations to the roller in the anti-clock wise direction from the main drive sprocket shaft of the combine harvester. The rotating roller facilitated easy forward movement of un-sieved material along with tubers, thus checking its back flow. This helped in the easy and fast flow of material including tubers. The roller functioned to break and help sieving down and resulting in removal of small clods and soil. The speed of the roller was kept adjustable to check its performance at different speeds and select the optimum speed for desired performance. The clearance between the roller and the chain conveyor was also kept adjustable for selection of optimum gap under the field conditions.

The system for the separation of trash, weeds, vines

etc. was also designed and fabricated and provided to the prototype. It consisted of an acrylic mat 2400 mm x 1000 mm x 15 mm size with projection of 10 mm over its surface. The mat was held apart with the help of two shafts supported by bearing brackets. The system is located behind the prototype immediately behind the primary rod chain conveyor. The mat is provided motion in the clockwise direction. It was designed to receive the material from the primary chain, catch the trash and allows the tubers to roll down in the lateral conveyor for transport into the trolley. The trash is dropped down behind the machine. The improved prototype of the potato combine harvester is shown in Fig.10. The major specifications and purpose of the improvements incorporated in the prototype are shown in Table1.

Fig .10. Improved prototype of potato combine harvester (Prototype-I)

Table 1. Major specifications and purpose of modifications and new systems incorporated in the prototype combine harvester

Sl. No.	Modifications effected/ new systems incorporated	Purpose	Specifications
1	Primary rod chain conveyor with PVC cover on rods	To check tuber bruising	Length - 5200 mm Width - 1170 mm No. of rods -135 Gap in rods —30 mm PVC cover -12 mm x 2 mm tube
2	New improved drive sprockets for primary rod chain conveyor	To check back flow and bruising of tubers	No. of sprockets -4 Size of each sprocket - 180 mm x30 mm No. of teeth -14
3	Replacing the second agitator shaft with plain wooden roller shaft	To reduce tuber bruising	No. of plain roller ---4 Size of roller —65 x 60 mm
4	Providing an anti –clodding system	To reduce size of clods	Type - Dicone diabolo rollers No. of rollers - 2 Size of rollers - 400 x 270 mm
5	Providing a clod crushing system	To break the clods and separate them out	Type - cylindrical rubber roller No. of rollers ---1 Size of roller - 1165 x 300 mm
6	Trash separation system	To separate out grass, weeds *etc*. from the produce	Type –Inclined belt with projections Size - 2520 mm x1000 mm

Field evaluation and testing: The prototype was run at no load condition in the laboratory. The speeds of different sub systems were optimized under simulated conditions. The prototype with the said improvements was evaluated in the actual field conditions (Fig. 11a). The field was well prepared before the testing for harvesting by the prototype combine harvester. The excessive weeds trash *etc.* were removed. The prototype machine was found to operate satisfactorily. The soil separation was found to be improved significantly due to better separation and cleaning action. The final collection with 85% clean produce and the tuber bruising below 2% was obtained (Table 2 & Fig. 11b). The clod formation during harvesting was reduced significantly due to the provision of anti clodding attachments. It resulted in better sieving action and thus providing collection of clean tubers. The rubber roller design and performance need to be improved further or else an alternative system needs to be developed for clod crushing or separation. The design of the trash separator though found to be effective to separate

out the weeds from the dug tubers, but it requires to be located at a better position which require major change in positioning of other systems to make way for the trash separator.

Table 2. Field performance of the improved prototype potato combine harvester

Sl. No.	Item	Performance
1	Type of soil	Sandy loam
2	Potato variety	Kufri Jyoti
3	Speed of operation	2.5-3.0 kmph
4	Effective field capacity	0.35 (ha/hr)
5	Soil separation efficiency	85%
6	Clod reduction efficiency	60%
7	Tuber bruising	< 2%
8	Field losses	1%
9	Labour requirement	3-4 persons
10	Tractor power requirement	40-45 HP

(a) *(b)*

Fig. 11 (a) Improved prototype combine harvester during actual field operation (b) View of harvested tubers collected in trolley

Design and development of tractor operated potato combine harvester for collection of tubers in bags/crates

The design and fabrication of another new type 2-row tractor operated potato combine harvester (Prototype-II) with provision for tuber inspection and simultaneous collection of tubers in bags or crates was carried out. Unlike the prototype-I developed in the past, it shall require only one tractor for its operation.

The systems for potato harvesting and conveying *viz*, the digger blades, differential gear box, vibrator system, main drive system, the rod chain conveyor and digger pulleys were fabricated. The potato digging and conveying system was developed. It consisted of main frame made of 75x10 mm MS channel. The major components fabricated and provided included the two numbers of triangular shaped blades for digging potato ridges at 65 mm row spacing. The elevator chain is made extra long of 100 rods with rod spacing of 25 mm. The other systems included the vibrators on a shaft, four chain supporting pulleys, and drive shaft with four sprockets. A differential gear box is provided as in elevator diggers and provision is made to draw power from both sides of the gear box. The power to the drive shafts is provided using double groove V-belt and pulleys. A ring or cage wheel type vertical conveyor was designed and fabricated which consisted of perforated wheel supported on four sets of 150 mm dia nylon wheels. The power was provided to the one set while other wheels were only

supporting the ring, The ring was made to receive the dug material from the primary chain conveyor. The systems developed were evaluated. While the primary digging-separation system functioned well. The vertical conveyor need to be improved. Further work on fabrication and improvement is in progress.

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

Improvement and modification work of the grading and power transmission systems of the small grader for experimental plots and also for the small farmers, as observed during its laboratory testing and also in order to reduce the bruising caused to the tubers, was carried out. The major systems of the grader are mainframe, grading mechanism and power transmission system. Efforts were made to keep the mechanism and operation of the machine as simple as possible. The materials used for the fabrication of different parts of the machine were MS angle, MS/GI wire, MS flat, MS rod, MS sheet, MS shaft, wood, ball-bearings, chain & sprockets, V-belt & pulleys, and miscellaneous small items. The sizing unit comprised of two endless wire belts having square openings of 35 and 50 mm size, one moving over the other at right angles to each other with gentle shaking. The shaking helps in changing the orientation of the produce and thus increases the grading efficiency.

The wire belts were fitted with the help of drive and driven wooden rollers of same lengths but different diameters in a way that the upper surface of the belt is held tight using wooden rollers. Grader wire belts can be tightened whenever required as the wooden rollers fitted with bearings and brackets have been made adjustable. Proper care has been taken to disallow any loosening of the wires of the grading belts during operation. Inclined chutes made out of GI/MS sheet (20 gauges) were also fabricated and provided to receive the three grades of potatoes falling through the wire belts. Proper inclinations to these chutes were given so that potatoes roll down smoothly on the chutes. The graded potatoes roll down smoothly to the plastic/bamboo baskets kept below the outlet of each chute. A feeding chute made up mainly of MS sheet and MS flat was fitted on top of the grader**.** The feeding chute and inclined chutes for graded tubers collection have been lined with commercially available gasket insertion rubber sheet of 3 mm thickness to avoid injury to the seed tubers. Wooden/GI sheet fenders have been provided to avoid spilling of produce over the sides. All the chains and sprockets in the power transmission system have been covered with MS sheet covers to protect them from dust and for the safety of the persons working on the grader. Provision has also been made in the system to operate it with an engine, if need.

This grader was tested both manually and also with the help of a diesel engine. Feeding to the grader was carried out manually with the help of baskets/gunny bags. Around 4-6 persons are required to work with this grader. They are used for operation, feeding, shifting of the filled plastic/bamboo baskets and replacing them with empty plastic/bamboo baskets. For easy transportation of the grader to any desired destination, two pairs of solid rubber lined wheels (size 200X50 mm), have been provided at front and rear sides of the frame. A handle (made up mainly of GI pipe), meant for manual pulling of the prototype, has also been provided for this purpose. (Fig. 12). With this potato grader, the potato tubers could be graded in to three different size grades *viz.*

(i) First grade with tuber diameter exceeding 5 cm,

(ii) Second grade with tuber diameter between 3.5 & 5 cm and

(iii) Third grade with tuber diameter below 3.5 cm.

When operated manually with the help of a flywheel, the machine could grade 1.4 tonne of potatoes in an hour. However, upon its operation with a diesel engine, it could grade 2.5 tonne of potatoes in an hour.

This grader is suitable for grading even the freshly harvested tubers, which have been cured in the heaps for about 15-20 days after harvesting. The damage to the tubers was almost negligible (Table 3).

Fig. 12. Small grader for experimental plots and for small farmers

Table 3. Salient features of small potato grader for potato experimental plot and for small farmers

Item	Specifications
Type	Manually/Engine operated
Overall length (mm)	1940
Overall width (mm)	1860
Overall height (mm)	1480
Size of the grading sieves	50 & 35 mm size square openings
Power requirement	a) Manual operation b) A 3-5 hp engine
Power transmission	Through chain drive and belt-pulley arrangement
Method of feeding	Generally manual feeding with baskets/gunny bags
Transportability	Four nos. of solid rubber lined transport wheels provided
Output capacity	a) 2.5 t/hr when operated with engine b) 1.4 t/hr when operated manually
Labour requirement	4-6
Suitability for freshly harvested tubers	Can be used for freshly harvested tubers after curing them in heaps for 15 to 20 days
Nos. of grades obtained & range	Three grades Ist grade with tuber diameter exceeding 5 cm IInd grade with tuber diameter between 3.5-5 cm IIIrd grade with tuber diameter below 3.5 cm.
Tuber damage	Almost negligible

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

Fabrication work of the main frame and of three numbers of grading sieves of the grader, was carried out. Grader shall mainly consists of main frame, grading mechanism and power transmission systems.

Main frame: The main frame of the grader resembles the shape of a rectangular box and is fabricated mainly out of MS channels, MS angles, MS square pipe and MS flat, which are readily available and are the most commonly used materials in the fabrication of farm machinery. Apart from providing MS channels (of size 75X38X6 mm) at the base of the frame, MS channels (of size100X50X6 mm) have also been provided at the top of the frame on vertical angle irons (of size 38X3/5 mm), acting as pillars. These vertical angle irons have been welded together and given the shape of a square pipe, in order to render them strong enough to combat the mechanical fatigue failure. A rectangular frame (made up of MS angle iron) for subsequent fitting of the grading sieves in it, has also been fabricated. Overall size of the main frame is 3200 X 1240 mm. All the joints have been made by welding to make the machine strong, rigid, and to reduce the vibration at the time of operation. Adjustable supports (four numbers) fabricated out of MS angle iron (size 50X 6 and 38X5 mm) and given the shape of square pipe, were also provided so that research prototype when used for the grading purposes can be easily parked on the level surface and given the requisite slope to the square wire mesh sieves for the proper grading purposes.

Grading mechanism: Fabrication work of the grading sieves (three numbers) having 20, 32 & 52 mm size square openings, made out of 8 SWG MS wire, for their subsequent use in the grading mechanism of the improved square wire mesh type of potato grader for pre-cold storage of potatoes, was carried out. All the wires have been so bent with the help of specially designed and fabricated dies that, 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. Assembly work of the grading sieves is under progress. A straight long MS wire (8 SWG) of equivalent length, is also being clamped together in between the two square opening wires, so as to have proper grading of the produce.

Development of farm machines and systems for seed potato cultivation

Comparison of different growth chambers in aeroponic system

A new brick plastered grow box was designed and constructed. New box has overall dimensions of 1800 x 1000 x 600 mm and is constructed from bricks

and plastered outside and inside with cement-sand mixture (1:5). Chamber was lined inside with polythene sheet of thickness 150 micron and was covered with a synthetic material of thickness 50 mm for holding plants. This new chamber was compared with thermocol and polythene aeroponic growth chambers. Temperature variation at different times was recorded under net house conditions to assess the possibility of soilless production of potato minitubers in these structures. A typical day temperature variation is shown in Fig 13.

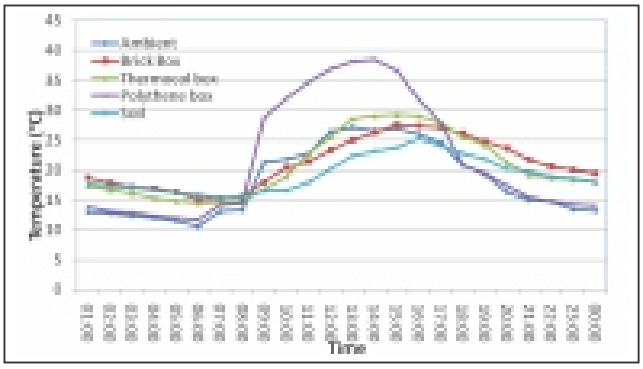


Fig. 13. Typical 24 hr temperature variation in aeroponic grow boxes and soil

Besides this, other studies related to aeroponics were conducted as follows -

- Two new ceramic nozzles were compared with the existing ones. Based upon this study ceramic nozzle with strainer, anti leakage diaphragm and quick assembly system was selected for future use in aeroponic systems.
- A new system was designed and tested for drudgery free and efficient tuber picking in aeroponic production system.
- Design of grow chambers was improved by which number of plants per unit area got increased by 26 % thereby reducing cost of production positively. Also nutrient supply to the plants became more efficient in new design.
- A mini portable soilless production system was developed for growing potatoes, tomato, bitter gourd, bottle gourd and other vegetable crops. This system has all the basic sub systems *viz.* grow chamber, nutrient storage tank, nutrient supply system and electrical control fitted in a single unit. This will be tested for conducting nutrient composition and other physiological studies. (Fig. 14).

Development of system for loose handling and treatment of seed potatoes

Existing pallet design for fork lift assisted handling and treatment of potatoes (in which plastic trays are used) was further improved (Fig. 15). After improvement pallet will have capacity of 750 kg loose potatoes/batch and will be suitable for handling, dip washing, dip treatment and spreading on level surface for drying. Per hour capacity with this system will be 8-10 ton depending upon distance between storage, washing tank and drying area.

Fig. 14. Portable soilless production (CPRI-SPS) system

Fig. 15. Pallet for potato handling and treatment using fork lift

Division of Plant Protection

Management of late blight

The effects of climate change are becoming imminent in terms of erratic and torrential rainfall, extremely lower temperatures, and diminishing sun shine hours during the winter potato growing season in the sub-tropical plains. The severe climatic conditions will apparently influence the disease causing pathogens including *P. infestans*, the causal organism of potato late blight and are expected to result in more aggressive, virulent races that need to be detected, monitored and suitable control measures deployed both in terms of host resistance and chemical sprays coupled with botanicals and bio-control agents. The latter control measures assumes more significance as the demand for organic food and processed products is rising sharply both in India and abroad. Therefore, region specific and variety specific late blight management strategies needs to be developed and deployed using software based disease appearance forecasting and need based fungicides application schedules.

Pathogen population structure

The disease appeared on 21 July, 2012 on cv. Kufri Jyoti in Shimla hills with severity ranging from 30-80%. In Punjab, though the disease appeared, on 12 November, 2012 in village Chakkowal in district Hoshiarpur, yet it remained restricted to a few fields and did not spread further till end of January 2013. Thereafter, the disease built up rapidly from the first week of February and severely affected the unsprayed crop. Late planted crop suffered heavily with severity ranging from 5 to 75% in different fields. In western Uttar Pradesh, it appeared in second week of February, 2013 on cv. Kufri Bahar with 5-20% disease severity.

P. infestans isolates collected from Himachal Pradesh, Meghalaya, Punjab, Uttar Pradesh and Bihar were analyzed for mating types, physiological races and metalaxyl sensitivity. The results revealed that the population consisted of most complex races having all the reported 11 genes. All the isolates from hills were A_2 mating type while those from plains were A_1 mating type. Analysis of *P. infestans* populations for metalaxyl sensitivity revealed that 67% population from Himachal Pradesh, 100% from Jalandhar and 38 % from Bihar exhibited tolerance at 300 ppm, while 100% population from Faizabad (UP) exhibited tolerance at 200 ppm. A sub set of population comprising of 70 isolates collected from Himachal Pradesh, Meghalaya, Assam, Tamilnadu, Karnataka, Uttar Pradesh and Uttarakhand was analysed for mitochondrial haplotyping and the results revealed that all the isolates belonged to the Ia haplotype (Fig. 1). Another set of population consisting of potato (20) and tomato (10) isolates were also analyzed with same primer sets and results revealed that both the isolates belonged to Ia haplotype as well. These results suggest that the new population (Ia) has displaced the old population (Ib) in most of the regions within a decade of its introduction in India.

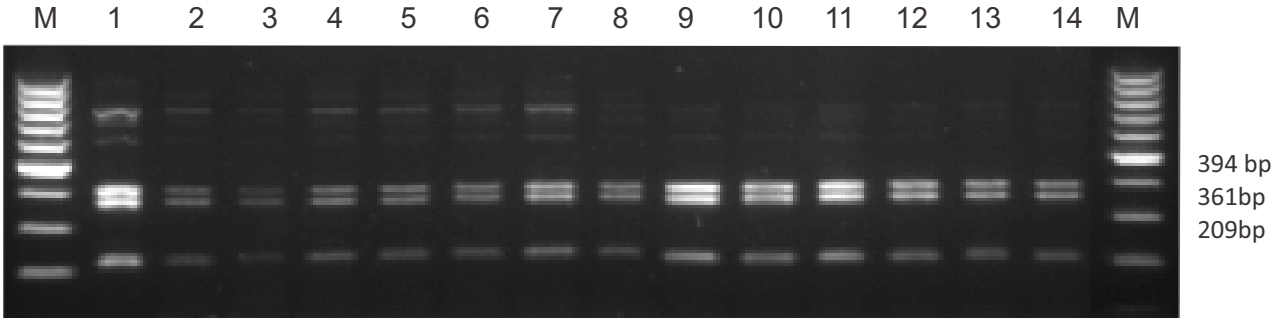


Fig. 1. Mt haplotyping of P. infestans isolates with primer P4F4 & P4R4 digested with EcoR1. Lane: 1-14 P. infestans isolates M: 100bp

Since the above referred conventional techniques were not able to distinguish new complex races in the population. Therefore, a sub set of 96 isolates collected from different regions of India was analyzed using two SSR primers i.e. Pi63 and Pi 04 (Fig. 2) and polymorphism was detected in this set of races. Therefore, it is proposed to analyse the entire collection with the SSR primers, so that new, virulent races could be detected and used in screening of breeding materials.

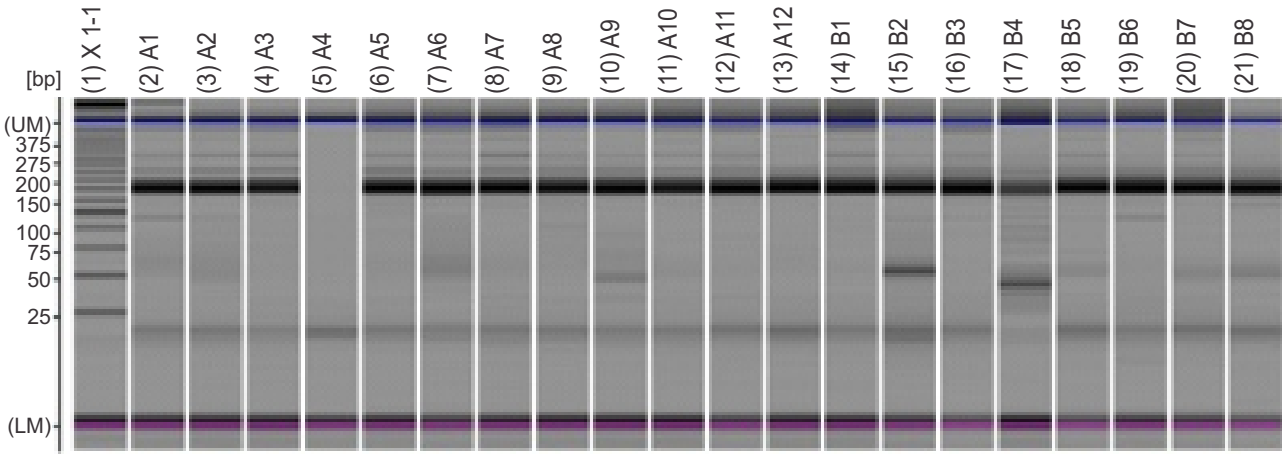


Fig. 2. SSR genotyping of P. infestans isolates with primer Pi04 Lane: 1-21 P. infestans isolates

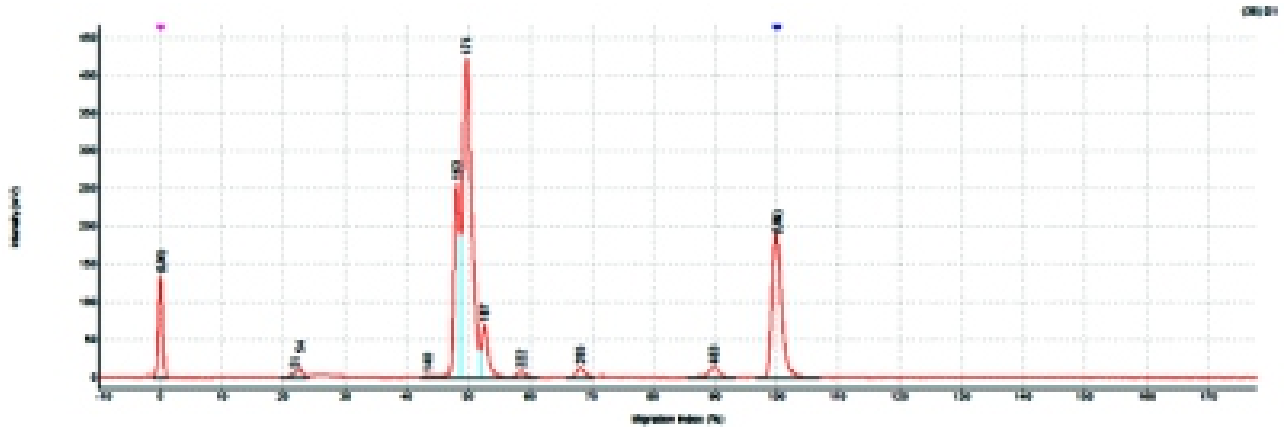


Fig. Electropherogram of P. infestans isolates with Pi04 primer

Detection and quantification of P. *infestans* from host tissue

To detect the latent infection in host tissues and quantification of inoculum load of *P. infestans*, real time PCR protocol was standardized. Leaves (cv. K. Bahar) were challenge inoculated with *P. infestans* (3.5×10^4 sporangia/ml) and samples were drawn at different distances (5, 10, 15, 20 and 25 mm) from the symptomatic area and at different time intervals (24, 48, 72, 96 and 120 hrs post inoculation) from point of inoculation. Maximum load (2.98 ng) was estimated at 5 mm away from the symptomatic area while minimum (0.03 ng) was estimated 25 mm away from symptomatic area (Fig. 3**)**. This indicates that the *P.*

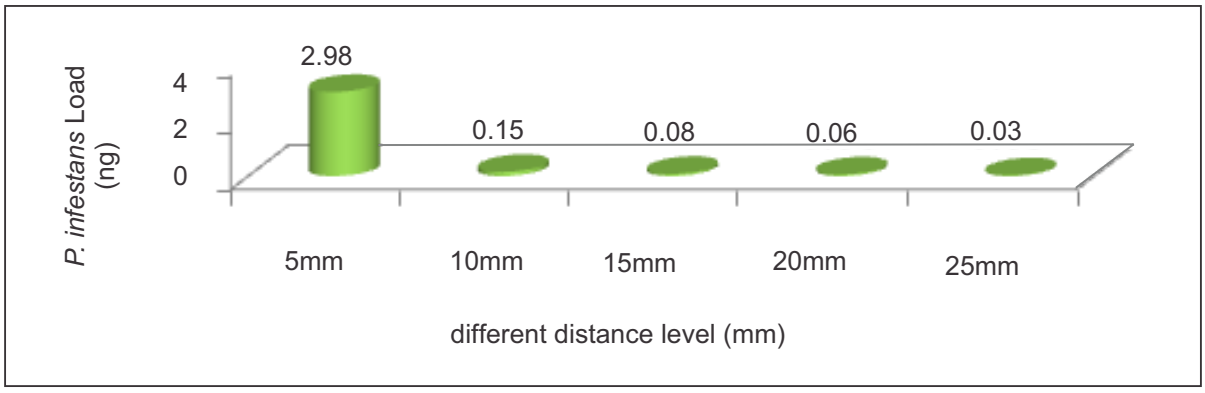


Fig. 3. Quantification of Phytophthora infestans at different distance intervals with qRT-PCR

infestans mycelium can spread/penetrate in the host tissue upto 25 mm away from the symptomatic area which could not be detected by naked eye. Similarly, minimum pathogen load (0.14 ng) was estimated 24hrs post-inoculation while highest load (2.29 ng) was estimated at 120hrs post-inoculation (Fig. 4).

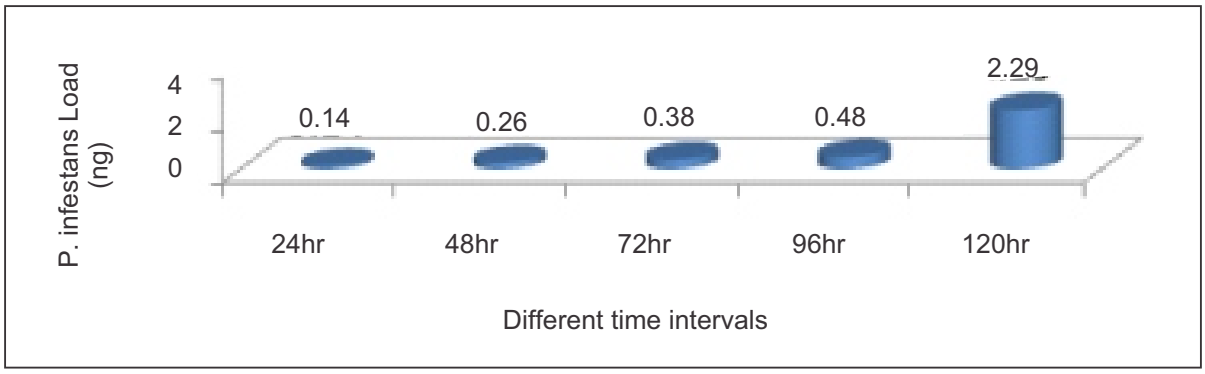


Fig. 4. Quantification of Phytophthora infestans at different time intervals with qRT-PCR

Disease epidemiology

JHULSACAST model has been successfully used to predict late blight appearance during December 2012 – January 2013. This model is forecasting accurately for the last 13 years. Similar forecasting model for first appearance of late blight in Tarai region of Uttarakhand was developed with some modifications in the JHULSACAST model. The modified model specifies that a 7 day moving ≥ 85 % relative humidity period ≥ 85 hours with a 7 day moving congenial temperature (7.2 to 26.6ºC) ≥ 135 hours prevail for 7-consecutive days, late blight would appear within 14 days in Tarai region of Uttarakhand. The modified model was developed using 15 years (1995-96 to 2009-10) weather data collected at GB Pant University of Agriculture & Technology, Pantnagar, Uttarakhand & validated for 3 years. This model successfully predicted disease appearance coinciding with the actual date of appearance with an accuracy of 86%. Similarly, JHULSACAST model developed for Punjab last year successfully predicted late blight appearance during the current year and the farmers were advised through press and All India Radio to protect the crop through prophylactic sprays.

An experiment was conducted to validate the software developed for need based application of fungicides vis-à-vis CPRI recommendations. Results revealed that software predicted applications of fungicides resulted in less disease severity compared to recommended spray schedule.

A non linear reciprocal hyperbola equation (Y = X /(X * A + B); Where, A= 0.004111; B= 16.93; X= AUDPC and Y= Yield loss (%), developed to predict yield losses due to late blight, was validated during 2012-13. Results revealed that deviation between observed yield losses and predicted yield losses ranged from 2.29 to 9.23 %.

Silencing of *RXLR* effector gene (*Avr3a*) of *P.infestans* using RNAi approach

Transgenic lines were challenge inoculated (35 DAP) with *P. infestans* (3.5 X 10^4 sporangia/ml) in screening chamber under controlled conditions. The disease severity ranged from 15-20% in transgenic lines as compared to 75-85% in non-transgenic lines (Fig. 5). Four lines from siRNA transgenic (K. Pukhraj SI2AS1 2086, K. Pukhraj SI2AS1 2173, K. Pukhraj SI2AS1 2155 and K. Khyati SI2AS1 1037) and 3 lines from amiRNA transgenic (amiR2.1153, K. Khyati

Fig. 5. Response of K. Khyati SI2AS1 1037 transgenic line and non transgenic line against late blight disease

amiR4.4091 and amiR4.5002) were selected. Real Time PCR analysis of *Avr3a* gene in transformed potato line (K. Khyati SI2AS1 1037) and non–transformed control plants confirmed the silencing of the *Avr3a* gene upon *P. infestans* challenge inoculation (Fig. 6&7). Based on microarray analysis of Kufri Girdhari in response to late blight, developed 22.7 HSP gene expression and RNAi construct driven by CaMv35S promoter.

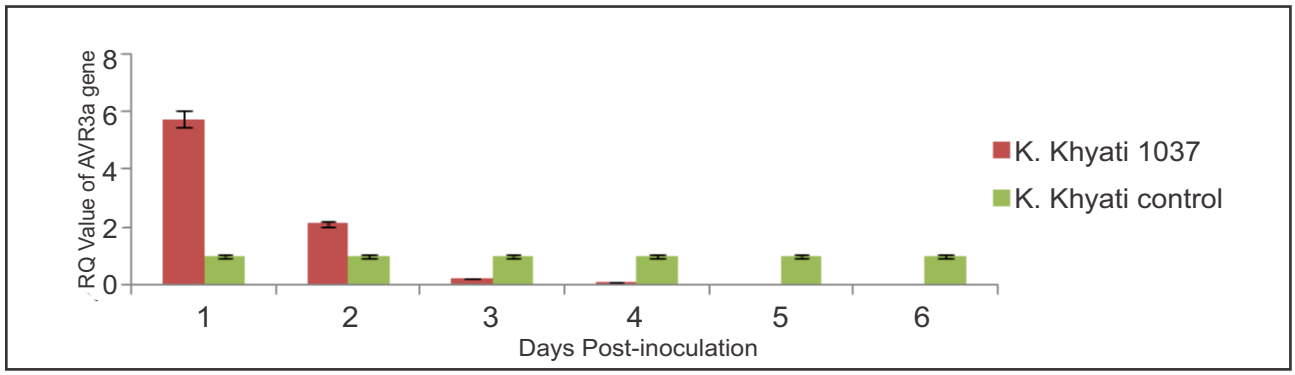


Fig. 6. Relative expression of Avr3a gene in transgenic K. Khyati SI2AS1 1037

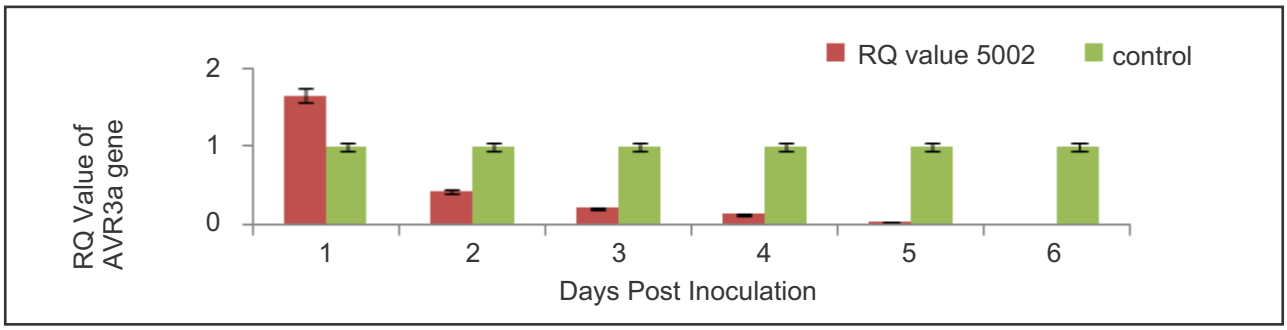


Fig. 7. Relative expression of Avr3a gene in transgenic K. Pukhraj amiR 5002

Disease management

In order to develop variety specific chemical management of late blight, experiments were initiated last year using three different combinations of fungicides with two popular varieties i.e. K. Bahar and K. Badshah. The experiment was repeated and the results confirmed that foliar application of chlorothalonil before appearance, followed by sprays of cymoxanil-based fungicides post-appearance of late blight were found best in both the varieties.

Integrated disease management using bio-agents can reduce the number of fungicides sprays for managing late blight. Therefore, an experiment initiated last year for integrated management of late blight was repeated to confirm the results. Among 10 treatments evaluated, treatment 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 in both the years. Similarly, botanical formulation was developed and tested in field against late blight of potato at two concentrations (0.5 & 1.0%) and 1.0% formulation showed better results against control treatment. These bioagents and botanical formulations will be tested in the hills under natural epiphytotic conditions before recommending them to the farmers.

Historically, *P. infestans* is known to adapt quickly to the new fungicides. Therefore, new fungicides need to be tested regularly to decide spray schedules for controlling the disease. Accordingly, an experiment was conducted with eight treatments. Treatment combination mancozeb (0.2%) - mancozeb (0.2%) + dimethomorph (0.2%) - mancozeb (0.2%) + dimethomorph (0.2%) recorded lowest disease severity (28.33) against control (98.33%).

Late blight infected tubers

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

The results of *P. infestans* monitoring for about a decade has very well established that the A_1 mating type has established itself in the sub-tropical plains, where disease appears infrequently and the inoculum load is also low. On the contrary, A_2 mating type is present in the hills where late blight epidemics are regular and the disease pressure is also high. Therefore, different strategies for developing and deploying the host resistances are needed both for hills and plains especially when the crop durations are drastically different in both the conditions and it is an established fact that the crop maturity is positively correlated with the higher levels of resistance. Moreover, other biotic stresses especially resistance to viruses is equally important and varieties need to be developed with multiple disease resistances. Therefore, region specific varieties need to be developed and deployed having desired level of resistances to the regional biotic stresses including late blight. Molecular markers have been validated for viruses, late blight and cyst nematodes and are being routinely used at the institute in precision breeding which is expected to develop new varieties with multiple resistances in few years.

A total of 1,06,545 hybrid TPS were produced from 54 successful crosses attempted among selected late blight resistant parents at Kufri/Shimla/Shillong. About 16,100 seedlings of 29 crosses were screened against late blight under controlled conditions at Shimla and 2190 resistant seedlings were selected. The highest number of resistant seedlings were obtained in the cross CP-2379 x SM/94-44 (22.96%) followed by CP-2011 x K. Girdhari (21.1%), CP-2011 x SM /94-44 (20.4%), VMT 5-3 x SM/94-44 (20.4%), CP-2379 x K. Girdhari (16.8%) and CP-2379 x K. Frysona (15.2%). At harvest 347 clones were obtained. At Shillong, 545 clones have been selected from 11 crosses based on tuber characters and resistance to late blight. In the initial stages (F_1C_1 to F_1C_5), 1620 genotypes were evaluated under natural field conditions at Kufri and Shillong for their disease resistance and adaptability and 485 clones were selected.

In advanced stage trials at Kufri, 15 hybrids were evaluated in replicated trials and 8 were selected. Hybrid SM/03-13 yielded (19.8 t/ha) significantly higher than the best control Kufri Girdhari (17.3 t/ha). This hybrid had high level of blight resistance also. At Shillong, 9 hybrids were tested in three replications for late blight resistance and tuber yield for second year. Based on pooled basis, three hybrids, SM/00-42, SM/00-191 SM/00-43 yielded statistically at par with Kufri Girdhari. Besides, these hybrids had moderate level of resistance to late blight also. At Ootacamund, seven hybrids were evaluated in replicated trials and three hybrids i.e. SM/02-07 (72t/ha), SM/00-42 (55.1 t/ha) and SM/02-01 (52.7t/ha) out yielded the best control K. Girdhari (50.8t/ha). Based on their consistent performance over the years, hybrids SM/00-42 and VMT 5-1 have been introduced into AICRP (P) for multi-location trials.

Identification and pyramiding of R-genes linked to late blight resistance using marker assisted selection

Molecular markers R1AS and COSA were used to detect the presence/absence of *R1* gene and *R3* (SCAR) marker was used to detect *R3a* gene in 68 accessions. *R1* gene was present in 5 accessions i.e. CP 3187, CP 3208, CP 4250, CP 4253 and CP 4327, while 12 accessions i.e. CP 3147, CP 3250, CP 3255, CP 3276, CP 3384, CP 3597, CP 4221, CP 4222, CP 4229, CP 4239, CP 4245 and CP 4231 showed presence of *R3a* gene .

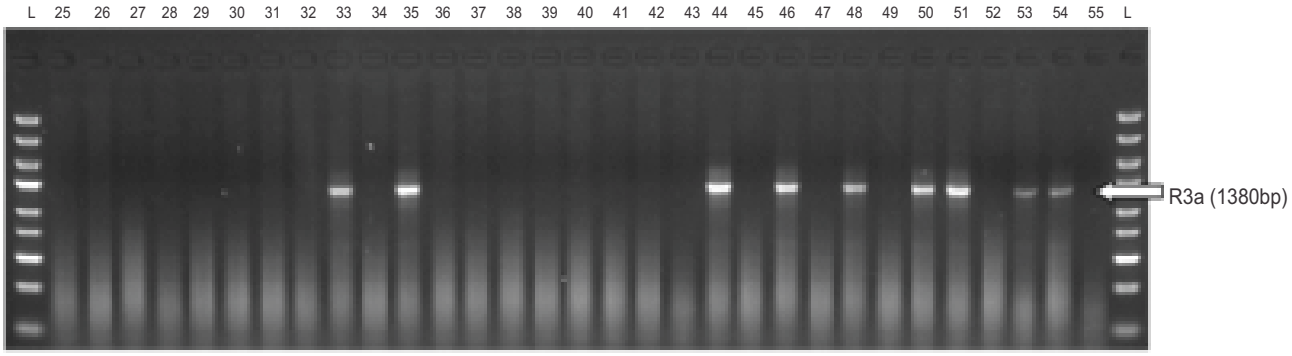


Fig. 8. Screening potato germplasm lines for presence of R3A gene

Besides, 7 accessions i.e. CP 3171, CP 4220, CP 4223, CP 4238, CP 4240, CP 4329 and CP 4330 possessed both *R1* and *R3a* genes. Hybridization was attempted to combine *R1* and *R3a* genes in single host background. Hybrid TPS extracted from six successful crosses i.e. K. Jyoti × CP-4055, SM/92-338 × K. Girdhari, K. Chipsona-3 × CP 4043, HR 5-2 × K. Himsona and CP 4045 × CP 1945 were used to raise seedlings in the glass house. Genomic DNA was extracted from a segregating population of about 280 genotypes and 15 clones were identified possessing both genes through MAS. Detached leaf bioassay was done for late blight resistance in selected clones along with parents and controls. The selected clones will be field screened for late blight resistance under natural epiphytotic conditions and desirable agronomic traits.

Pyramiding multiple disease resistances in potato using marker assisted selection

Molecular markers, RYSC-3 & 4 (SCAR) and *Rysto* 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 used to identify parental lines which were later intercrossed for gene pyramiding (Fig. 9). Out of nine successful crosses, about 9,435 hybrid seeds were extracted. These hybrid seeds will be used next year to raise the segregating population of different crosses for the identification of recombinants with multiple disease resistance genes and yield through MAS.

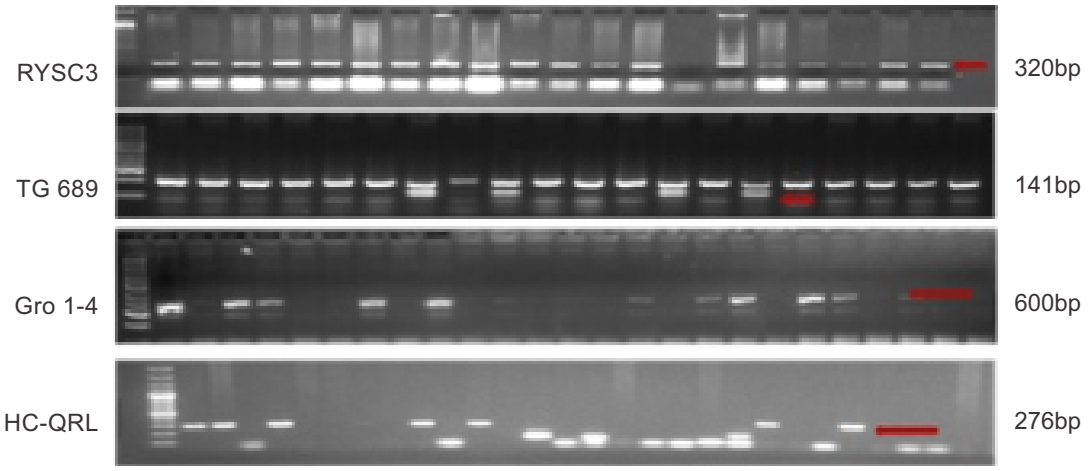


Fig. 9. Validation of PVY resistance with RYSC-3, Cyst nematode resistance with TG689, Gro1-4 and HC-QRL

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. ToLCNDV-potato was maintained in infected potato tubers, and PSTVd on tomato and potato germplasms viz., CP Nos.1291, 1641, 1874, 2419, and 3166. *Potato Virus Y* was propagated in large quantities in the propagative host and the purified PVY particles were used to inject rabbit to raise antisera. Twenty five microlitre of antisera was obtained with 1:800 titer. ToLCNDV-potato infected plants were mass multiplied in tissue culture and nearly hundred plants were planted in virus pure culture facility. The virus was purified from one kg of infected leaves using standard virus purification procedure; the particles were viewed under electron microscope.

Screening of germplasm accessions for virus resistance through DAS-ELISA

Seventy four germplasm accessions were planted in the glass house and screened for resistance to PVY and PVX through mechanical inoculation followed by DAS-ELISA. Out of which, 25 germplasm accessions were found having combined resistance to PVX and PVY. Twenty six and seventeen accessions showed resistance to PVY and PVX, respectively.

Testing for viruses, potato spindle tuber viroid and quarantine pathogens

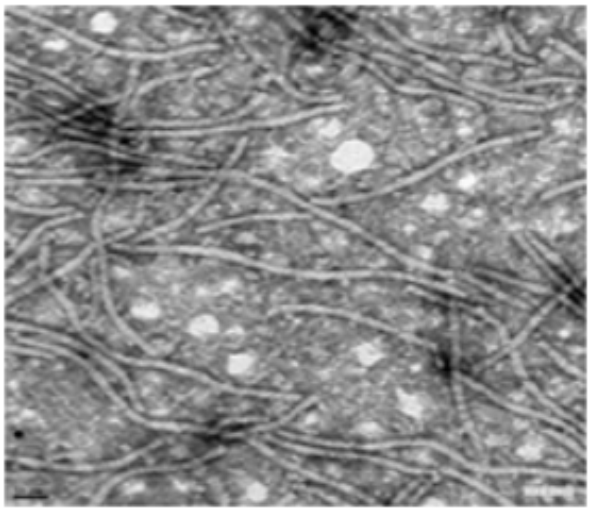
One thousand one hundred and twenty two leaf samples of M/s Technico Agri Science Pvt. Ltd. Baddi, Distt. Solan (HP) and M/s Pepsico India Holding, Channo, Distt. Hoshiarpur (Punjab) were tested for the presence of PVX, PVS, PVY, PVA, PVM, PLRV, CMV, PMTV, TMV, TNV, TRSV, TSV, TSWV, PYDV by DAS- ELISA and PSTVd by RT-PCR under Accredited Test Laboratory (NCS-TCP). Besides, 24 potato varieties of M/s Technico Agri Science and 69 *in-vitro* CP Nos. and TPS samples of Crop Improvement Division were planted in the glass house and tested for PVT, PYDV, AVB, APMoV, APLV, TRV, TRSV and *Clavibacter michiganensis* ssp. *sepedonicus* under post entry quarantine testing. Among 168 samples tested for PSTVd through RT-PCR, 14 were found positive. Similarly among 39 samples tested for PLRV, 13 were found positive.

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. The test results were compared with DAS-ELISA.

Electron microscopic detection of potato virus by leaf-dip method

Electron microscope (EM) was used to detect *Potato virus A* (PVA) from suspected potato plant samples by leaf dip method and examined under EM (120kV) which revealed the presence of elongated flexible particles resembling PVA in suspected leaf samples.



Transmission electron microscopic image of Potato virus A

RT-PCR protocols for detection of potato viruses

A Reverse Transcription Polymerase Chain Reaction (RT-PCR) assay was designed to detect *Potato leafroll virus* (PLRV) in field collected aphids using the primers specific to coat protein (CP) gene. PCR conditions were standardized by varying annealing temperatures to amplify CP and mt COI (internal control) specific genes of PLRV and aphids, respectively. Specific bands of 464 and 579 bp corresponding to PLRV and aphid were observed without any multiple bands (Fig. 10). The electrophoressed product of PLRV and mt COI band was eluted, sequenced and BLAST analysis revealed 99 % similarity with reported coat protein sequence of PLRV confirming the viruliferous nature of the aphids. The sequence of mt COI also showed 99 per cent similarity with the reported mt COI sequence of *Myzus persicae* indicating molecular identification of the aphid used for the study. The robustness of this RT-PCR technique was used further to detect PLRV in field collected aphids from Shillong, Shimla, Meghalaya and Jalandhar. The results illustrate that

the aphids collected from Shillong showed the presence of PLRV of expected size. Therefore, this protocol can be successfully employed for molecular detection of PLRV and other potato viruses in aphids.

Aphids trapped on yellow sticky trap

Potato leaf infected with aphids

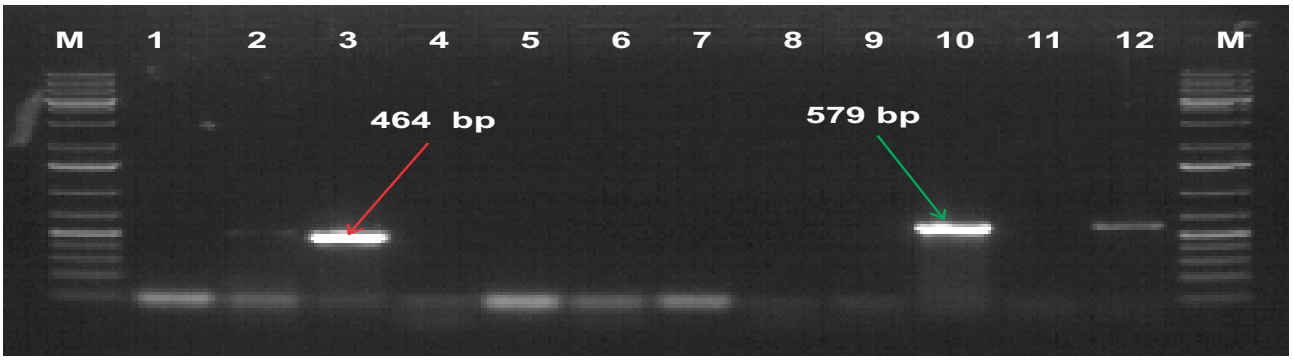


Fig. 10. M-1 kb plus, Lane1-Water control (PLRV), Lane 2-healthy control (PLRV), Lane 3-Positive control (PLRV Shillong), Lane 4 to 6 (PLRV) Shimla, Lane 7 to 9 (PLRV) Meghalaya. Lane10, 11 & 12 are IC for the samples from Shillong, Shimla and Meghalaya, respectively

Duplex Reverse Transcription Polymerase Chain Reaction (RT-PCR) assays were developed for simultaneous detection of *Potato virus S* (PVS) and *Potato virus A* (PVA) (Fig. 11), and Potyvirus *(Potato virus Y*) and Carlavirus *(Potato virus S*) (Fig. 12) with an internal control to minimize the risk of getting false negative results. Uniplex RT-PCR assay was standardized for the detection of these viruses individually and later for duplex detection of these viruses. The results were confirmed by sequencing the amplified product and then by BLAST analysis. Robustness of the technique was further validated wherein; duplex RT-PCR was carried out to detect both the viruses in field infected potato plants and in dormant potato tubers as well. The duplex RT-PCR assay has detection sensitivity as that of uniplex RT-PCR assay for respective viruses.

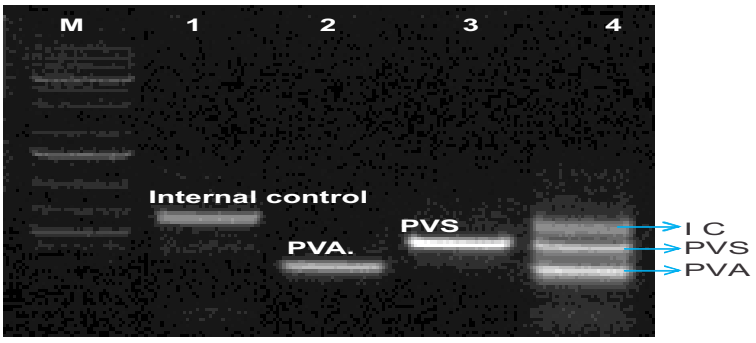


Fig. 11. Duplex RT-PCR for simultaneous detection of PVS and PVA Lane M : 1 Kb ladder, 1: Internal control, 2: PVA, 3: PVS and 4: Combination of internal control, PVS and PVA.

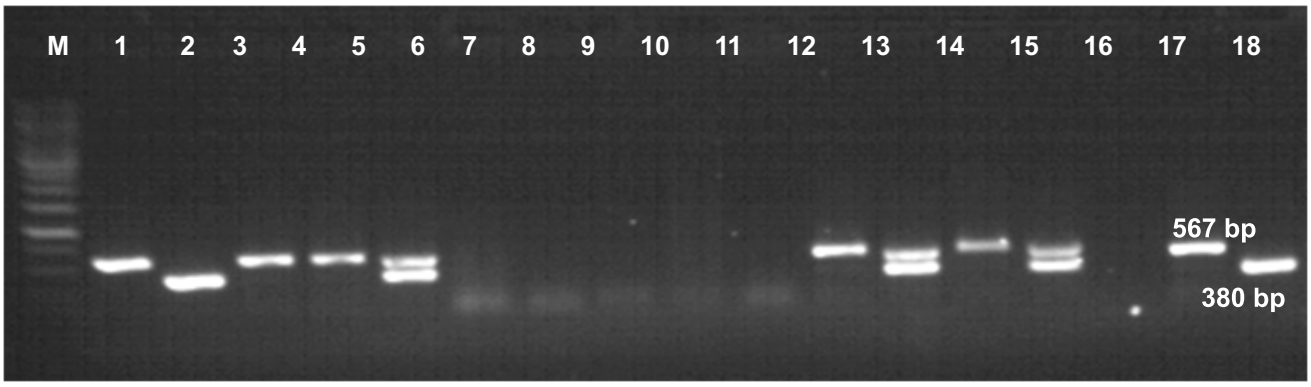


Fig. 12. Representative picture of duplex & uniplex PCR of PVY & PVS. M: Ladder; 1-14: Screened samples from various locations 15-Duplex (P); 16 –Negative, 17- Uniplex PVY (P) 18 Uniplex PVS (P)

Four set of primers targeting coat protein and replicase gene of PAMV were designed and used in RT-PCR protocol standardization at different annealing temperatures. Primer sets, which showed a single specific amplified band in positive control and without any non-specific amplification in healthy control, were selected for further use in detection.

Recombinant coat proteins for antisera production

Multiplication of potato viruses in corresponding propagative hosts and their extraction is a technically challenging task. On the contrary, heterologous expression of the recombinant CP protein of different potato viruses in *E.coli* can ensure unlimited availability of pure immunogenic epitopes of different viruses that can be used for antisera production. With that objective, attempts were made to clone and express CP genes of major potato viruses in *E. coli*. The coat protein gene of PVX was induced in *E.coli* strain BL21 cells using IPTG and the recombinant protein was purified using Ni-NTA his tag protein purification kit. Western blotting analysis and dot-blot assay were performed with PVX specific polyclonal antibody for further confirmation (Fig. 13).

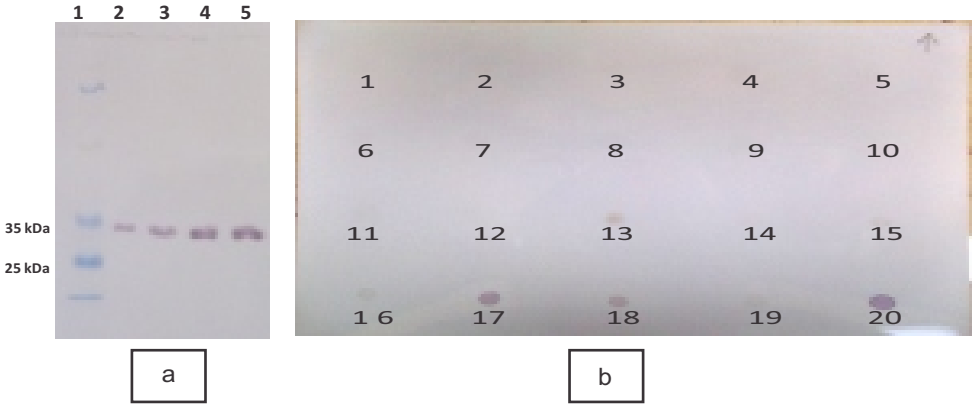


Fig. 13. a) Western blot analysis and b) Dot blot analysis

Production of antibody against CP protein of PVX and PVY

Purified CP protein of PVX 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. The titre of the antiserum was 1:3200 as determined by checker board method.

Transgenics for virus resistance

Potato apical leaf curl (TOLCNDV-Potato) 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 was used to develop resistant variety. The replication-associated protein gene (*AC1*) of the virus was used for engineering pathogen

derived resistance in two popular potato cultivars Kufri Pukhraj and Kufri Badshah. Transgenic lines of Kufri Badshah (2 lines- GTLC2-90 & GTLC2-127) and Kufri Pukhraj (5 lines -KPLC2-30, KPLC2-37, KPLC2-53, KPLC2-54 and KPLC2-44) carrying hairpin replicase constructs, which were found resistant to ToLCNDV-potato, were planted in containment facility and the tubers have been harvested for studying the tuber characters (Fig. 14).

Fig. 14. Tubers of transgenic lines resistant to ToLCNDV-potato (K. Pukhraj and K. Badshah)

Comparative genome analysis of potato pathogens

The CP gene region and whole genome of eight isolates of ToLCNDV potato were compared with ToLCNDV isolates from other crops. Phylogenetic analysis grouped the isolates into two clusters which shared 95.9 % - 100.0 % sequence identity within the isolates. The complete nucleotide sequences of DNA A and DNA B components of eight representative isolates were also determined. The DNA A and DNA B components were 2739-2741 and 2692-2694 nts long and showed 94.6-99.4 % and 97.2-99.5 % homology within the isolates, respectively. The DNA A components of two isolates, GWA-5 and FAI-19 had minimum sequence identity of 94.6-95.3 % to other six isolates and was found to form a sub-cluster within ToLCNDV-potato isolates. The DNA A components of the isolates shared more than 90.0 % similarity with ToLCNDV isolates from cucurbitaceous crops, tomato, okra, 89.0 – 90.0 % with papaya isolates and 70.4-74.0 % with other ToLCVs. Whereas, the DNA B components shared 87.8-88.4 %, 86.6-90.5 % and 87.3-91.7 % with ToLCNDV isolates from cucurbits, tomato and okra, respectively. Evidence for recombination was detected in DNA A components with maximum of two events in GWA-5 and FAI-19 isolates while no recombination was predicted in DNA B components.

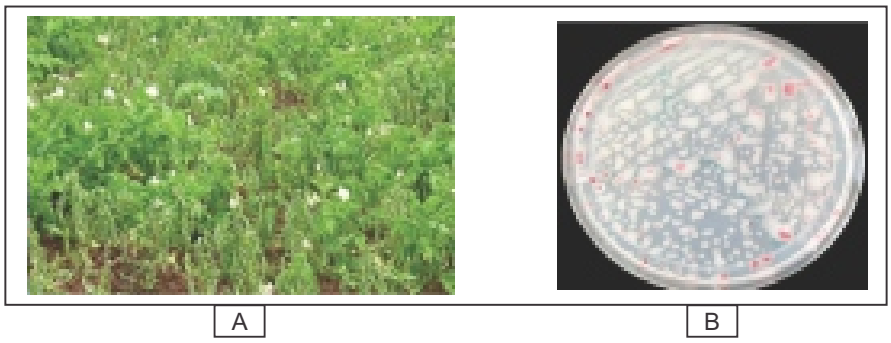
The ssRNA genome of five isolates of PLRV collected from Himachal Pradesh, Punjab, Bihar, Meghalaya and Tamil Nadu were cloned in pDrive cloning vector and sequenced. The genome comprised of 5883 nucleotides and was compared with sixteen PLRV genome sequences reported from other countries. About 97.6 to 98.7 % similarly was observed within the Indian isolates and were more close to European, Canadian, African, American and Czech isolates (95.8 to 98.6 %) than to Australian isolate (92.9 to 93.4 %).

Suspected potato accuba mosaic virus (PAMV) samples (278) were collected from different potato growing regions of India and CP gene was amplified and sequenced for five positive samples/isolates. Full length RNA genome of two isolates of PAMV was cloned in TA cloning vector and sequenced. Sequence analysis was done by using Clustal X.

To understand the species complex and the strainal variations in *Ralstonia solanacearum,* the whole genome sequencing of 3 phylotypes of *R. solanacearum* covering 25X depth of each phylotype having 5.8 Mb genomic sizes was completed. Preliminary studies revealed that the genome is known to possess a core chromosomal element of 2.543 Mb and an extra chromosomal element of 3.538 Mb. The genome data of these strains are being assessed for their protein coding genes including disease causing, repeat elements, and strainal variations, so as to use this information in formulating the geographic region/strain based management practices for potato bacterial wilt.

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

Soil and tuber borne diseases are a major constraint in production of potato of good quality. Bacterial wilt caused by *Ralstonia solanacearum* is limiting production in many parts of the country. Common scab caused by *Streptomyces* spp and black scurf caused by *Rhizoctonia solani* have spread to a large track of potato where potato is grown year after year in the same fields without following rotations with other crops and therefore, require special attention. Understanding diversity in pathogen population is the foundation to the successful disease management programme. Therefore, during the current year, attention was paid to study in detail the genetic diversity prevalent in *R. solanacearum* and *Streptomyces* spp. The pathogenicity of different strains of *Streptomyces* spp. at different level of moisture in soil was studied so as to understand the role of moisture and revise the recommendation if necessary. Identification of suitable seed and soil treatment which can be deployed to manage the major tuber diseases is of paramount importance to manage such diseases. A need is felt to develop a seed priming material which can applied to seed tubers to take care of major potato tuber borne diseases, manage sucking pests and also bring about an increase in yield. Suitable seed priming formulations were prepared and evaluated in field trials to achieve this objective.



A) Standing crop of potato infected with bacterial wilt caused by *R. solanacearum*;
B) Colonies of *R. solanacearum* on TZC agar medium

a) Symptoms of brown rot on tubers; b) vascular browning in tubers due to Ralstonia solanacearum; c) rotting of tubers in the field due to R. solanacearum

Characterization and detection of tuber borne pathogens of potato

A total of 95 isolates of *R. solanacearum* collected from Uttarakhand (28 isolates) and Meghalaya (67 isolates) were characterized into biovars. The study revealed that out of 28 isolates from Uttarakhand, 12 isolates (42.86%) belonged to biovar 2; whereas 16 isolates (57.14%) belonged to biovar 3 of the pathogen. Of the 67 isolates collected from Meghalaya, only 20 isolates (29.9%) belonged to biovar 2; 3 isolates (4.5%) to biovar 3 and 44 isolates (65.6%) to biovar 2T of *R. solanacearum* (Fig. 15).

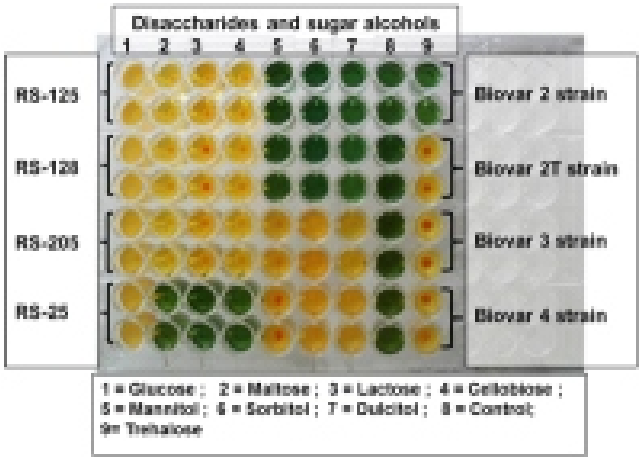


Fig. 15. Microtitre plate showing biovar test of four strains of R. solanacearum

Identification and phylotype affiliation was determined by multiplex PCR (Pmx-PCR) which confirmed all the isolates to be *R. solanacearum.* Analysis for phylotype revealed that phylotype I (Asian), phylotype II (American) and Phylotype IV (Tropical) were prevalent in Meghalaya while phylotype I and phylotype II were prevalent in Uttarakhand. In Uttarakhand 57.1% of the isolates belonged to phylotype I and 42.9% to phylotype II. In Meghalaya, 65.6% of the isolates belonged to phylotype IV, 29.9% to phylotype II and 4.5% to phylotype I.

Taqman real time PCR assay using 756R/F could detect isolates belonging to phylotype I, II and III but could not detect phylotype IV because of slight variation in nucleotide sequence in probe region. Hence, new primer probe using the upstream region of the *R. solanacearum* UDP-3-O-acyl-GlcNAc deacetylase gene was designed and which could detect the isolates belonging to all phylotypes (Fig. 16). Since the new primer-probes showed non-specific signal with few soil borne bacteria and *P. infestans,* so again the target gene was changed and two set of primer-probes each specific to *egl* and ITS region of *R. solanacearum* were designed using Primer Express 3.0 software and the protocol was standardized using these primer-probes. The sensitivity of the new primer-probes is being compared with the 756R/F universal primer based real time PCR detection.

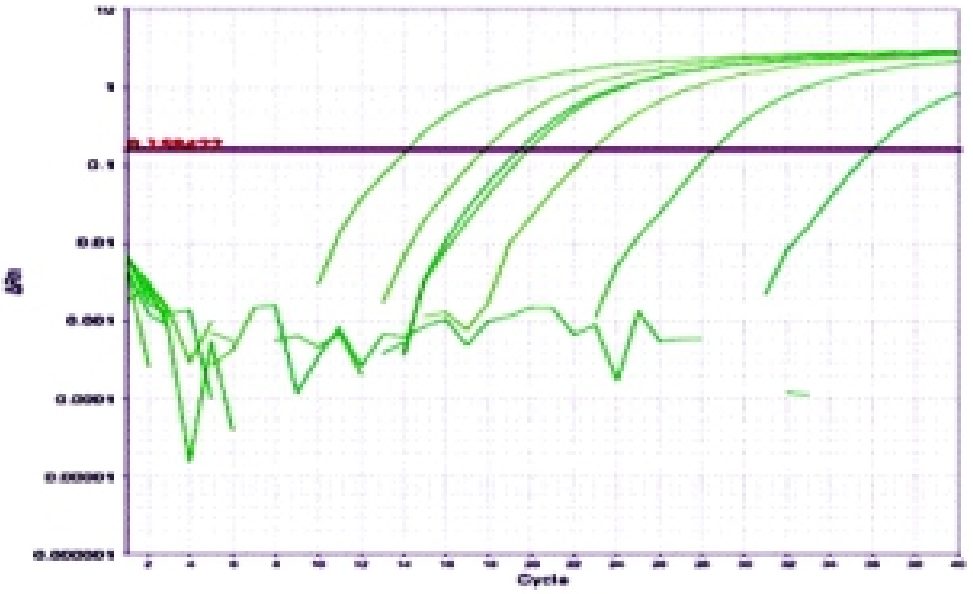


Fig. 16. Real time PCR detection of Ralstonia solanacearum isolates belonging to phylotypes I, II, III and IV using new primer-probes

Forty eight *Streptomyces* strains collected from different parts of the country were streaked on starch casein agar medium in plates and incubated at 28°C. The morphological characters *viz.*, mycelium, spore colour and pigmentation of 48 strains of *Streptomyces* spp. were studied. The strains were variable in their appearance and in production of pigments on the culture medium. The mycelium colour ranged from cream and light brown to grey and spore colour ranging from white and light grey to blackish grey. The diffusible pigment colour ranged from cream and light yellow to brownish yellow and

brown (Fig. 17). Pathogenicity examined through tuber slice assay revealed all strains to be pathogenic **(**Fig. 18). The 16S rRNA gene was amplified from all 48 *Streptomyces* strains by PCR using the primers 16S-1F and 16S-1R and DNA bands of expected size (1500bp) obtained (Fig. 19). The PCR products were purified and sequenced through an automated chain termination method.

The phylognetic analysis showed that 14 isolates were closely related to *S. scabies* and *S. europaescabies*, 12 isolates to *S. bottropensis* and 4 isolates to *S. stelliscabies*. Whereas, eight isolates were grouped with the non-pathogenic strains like *S. griseus* and *S. coelicolor*. Nine isolates were distantly separated from other 39 isolates. This study revealed the association of both pathogenic (*S. scabies, S. europaescabies, S. bottropensis*) and non-pathogenic (*S. griseus, S. coelicolor*) strains with potato tubers (Fig. 20).

The *Streptomyces* strains were also tested by PCR for the presence of pathogenicity genes using specific primers TxtAB1/TxtAB2 to the *TxtAB* operon, Tom3/Tom4 to the *tomA* gene and Nf/Nr to the *nec1* gene. The study revealed only 20 strains as *txtAB* positive, 8 strains as *nec1* positive, 4 strains as *tomA* positive. Only 3 strains had all three PAI marker genes, whereas 25 strains were negative for all the three PAI marker genes.

Deep pitted common scab on potato tubers caused by Streptomyces spp.

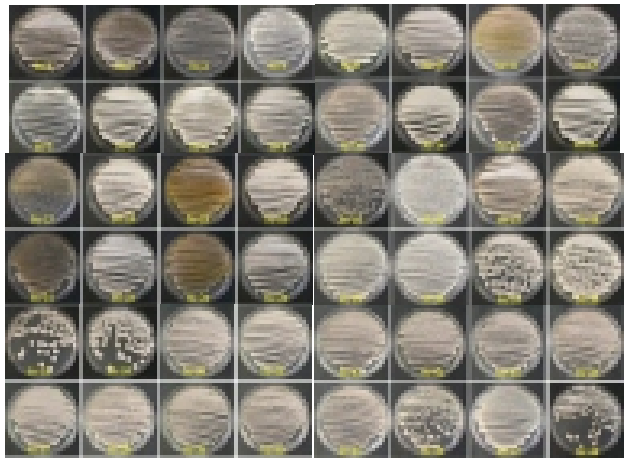


Fig. 17. Growth of 48 strains of Streptomyces species on Starch Casein Agar (SCA) medium after 10 days of incubation at 28±1°C

Fig. 18. Pathogenicity assay of Streptomyces spp. on tuber slices

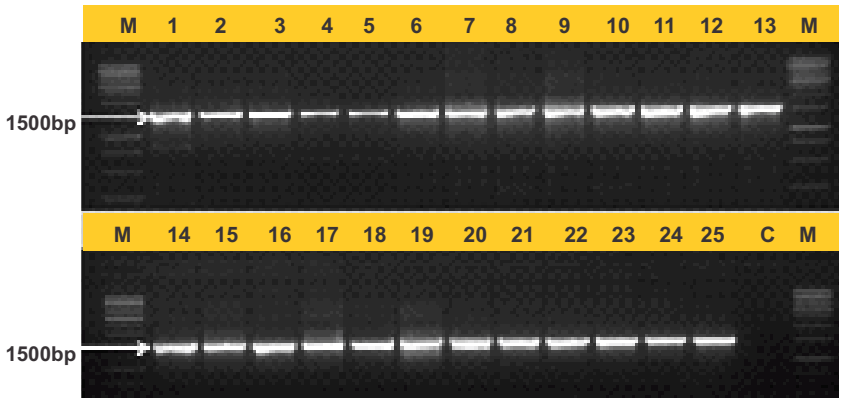


Fig. 19. PCR amplification of 1500bp amplicon of 16S rRNA gene using the primer pair 16S-1F/ 16S-1R. (Lane M=1 kb ladder, lane 1-25= Strains of Streptomyces species, C= Control

Fig. 20. Phylogenetic tree of 48 strains of Streptomyces species isolates from potato scab lesions based on 16S rRNA gene sequence. Sequences of 13 type strains were obtained from the gene bank.

Management of major soil and tuber borne pathogens of potato

Six strains of *Streptomyces* spp. isolated from deep pitted common scab (Str-2 & 8, *S.stelliscabies*, Str-17, *S.aureofasicns*), russet scab (Str-31 & 34, S. *europascabies*) and corky scab (Str-46, *S. scabies*) were evaluated for development of the disease under three different moisture regimes. Observations recorded at harvest revealed that no strain developed scab in plants grown under the minimum irrigations regime while two strains (Str-2 and Str- 46) developed scab lesions under moderate irrigation and all the six isolates developed severe scab lesions under high irrigation regime. Isolate Str-46 was the most aggressive and produced highest disease incidence (45.2%) and disease severity (9.0%) followed by Str-8 which resulted in disease incidence of 35.1% and disease severity of 7.0%. The other strains (Str- 2, 17, 31 & 34) were less aggressive and produced disease incidence between 3.3 to 18.6% and disease severity 0.7 to 3.7% (Fig. 21). The results revealed that the recommendation of providing excess irrigation from tuber initiation stage onward for control of common scab may not work for some strains of *Streptomyces* and alternate strategies need to be developed to manage the disease.

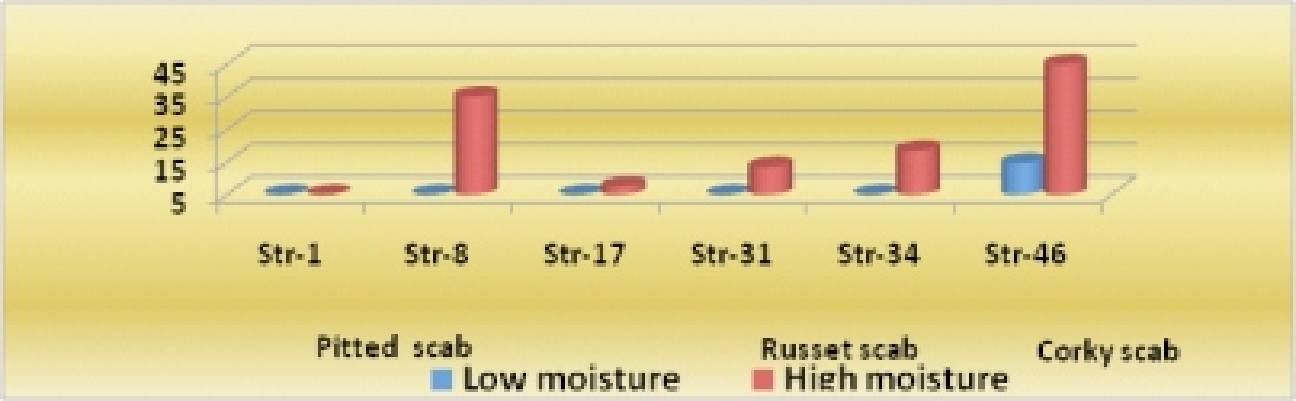
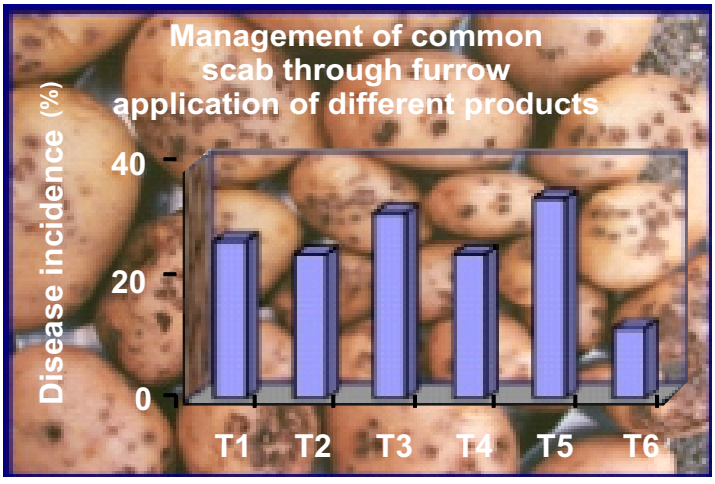


Fig. 21 Development of common scab by different strains of Streptomyces spp under different moisture regimes

A field trial to manage common scab was carried out in a scab infested farmer's field at Hoshiarpur. Application of *Trichoderma viride* @ 100 kg/ha over the seed tubers in furrows at planting significantly reduced incidence and severity of common scab. In plots applied with *T.viride* the common scab disease incidence was reduced to 12.1% as compared to 26.9% in the control. Similarly, the disease severity was reduced to 3.2% as compared to 6.7% in untreated control (Fig. 22).



T1=Untreated control; T2=Axoxystrobin 23%@ 0.1% spray; T3= Thiophanate Methyl 70% @0.3% spray; T4=Manganese sulphate @100kg/ha; T5= Boric acid @10kg/ha;T6= *Trichoderma viride* (A-7) @100 kg/ha

Fig. 22. Management of common scab through chemicals and T.viride applied at planting

In another trial azoxystrobin, thiophanate methyl, boric acid, *Trichoderma viride* (A-7), *Bacillus subtilis* (B5), manganese sulphate and gypsum were evaluated for control of both black scurf and common scab diseases as a common seed /soil treatment. Application of *T.viride (*A-7) reduced severity of black scurf from 37.4% in the untreated control to 18.5% in the treated and common scab disease severity from 23.2% in control to 4.0% in the treated. Similarly application of boric acid could reduce black scurf to 2.7% and common scab to13.0%. The other treatments could control either black scurf or common scab and not the both diseases. Results of the trial revealed that furrow application of *T.viride* (A7) or boric acid at planting were effective for the management of both common scab and black scurf diseases of potato (Fig. 23).

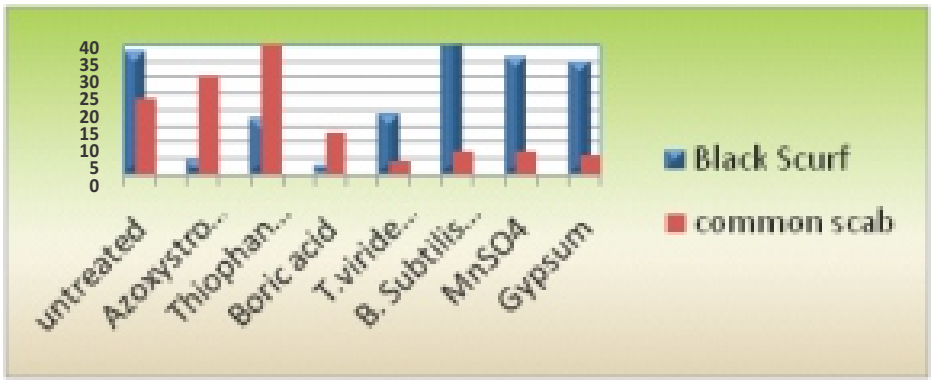


Fig. 23. Management of black scurf and common scab through a common treatment

Eight seed priming formulations were prepared and evaluated in a field trial to manage potato tuber borne diseases, sucking pests and to increase yield as a single capsule treatment. Slurry prepared by combining *Bacillus subtilis, Trichoderma viride*, PSB, Hoagland solution, vermiwash and imidacloprid was applied to the seed tubers at planting. Application of boric acid was carried out as a separate layer through a sprayer a day before planting. This prevented any decline in crop emergence which was observed in the previous year when boric acid was also added to the slurry. A significant decrease in black scurf was recorded in the tubers produced from the treated seed tubers. No significant differences were recorded in number of stems produced by the treated tubers or yield. The seed priming treatment was found not suitable for the cut seed tubers.

Heat sterilized saw dust impregnated with nutrients was applied to seed tubers by mixing with gum Arabic as an adhesive. It served as a carrier of chemicals and biocontrol agents and a good osmo-priming material to prevent anaerobic conditions around the seed tubers. *Trichoderma viride* (A-7), boric acid or azoxystobin applied to seed tubers along with the saw dust did not decrease crop emergence or yield. The combined formulation significantly reduced incidence and severity of black scurf. Application of azoxystrobin @0.06% as a component of the formulation reduced severity of black scurf to 3.5% as compared to 54.1% observed in untreated control.

A spray of 3% boric acid on seed tubers reduced soft rots to10.7% as against 26.0% observed in the untreated control tubers. A spray of Streptomycin sulphate @ 100ppm on the seed tubers was the next best treatment resulting in 12.2% soft rots as against 26.0% observed in untreated control.

Population dynamics and management of potato pests

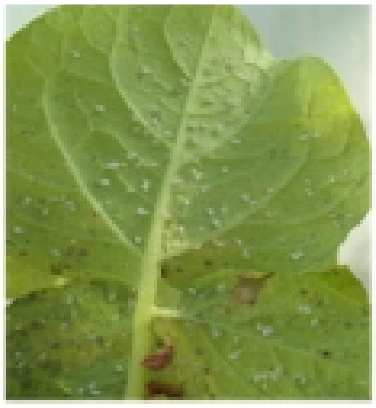
Monitoring of potato pests

Monitoring of *M. persicae* was done on forty varieties planted in last week of October at CPRIC, Modipuram. The trend obtained was similar to that of 2010-11 and 2011-12. Kufri Anand, Kufri Kundan and Kufri Safed were the ones which had 20 aphids/ leaf in second week of December 2012 (Max temp 21.2°C and min temp 10.3°C). Kufri Chipsona-3, Kufri Jawahar, Kufri Kanchan, Kufri Red and Kufri Surya were among the few which recorded more than 20 aphids/100 compound leaves till third week of December. Only variety which had number less than critical level was Kufri Girdhari.

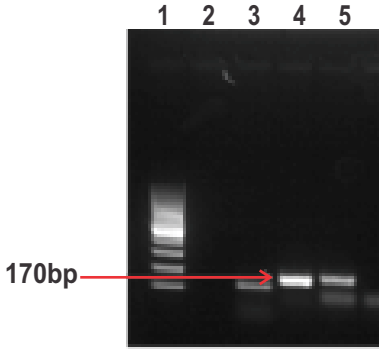
Incidence of whitefly was recorded on tomato (*Lycopersicon esculentum*), chillies (*Capsicum annuum*), brinjal (*Solanum melongena*), bhindi (*Abelmoschus esculentus)*, urd (*Vigna radiate)*, green gram (*Cicer arietinum*), tori (*Luffa cylindrical*) and bathua (*Chenopodium album)* during off season from July to September, 2012. The highest population of whitefly (11.06/plant) was recorded on tomato during first week of August followed by urd (9.6/ plant). The whitefly population remained active on brinjal crop. Subsequently, population was shifted to early potato crop.

Molecular identification of greenhouse whiteflies, *Trialeurodes vaporariorum*

Molecular studies were conducted to identify glasshouse whitefly using species specific mitochondrial COI primers. Isolation of mitochondrial genomic DNA, PCR amplification, gel extraction, DNA purification and sequencing was carried out using standard protocols. The BLAST analysis of genome sequences confirmed the identification of whiteflies as *Trialeurodes vaporariorum.*



Trialeurodes vaporariorum
Infestation on potato



Lane 1- 1kb lodder, Lane 2- water control
Lane 3,4,5- mitochondrial COI gene *T. vaporariprum*

PCR amplification of mitochondrial COI gene
of Trialeurodes vaporariprum

Molecular detection of tomato leaf curl New Delhi virus- (Potato) from single glasshouse whitefly using print-capture polymerase chain reaction (PC-PCR)

The ability of whitefly (*T. vaporariorum*) to acquire the tomato leaf curl New Delhi virus (ToLCNDV-potato) was studied by exposing healthy adults to an acquisition period of 24 hours on virus infected plants in cages. Individual fed whiteflies were macerated using micropestle in PBST buffer and printed on to nitrocellulose membrane to capture genomic DNA. The printed spots were cut into pieces and transferred to PCR tubes containing sterile distilled water and denatured. Then the eluted genomic DNA was used in a PCR assay with coat protein specific primers and a specific band of 491bp was observed. The electrophoresed product was further confirmed by elution and sequencing in ABI 3500 genetic analyzer. The BLAST analysis of nucleotide sequence revealed 99 % similarity with ToLCNDV-potato isolate Hapur segment and this confirmed viruliferous nature of *T. vaporariorum*. This finding

indicated that the greenhouse whiteflies could acquire ToLCNDV-potato and also confirms that the PC-PCR protocol can be successfully employed for molecular detection of ToLCNDV-potato in whiteflies which in turn would aid in development of timely management practices for quality potato seed production.

Similarly, a reverse transcription polymerase chain reaction (RT-PCR) assay was designed to detect Potato virus Y (PVY) in field collected aphids using the primers specific to coat protein (CP) gene. A faint band of expected size of 385bp corresponding to PVY and 580bp corresponding to aphid (internal control) was detected. The amplicons were further confirmed by sequencing and sequence showed 99% similarity with PVY CP. The aphids collected from Shillong and Modipuram gave a specific amplicon of 340bp indicating the presence of PVY, while remaining aphids from other locations were not carrying the virus.

Management of potato pests

Granular insecticides as phorate 10G (25kg/ha), carbofuran 3G (25kg/ha), fipronil 0.3G (50 @ 100 a.i./ha) and Thiamethoxam 25WG (320 g/ha) were used at the time of earthing up and quinalphos 20EC (2.5 l/ha), imidacloprid 200SL (240ml) and bifenthrin (500ml/ha) as soil drench at the time of planting against leafhopper, white grub and mite. Results revealed that all the chemicals were effective against leafhopper as only curling of the leaves was observed and there was no burning. Grubs could be found only in control plot. Mite burn was lowest in phorate (35%) and fipronil treated (40%) plots. Fipronil 0.3G@ 100 a.i./ha and carbofuran 3G@25kg gave the highest yield of 14.2t/ha. Similarly, efficacy of Emamectin benzoate 5SG (30g a.i./ha) and Abamectin benzoate 1.9EC (12 ml a.i./ha) was tested alone or in combination with spiromesifen (48 g a.i./ha) at CPRIC, Modipuram. Two foliar sprays of combination of Abamectin benzoate and spiromesifen resulted in minimum mite burn (20%) after 70 days and highest yield (15.5t/ha). Similar results were obtained at CPRS, Gwalior when two sprays of abamectin benzoate (12 ml a.i./ha) were applied.

A laboratory study was carried out to assess the effect of new molecules of insecticide against potato aphids, *Aphis gossypii* and *Myzus persicae.* The bifenthrin 10% EC recorded 94.74% percent mortality of *A. gossypii* after 24 hrs with quick knock down effect followed by ethion 50% EC with 83.72% mortality of aphids. Similar trend was observed against *M. persicae*. Other insecticides like imidacloprid and clothionidin were also effective and controlled the aphid population after 72 hrs exposure.

Efficacy of plant extracts on mortality of whitefly (*Bemisia tabaci*) and aphids (*Aphis gossypii*) was studied under lab conditions. The percent mortality of aphids and whitefly was recorded after 24, 48 and 72 hrs after spray of respective plant product extracts. The highest mortality of whitefly (65.91%) was recorded in methanol extract of Plant extract 1 followed by hexane extract (64.30%) of Plant extract 2 and methanol extract (64.03%) of Plant extract 3 after 72 hrs. However, the highest mortality (44.06%) of aphids was recorded in ethyl acetate seed extract of Plant extract 4 followed by methanol extract of Plant extract 1(40.81%) and methanol extract Plant extract 2 (40.72%) after 72 hrs. The check insecticide recorded cent percent mortality.

Management of potato nematodes

Potato cyst nematodes (PCN) *Globodera rostochiensis* and *G. pallida* and late blight (LB) disease, *Phytophthora infestans* are the major plant protection problems that seriously affect the sustainable production of potato in The Nilgiris. The occurrence of three pathotypes in each species of PCN and more virulent strains of LB organism calls for continued research activities for developing potatoes having combined resistance to these major biotic constraints. The programme aims at development of an 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, 53,200 hybrid TPS were produced from 23 bi-parental crosses involving selected late blight and potato cyst nematode resistant parents. In the F_1 generation about 12,000 true seeds belonging to 7 cross combinations were sown in boxes. Nine thousand five hundred seedlings were transplanted in field /poly house and screened under natural conditions of late blight. On maturity the seedlings were harvested and 1,011 selections were made. In initial evaluation trials, one thousand and seven hybrids were evaluated in observational rows/single hill along with K. Girdhari and K. Swarna as check varieties. Of these, 602 hybrids were selected.

Fifty three advance generation hybrids were evaluated in five replicated trials along with Kufri Girdhari and Kufri Swarna as checks. Of these, forty three hybrids were selected on the basis of agronomic traits and resistance to potato cyst nematodes and late blight. Three promising advance generation hybrids were assessed in 4 replications along with check varieties K. Swarna, K. Girdhari and K. Jyoti of which two hybrids OS/94-I-126 (33.8 t/ha) and OS/01-161 (34.4 t/ha) hold promising and were found resistant to both species of potato cyst nematodes and field resistant to late blight.

Integrated management of potato cyst nematodes

Soil solarization, combined with neem cake (5 t/ha) and *T. viride* (0.5 kg/ha) recorded the maximum yield in Kufri Giriraj (31.1 t/ha) and minimum PCN reproduction (Rf – 0.99) which was on par with solarization treatment combined with carbofuran.

Solanum tuberosum cv. Kufri Jyoti (susceptible to PCN) and Kufri Swarna (resistant to PCN) were evaluated as trap crops for PCN, 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 and recorded greater reduction in cyst population (31%) than K. Swarna (22%). In the succeeding crop K. Girdhari, the treatment with K. Jyoti as trap crop recorded higher yield (31.8 t/ha) than K. Swarna as trap crop (26.75 t/ha) (Fig. 24).

As potato cyst nematodes prefer solanaceous crops (potato, tomato, brinjal) for feeding and multiplication, various non-solacaneous crops *viz.,* cabbage, carrot, radish, beet-root, cauliflower, garlic, marigold and French-beans were evaluated on survival of PCN. Among the crops tested, radish recorded 21.8 per cent reduction in number of cysts and 12.2 per cent reduction in number of eggs per cyst. It was followed by garlic which recorded 17.9 per cent and 10.3 per cent reduction in number of cysts and eggs, respectively (Fig. 25).

To eradicate PCN, various management options *viz.,* chemical, non-chemical and integrated management were evaluated in resistant cultivar Kufri Neelima. Integration of chemical and non-chemical management options significantly recorded higher yield (23.29 t/ha) and lower nematode reproduction (Rf-1.03) (Fig. 26)

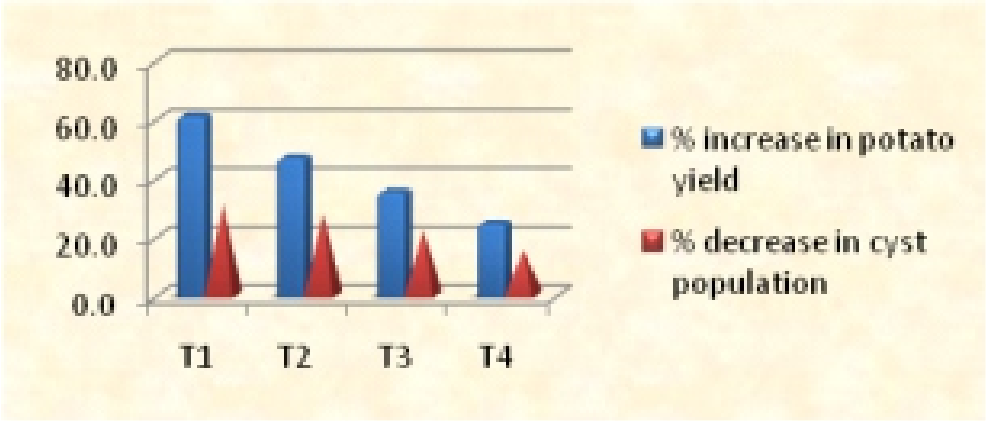


Fig. 24. Evaluation of trap crops on PCN and succeeding potato crop yield

[T1 – Kufri Jyoti (60 x 20 cm^2); T2 – Kufri Jyoti (45 x 15 cm^2); T3 – Kufri Swarna (60 x 20 cm^2); T4 – Kufri Swarna (45 x 15 cm^2); T5 – Control]

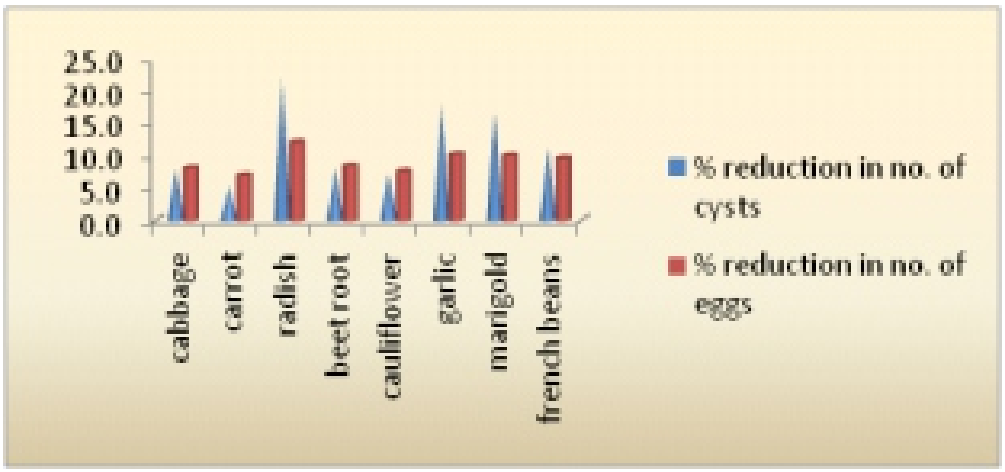


Fig. 25. Effect of non-host crops on PCN cysts and eggs

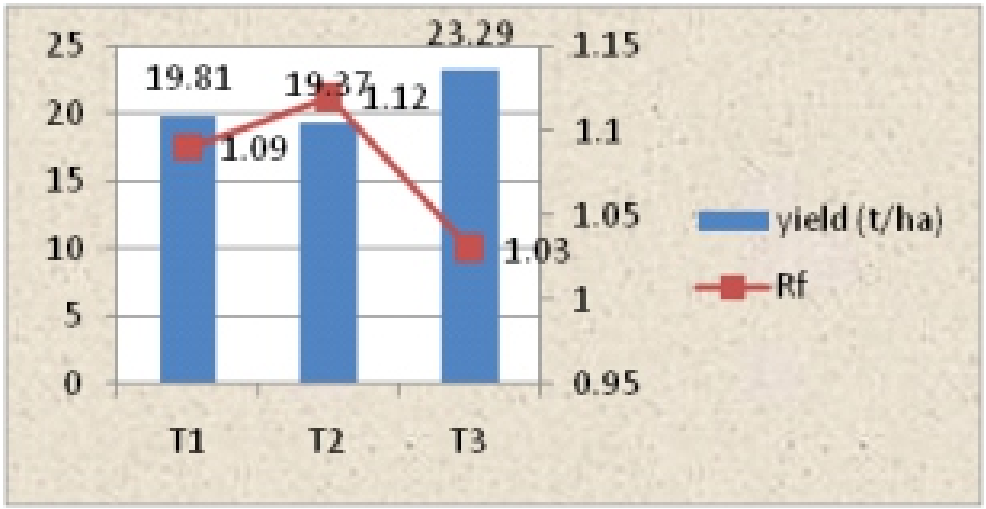


Fig. 26. Evaluation of various management options for eradication of PCN

Non-solanaceous crops *viz.,* marigold (*Tagetes* sp) and radish (*Raphanus sativus*) were evaluated in potato based intercropping systems. Both the intercrops were found effective in restraining the proliferation of PCN population. Radish was more effective than marigold in PCN control because, the Rf value of PCN in the plots intercropped with radish is lower when compared with that of marigold intercropped plots. However, marigold in 2:1 row proportion was effective in bringing down PCN population in K. Jyoti a susceptible variety from Rf value of 1.51 to 1.14 (Fig. 27).

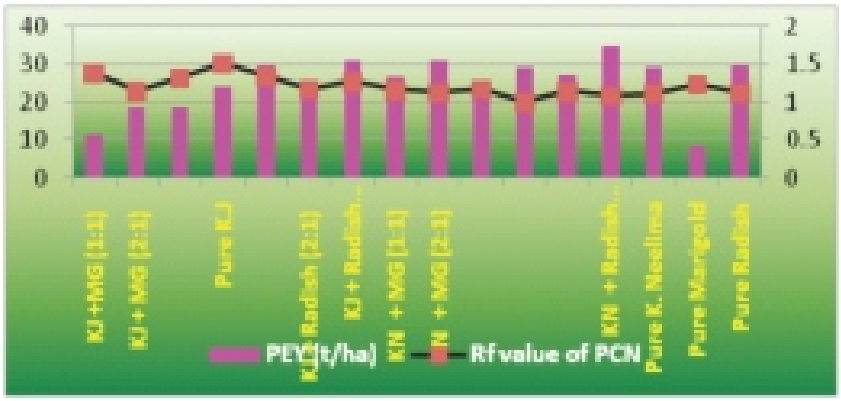


Fig. 27. Effect of potato based intercropping systems on PCN dynamics (KJ : K Jyoti, KN : K Neelima)

Division of Crop Physiology, Biochemistry & Post Harvest Technology

Nutritional value of potato and potato products

Sugars and starch fractions in cooked potato tubers

Starch foods cooked at high temperature in excess water contain high levels of Rapidly Digestible Starch (RDS). Low temperature storage of such foods is reported to decrease the RDS content and increase the Resistant Starch (RS) contents. Therefore, an experiment was conducted to determine the extent of decrease in RDS and increase in RS in cooked potatoes stored at low temperatures. In this experiment three cultivars viz. Kufri Bahar, Kufri Jyoti and Kufri Sindhuri, three cooking methods viz. boiling, pressure cooking and microwave cooking, three storage temperatures viz. -20, 4 and 12^{0}C, and three storage durations viz. 12, 24 and 48 h were used.

Reducing sugars content was significantly higher in Kufri Bahar and the sucrose content was significantly higher in Kufri Jyoti. Changes in reducing sugars and sucrose contents varied with the cooking method and cultivar. The reducing sugars and sucrose contents increased when cooked tubers were stored at low temperatures (Fig.1 and 2). Starch content

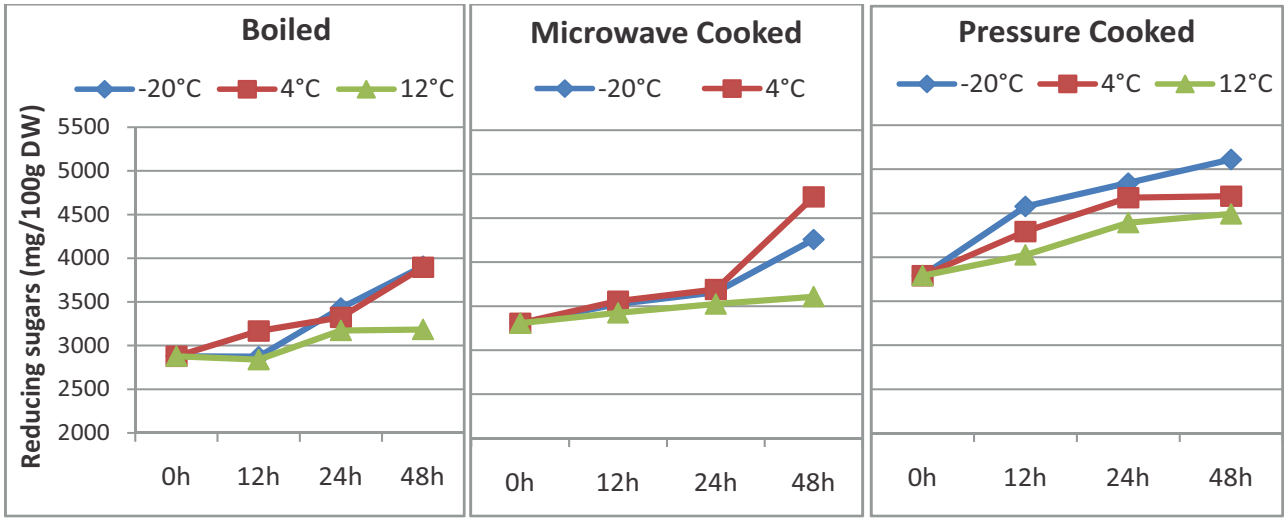


Fig. 1. Changes in reducing sugars content (mg/ 100g DW) in potato tubers cooked by different methods and stored at different temperatures (cv. Kufri Bahar)

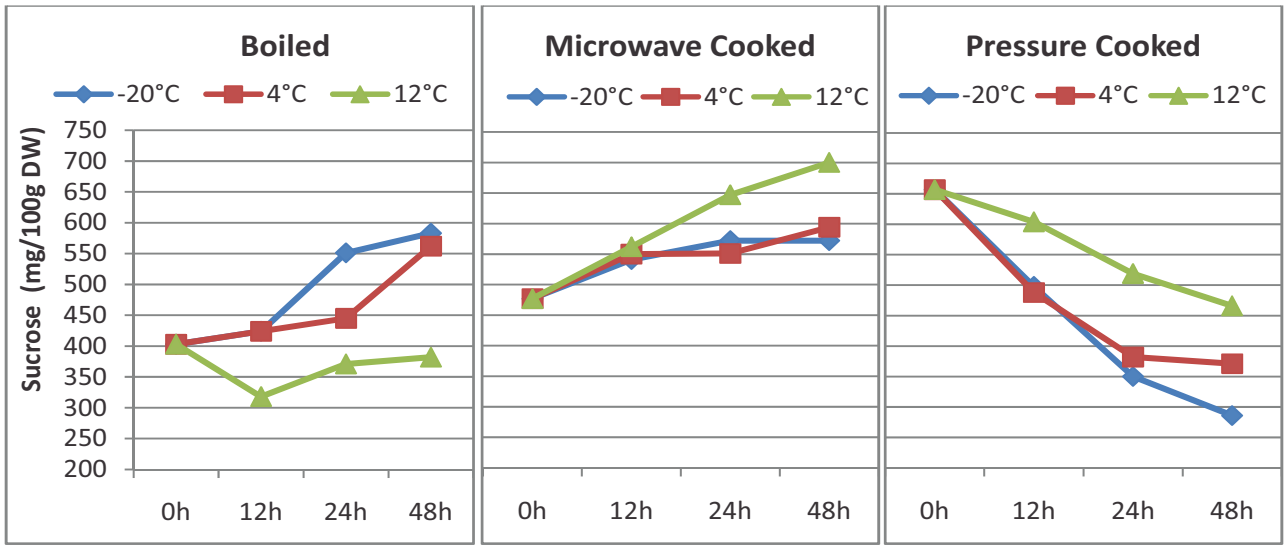


Fig. 2. Changes in sucrose content (mg/ 100g DW) in potato tubers cooked by different methods and stored at different temperatures (cv. Kufri Bahar)

decreased in boiled and microwave cooked tubers (Fig.3) RDS content was high in boiled (58%), microwave cooked (51%) and pressure cooked (54%) tubers of Kufri Bahar but decreased when stored at low temperature (Fig.4). The decrease was more in boiled tubers stored for 24 h at -20^{0}C (13%) and 4^{0}C (15%). This decrease in RDS content was accompanied by an increase in RS content. The increase in RS content in boiled tubers of Kufri Bahar stored for 48 h was 67, 63 and 64% at -20, 4 and 12^{0}C, respectively (Fig.5). These results indicate that cool storage of cooked potatoes for up to 48 h can result in lower levels of RDS and higher levels of RS leading to improved nutritional value.

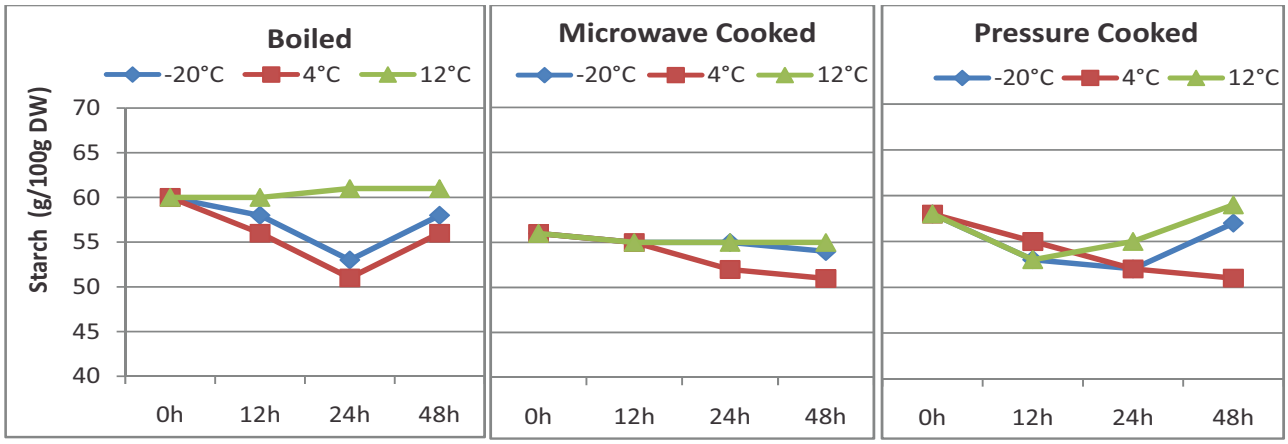


Fig. 3. Changes in starch content (g/100g DW) in potato tubers cooked by different methods and stored at different temperatures (cv. Kufri Bahar)

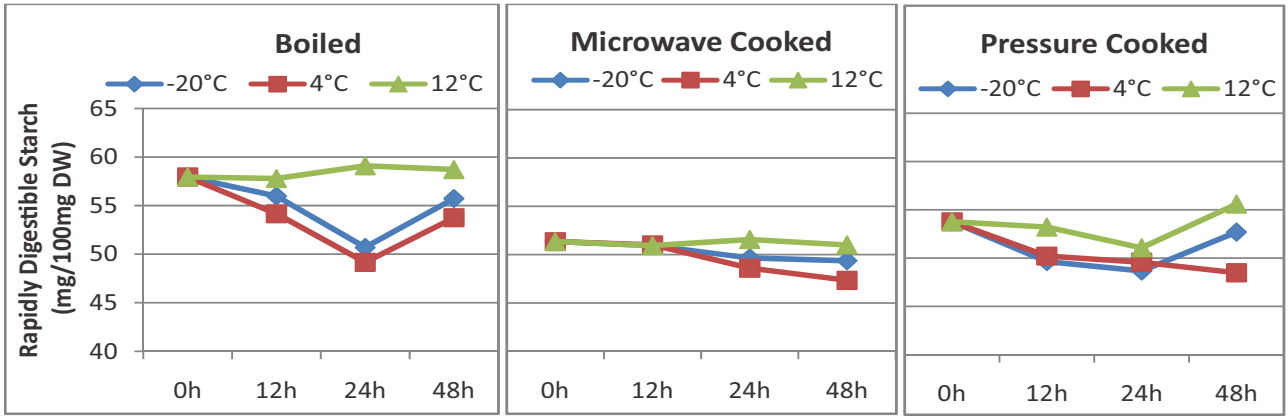


Fig. 4. Changes in rapidly digestible starch content (mg/ 100mg DW) in potato tubers cooked by different methods and stored at different temperatures (cv. Kufri Bahar)

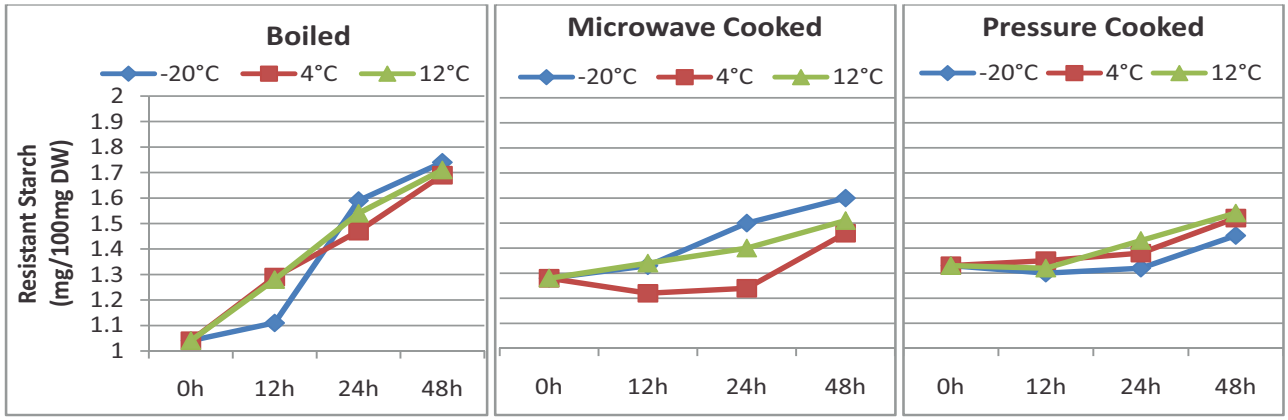


Fig 5. Changes in resistant starch content (mg/ 100mg DW) in potato tubers cooked by different methods and stored at different temperatures (cv. Kufri Bahar)

Nutrients Content in Indian potato varieties : Tubers of forty four Indian potato varieties were analyzed for ascorbic acid and protein content before storage and after 90 and 180 days of storage (DOS) at 10-12^{0}C. The ascorbic acid content varied from 13 (Kufri Sutlej) to 26 mg/100g tuber FW (Kufri Surya, Kufri Sindhuri). The ascorbic acid content decreased after 90 and 180 DOS. At 90 DOS highest decrease in ascorbic acid content was observed in Kufri Khasigaro (52%) followed by Kufri Giriraj (51%). At 180 DOS also, maximum decrease in ascorbic acid content was observed in Kufri Khasigaro (69%). The protein content varied from 143 (Kufri Naveen) to 299 mg/100g FW (Kufri Arun). The protein content decreased after storage but the decrease was less as compared to that in ascorbic acid. Maximum decrease at 90 DOS was observed in Kufri Khasigaro (28%) and at 180 DOS the decrease was 22% in Kufri Lalima and Kufri Kundan.

Nutritional compounds in potato tubers : Freshly harvested potatoes were analysed for anti-oxidants viz. ascorbic acid, anthocyanin and total carotenoids. The ascorbic acid content was highest in Kufri Chipsona-1 followed by Kufri Lalima. The Anthocyanin content was maximum in Kufri Chandramukhi, followed by K. Ashoka, whereas, the carotenoids were highest in Kufri Chipsona-2 and were minimum in Kufri Khayati (Fig. 6).

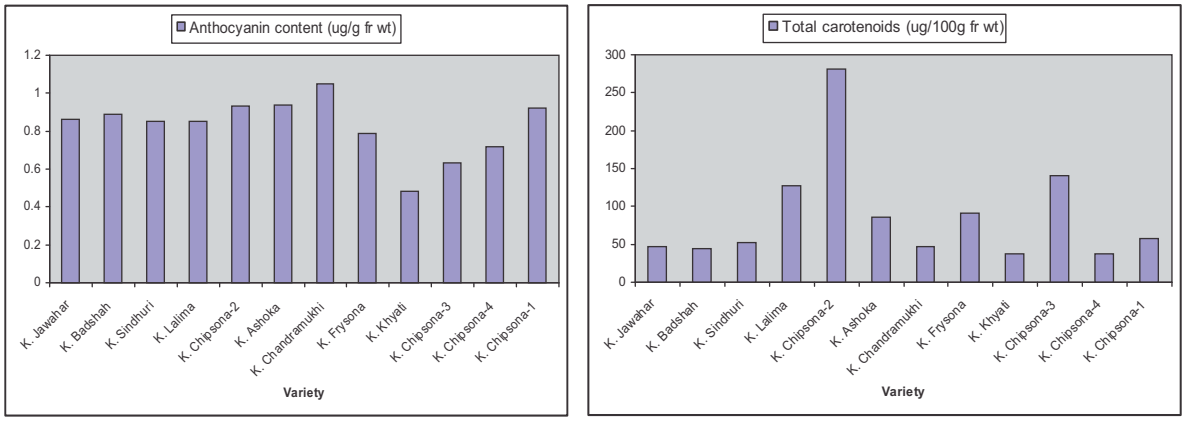


Fig. 6. Anthocyanin and total carotenoids in potato tubers

Glyco-alkaloids in freshly harvested potatoes : Potato tubers are known to contain nitrogenous steroidal glycosides, called glyco-alkaloids. The potato glyco-alkaloids solanine and chaconine were detected in peels of freshly harvested tubers. The maximum concentration of solanine was observed in Kufri Badshah followed by Kufri Pukhraj, whereas, the minimum concentration was observed in Kufri Jyoti (Fig. 7). The chaconine content was also highest in Kufri Badshah and lowest in Kufri Jyoti.

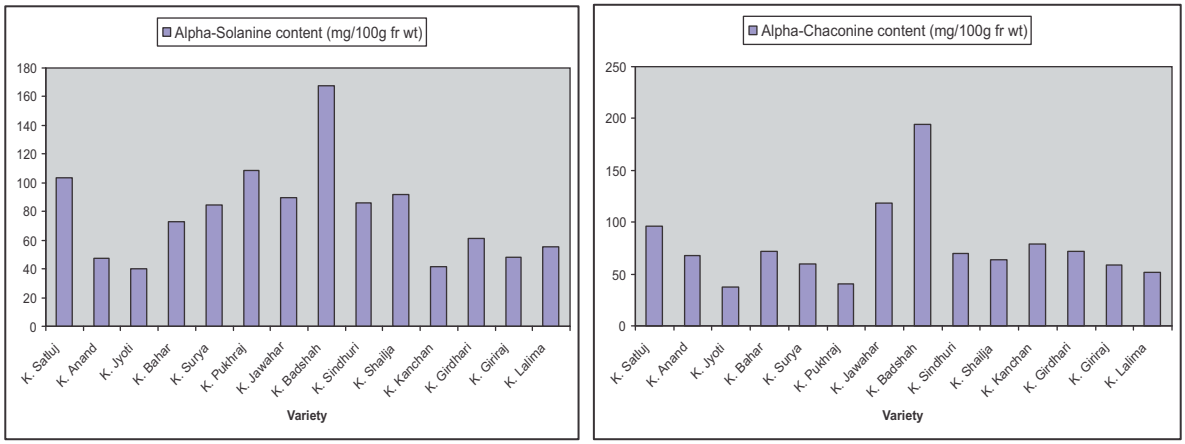


Fig. 7. Glycoalkaloid content (mg/100g FW) in potato peels of tubers

Biochemical constituents in peels and flesh of potato: Twelve commercial varieties were analysed for biochemical constituents *viz*. total phenols, vitamin-C, reducing sugar, sucrose and free amino acids in peels and flesh. Results confirmed last year's findings that peels are rich source of

antioxidants (phenol and vitamin-C) while concentrations of reducing sugars and free amino acids was higher in the flesh.

Development of minimal frying/ microwaveable frozen potato products: On the basis of last year's results of osmotic dehydration (OD) experiment, the best treatments were further evaluated in combination with anti-browning chemicals *viz.* potassium metabisulphite (KMS) and sodium citrate. An experiment was done with eleven treatment combinations of NaCl (1%), sucrose (7.5 and 15%), KMS (0.5%), sodium citrate (0.5%), and ascorbic acid (1, 2 and 3%) with heap stored potatoes of Kufri Chipsona-1. Freshly cut fries were dipped in different solutions (sample: solution ratio 1:4) for 4 hrs, washed in water, extra moisture was blotted off, frozen for 24 hrs and fried for 1.5 minutes at 180°C. Weight loss in fry cuts after OD ranged between 16.91 and 27.10% and solute gain ranged between -1.052 and 4.113%. Solute gain was higher in OD treatments with 15% sucrose and maximum (4.113%) was recorded in treatment with 3% ascorbic acid. Organoleptic evaluation of fried frozen products recorded acceptable colour and taste with 1% NaCl + 7.5% sucrose + 0.5% KMS + 0.5 % sodium citrate + 1% ascorbic acid (Table 1). Salt and sugar taste was appropriate in all treatments and taste was good due to sour-sweet taste. There was no need to put additional salt. The oil content in the finished fried OD product was significantly low (2.5-4.25 %) compared to frozen French fries (16.9%). Though the OD products were less crispy as compared to French fries, still significantly low oil content and higher nutritive value can be of much importance for older generation and calorie conscious people.

Table 1. Evaluation of osmotically dehydrated (OD) frozen fried products made from potatoes stored in heaps for 3-4 months (cv. K. Chipsona-1).

Treatments	*Wt loss (%)	* Solute gain(%)	Dry matter (%)	** Reducing sugars	** Sucrose	** Phenol	** Free amino acids	** Vit-C	Oil content (%)	*** Colour	Taste
1% NaCl + 7.5% Sucrose	16.91	-2.353		88.4	1185.4	172.9	1572.8	13.46	3.25	2.25	Acceptable
1% NaCl + 7.5% Sucrose +0.5% KMS	17.17	-1.052	36.2	246.7	1232.6	163.9	1498.0	18.71	2.5	1.75	Acceptable
1% NaCl + 7.5% Sucrose+0.5% KMS + 0.5 %Sod. Citrate + 1%Ascorbic acid	18.78	-0.247	46.4	170.2	3892.8	254.7	1228.6	528.70	3.85	2.25	Good
Control-water dip	19.32	0.026	34.3	478.0	552.2	179.1	1079.0	14.44	2.45	3.0	Unacceptable
Raw Tuber			21.2	50.4	325.2	115.9	903.7	12.14	-		

* Recorded in French fry cuts following OD, **mg/100g FW in the final fried product, ***Colour up to 4.0 was acceptable,

Efforts were made to reduce the oil content and to improve the texture of oven cooked fries, while maintaining the taste and sensory quality characters. Cooking in microwave oven in convection mode for different durations (5-17 minutes) and different temperatures (150-230°C) was tried. Convection for 15 minutes at 180°C showed the best results with respect to improvement in crispness of the French fries. Taste analysis showed that final fries were found acceptable in colour (better than final fried) and taste with significantly low oil content (4.49%) compared to final fried frozen French fries (16.04%). Cooking in convection mode helped to improve the texture of fries compared to microwave mode evaluated last year.

Fractionation of potato stem and leaf : Dry matter varied from 7.18 to 21.35 % with minimum and maximum values in stem and leaf fibre, respectively. Leaf (20.12 %) and stem coagulum (19.77 %) almost gave similar dry matter. The efficiency of extraction of fibre and coagulum was assessed by taking the known amount of leaf and stem (1000g). The juice obtained after pressing leaves and stems was subjected to heat to 80°C to obtain coagulum and whey. Per cent recovery obtained in fractionated portion of leaf and stem varied from 2.3 to 73 %. Leaf fibre and stem fibre portion provided 26 and 43.9 (%) recovery. Whereas, for leaf and stem coagulum it was 7.05 and 4.2 %, respectively.

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

Potatoes for specific end use must be stored according to their requirements to minimize loss in quantity and quality. This programme aims to provide a method for sprout inhibition using a compound which is naturally occurring, has low mammalian toxicity and does not impart an unpleasant taste/odour to treated potatoes and adversely affect the processing quality. Physiological and hormonal changes associated with dormancy release and during storage are being investigated for better understanding of the underlying processes in potato tubers.

Use of growth retardants to prolong dormancy and improve the processing quality of potatoes

Foliar spray of paclobutrazol, a gibberellin bio-synthesis inhibitor, increased the dry matter content, decreased the reducing sugar and sucrose content and improved the chip colour of potatoes at harvest (Table 2), but had no effect on the sprouting behaviour of tubers. While, dip treatment with paclobutrazol significantly reduced sprouting, sprout growth and total losses in cv. Kufri Lauvkar up to 90 days of storage in heaps.

Table 2. Effect of foliar spray of paclobutrazol on processing quality of potatoes at harvest (cv. Kufri Lauvkar)

Treatment (Concentration/time of spray)	Dry matter (%)	Reducing sugar (mg/100 g fr wt)	Sucrose (mg/100 g fr wt)	Chip colour score
1000 ppm/6 weeks before harvest	20.3	153.9	271.6	4.5
1200 ppm/6 weeks before harvest	20.6	125.8	260.7	4.5
1400 ppm/6 weeks before harvest	19.4	108.4	244.4	5.25
1000 ppm/4 weeks before harvest	18.6	178.1	270.8	5.5
1200 ppm/ 4 weeks before harvest	20.5	163.0	326.7	5.25
1400 ppm/4 weeks before harvest	20.0	199.7	313.5	6.0
Control (water spray)	18.9	235.2	365.5	7.25

Sprout inhibition in potatoes with naturally occurring compounds

Continuous vapour treatment of potatoes with salicylaldehyde (300-600 ppm) induced complete sprout inhibition up to 75 days of storage at 24°C (Fig. 12). A concentration of 300 ppm gave the best results with reduced rotting (3.6%) and total losses (12.5%) in potatoes. Salicylaldehyde treatment had no effect on sugar contents and the chip colour of potatoes. Taste/flavour of potatoes treated with lower concentration (300 ppm) was at par with the control.

Sprout suppression in potatoes with plant essential oils

Four essential oils extracted through hydro distillation, were evaluated for sprout suppression at 18°C and 85% relative humidity at two concentrations (1% and 5%) in cold stored tubers of cv. Kufri Chipsona-1. Tuber treatment with Mentha oil (5%) induced significant sprout inhibition without any increase in rotting in potatoes as compared to control (Table 3).

Fig. 12. Treated (salicyaldehyde-300 ppm) v/s control potatoes after 75 days of storage.

Table 2. Sprout suppression effect of plant essential oils after 65 days of storage at 180C.

Name of essential oil	Maximum sprout length (cm)		Rotting %	
Treatment (conc.)	1%	5%	1%	5%
Mentha oil	0.00	0.00	36.66	20.00
Palmrosa Oil	1.23	1.79	60.00	40.00
Anise Oil	0.68	0.74	56.66	60.00
Celery oil	1.53	1.69	70.00	53.00
Control	2.28	2.28	20.0	20.0
CD at 5%	0.60	0.61	2.56	2.56

Seed dormancy enhancement under diffused light storage

Seed tubers of two potato varieties treated with commercial formulation of 1,4-dimethylnaphthalene (1,4 DMN) named 1,4 Seed in four concentrations were stored under diffused light. By 180 days, all the treated and control tubers had almost 100% sprouting. Number of sprouts/tuber, length of sprouts and the sprouting index were reduced in treated tubers. The tubers were planted in the field and the seed vigour was estimated. A 20 ppm concentration of DMN was sufficient to delay sprouting in seed potatoes under diffused light, as the number of tubers and the tuber yield increased till 20 ppm treatment (Fig. 2).

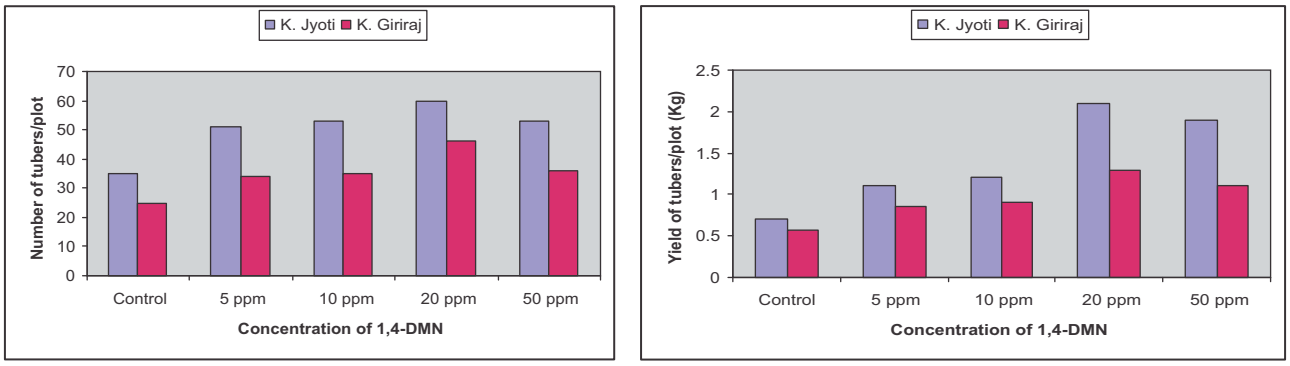


Fig. 13. Yield attributes in seed tubers as affected by 1,4-dimethylnaphthalene

Residues of 1,4-DMN in relation to dormancy release

Three potato cultivars treated with four concentrations of 1,4-DMN were stored at 18°C and 85% relative humidity and periodical observations on dormancy release and sprouting were recorded along with analysis for DMN residues on the tuber skin. Kufri Giriraj showed chitting after 90 days of harvest, followed by Kufri Jyoti (110 days) and Kufri Girdhari (150 days). Analysis at 0 day (immediately after treatment) showed varied levels of residues with higher concentrations in high doses of treatment (Fig. 13). After 120 days, the residues reduced drastically. In untreated tubers, the residues were higher in Kufri Girdhari (0.52 ppm), followed by Kufri Jyoti and Kufri Giriraj (0.37 and 0.19 ppm, respectively), which were well related with the end of dormancy in these cultivars.

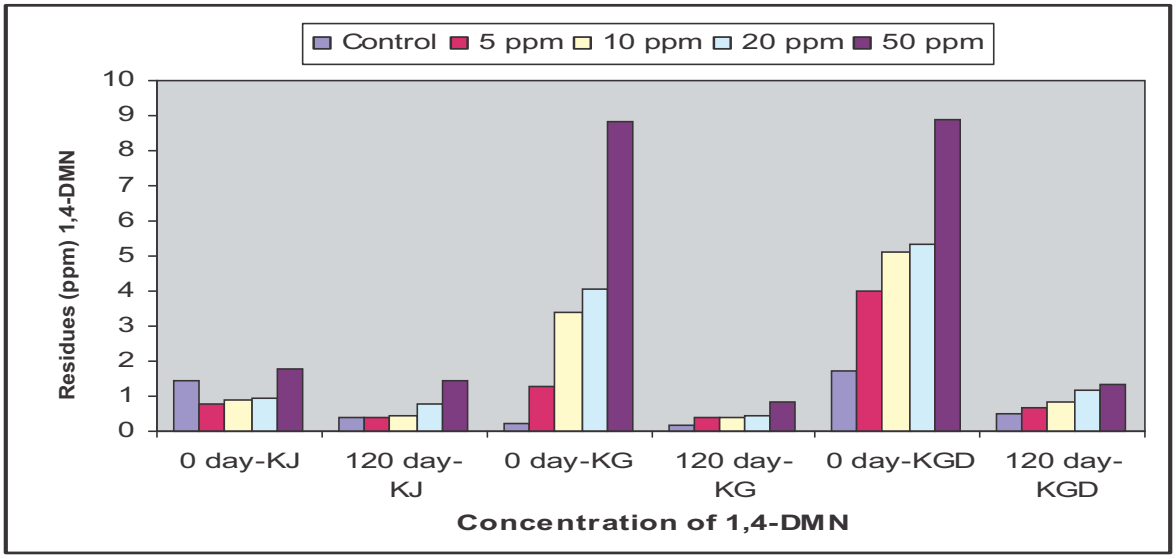


Fig. 14. DMN residues in three potato varieties in response to the treatment (KJ = Kufri Jyoti, KG = Kufri Giriraj, KGD = Kufri Girdhari)

Storage of processing varieties in heaps

Six Indian and one exotic processing cultivar raised in North-western plains were evaluated under heap storage up to 90 days. Chip and the fry colour at harvest was either unacceptable or at the borderline of acceptance. Reducing sugar contents decreased by 23%, the colour improved during storage and became highly acceptable in all the cultivars. Out of these, Kufri Chipsona-1 and Kufri Surya recording lower storage losses (<7%) (Fig. 15), can meet the short-term needs of the processing industry with 1/4th of the refrigerated storage cost.

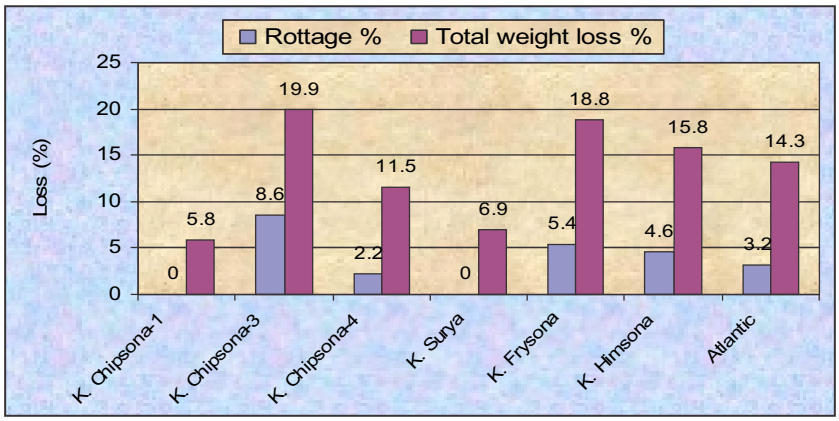


Fig. 15. Losses in processing varieties up to 90 days of storage in heaps

Evaluation of potato varieties for export

Processing quality of five varieties raised in North-western plains was studied after harvest at ambient temperatures with CIPC treatment. CIPC treated potatoes of Kufri Chipsona-1 and Kufri Surya recorded low reducing sugar contents and made good colour chips up to 60 days after harvest (Fig. 16). Freshly harvested potatoes of these two cultivars with lower total losses (<7.0%) can be exported as table as well as processing potatoes whereas Kufri Jyoti, Kufri Pukhraj and Kufri Bahar with total losses up to 8.5 % were suitable for only table purpose.

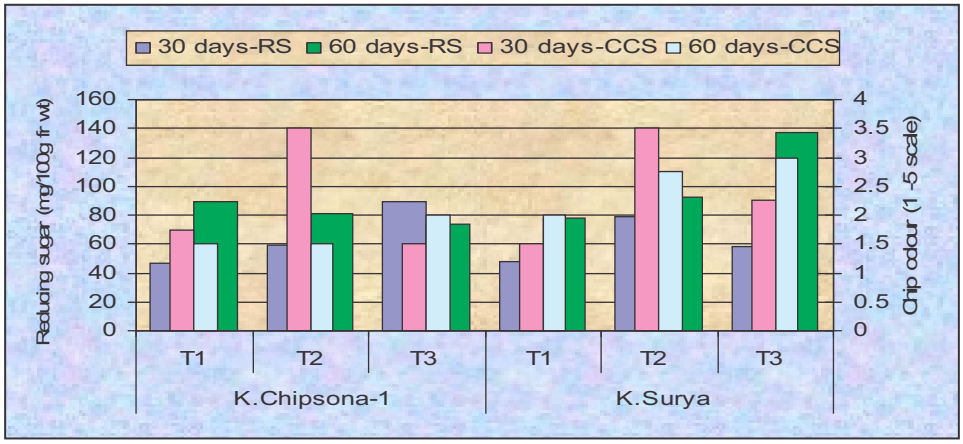


Fig. 16. Reducing sugar contents (RS) and chip colour score (CCS) in two potato varieties after harvest with CIPC treatment. T1= 25 mg a.i. kg^{-1} tubers, T2= 30 mg a.i. kg^{-1} tubers, T3= Untreated.

Reducing sugar contents in potatoes stored in cold storage (2-4°C) for 5 months were very high (861-1431 mg/100g fresh weight). The contents decreased at ambient temperatures after removal from the cold storage but the chip colour remained unacceptable in all the 5 varieties. Only two varieties (Kufri Chipsona-1 and Kufri Surya) with reduced total losses (<10% up to 45 days) can be exported as table potatoes after treatment with CIPC.

Storability and processing quality of potatoes as affected by pre-harvest factors

Effect of tuber maturity and curing of skin on storage parameters was evaluated at 4 and 12°C in three potato cultivars harvested at two maturity dates with/without a curing period of 15 days following haulm cutting. Haulm cutting prior to harvest significantly reduced losses compared to direct harvest (Table 4). Weight loss in potatoes was minimum in treatments harvested at full maturity

Table 4. Effect of tuber maturity and curing on weight loss and reducing sugar contents in potatoes stored at 4 and 12°C (Values are mean of three cultivars).

Treatment	Storage period/ temperature							
	60 days		120 days		180 days		300 days	
	4°C	12°C	4°C	12°C	4°C	12°C	4°C	12°C
	Weight loss (%)							
Mature	1.7	3.9	2.3	5.3	4.1	7.9	5.6	11.2
Mature + cured	1.4	3.5	2.1	4.8	3.6	7.3	5.7	10.0
Immature	1.6	4.0	2.5	5.4	4.2	8.4	6.3	13.2
Immature + cured	1.4	3.8	2.3	5.1	4.0	7.8	6.2	11.6
	Reducing sugar (mg/100g fresh weight)							
Mature	325	137	446	173	496	207	625	462
Mature + cured	370	130	459	150	517	201	656	553
Immature	410	136	470	154	507	204	675	594
Immature + cured	405	144	517	203	550	264	750	611

after the curing period (T2). Mature and cured potatoes of Kufri Chipsona-1 and Kufri Jyoti could be stored at 12°C for table purpose up to 300 days with acceptable losses (<10%) and minimum sugar accumulation, while cv. Kufri Pukhraj could be stored upto 180 days.

Lipid peroxidation during ageing and at low temperature storage

Malondialdehyde occurrence is considered a useful biomarker to assess lipid peroxidation. Malondialdehyde content increased with duration of storage and was found higher at 4°C than at 12°C (Fig. 17). Out of three cultivars, Kufri Pukhraj recorded higher malondialdehyde content before storage (0.204 nmol.ml^{-1}) than Kufri Jyoti (0.070 nmol.ml^{-1}) and Kufri Chipsona-I (0.053 nmol.ml^{-1}). Even up to 180 days of storage, lipid peroxidation was highest in Kufri Pukhraj and lowest in Kufri Chipsona-1.

Results are well related to the keeping quality of the three cultivars as Kufri Pukhraj is considered an average keeper. Also cold induced sweetening of potato during prolonged storage is highly correlated with increased peroxidative damage.

Ascorbate peroxidase activity during storage

Higher ascorbate peroxidase activity was recorded at 4°C compared to 12°C (Fig. 18), showing thereby greater formation of active oxygen species at relatively lower temperature storage. Varieties behaved differently during storage and cv. Kufri Chipsona-1 recorded highest activity at 60 days of storage at 4°C and lowest activity was recorded in Kufri Pukhraj after 150 days of storage at 12°C.

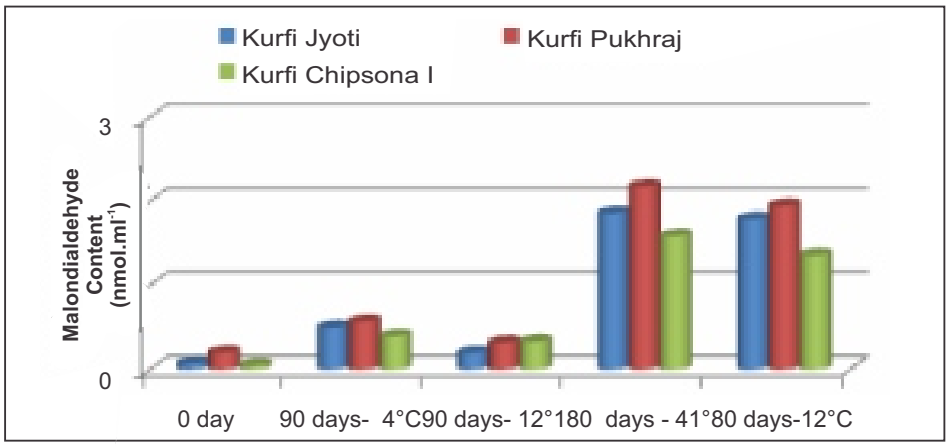


Fig. 17. Changes in malondialdehyde content during storage at 4°C and 12°C

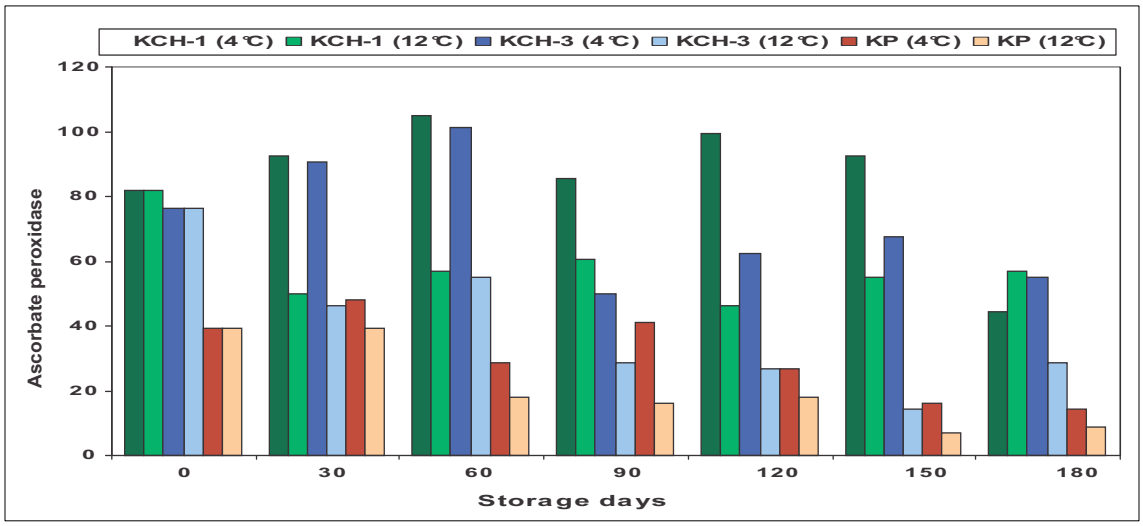


Fig. 18. Changes in ascorbate peroxidase activity during storage at 4 and 12°C. KCH-1= Kufri Chipsona-1, KCH-3=Kufri Chipsona-3, KP= Kufri Pukhraj.

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

Hybridization and Evaluation of clones for heat tolerance

Ninety three crosses were attempted at Kufri, out of which 58 were successful and yielded 66049 seeds. During winter 44 successful crosses at Modipuram yielded 82495 seeds. Seedlings were raised from 40781 seeds of 27 crosses and 432 selections were made based on tuber characters like size, color, shape, synchrony, eye depth etc. At Shimla 2200 seeds from 12 crosses were screened in a heated glass house and 319 selections were made (Fig. 8). 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.

Fig. 8. Photograph of a non-tuberizing and a tuberizing seedling in the glass house

Confirmation of heat tolerance in advanced hybrids under controlled conditions

Six advanced hybrids were tested for their ability to tuberize at 24C° night temperature by leaf bud cutting technique. Sessile tuber formation was observed only in HT/07-239, whereas, amongst controls, only Kufri Surya showed sessile tuber formation. At 22C night temperature also, the best performance was obtained in HT/07-239 (Fig. 9). The tuber weight was found to be the highest in hybrid HT/07-239 (700mg) compared to control K. Surya (148mg). The results clearly depict the heat tolerance attribute of this hybrid HT/07-239.

Fig. 9. Tuberization on leaf bud cuttings in Heat Tolerant hybrid HT/07-239

Night temperature and tuberization

Effect of night temperature was studied in K. Surya and Kufri Chandramukhi using leaf bud cuttings at 18, 24 and 26 C day/night temperature. Leaf buds provided with 18C gave the best results for tuberisation in the form of sessile as well as stolonised tubers. At 24C, the tuberisation was seen only in K. Surya, whereas in K. Chandramukhi few tubers on stolons could be observed. At 26C, no tuberisation was encountered in both the varieties. This showed that Kufri Surya has heat tolerance ability and can tuberize up to 24C and not beyond that.

Evaluation of primary CRFs of paclobutrazol for dwarf plant architecture and productivity in potato

Two controlled release formulations (PP-10 and PS-10) developed in collaboration with IARI were evaluated during early crop. The treatments were finalized on the basis of previous results where in foliar use of paclobutrazole (10 ppm) was effective in changing the plant architecture and enhancing yield. In the case of CRFs, treatments of seed tuber dip were also added and Kufri Surya was planted during heat stress conditions and foliar spray was applied at 35 DAP . The farm grade plant growth regulator (CULTAR having Paclobutrazole 25%W/V, from Syngenta) was also used along with CRFs.

Germination at 30 DAP was reduced to about 70 % in all the concentration of CRFs when used as seed treatment as compared to control. Effect of delayed canopy development was reflected in low tuber yield in all the treatments involving seed treatments. Among foliar applications 5.0 ppm concentration of both the formulations was effective probably due to their slow release action and improved yield of marketable tubers as well as total TY significantly. Effect on the yield of small tubers and also on the harvest index was non significant. The present findings suggest that CRFs application through seed treatments are not effective and results of foliar sprays are indicative which needs further confirmation.

Performance of Kufri Surya during early planting at Jalandhar

Kufri Pukhraj is the predominant variety grown during early planting in Jalandhar and surrounding areas. Since CPRI has released heat tolerant variety Kufri Surya, which is suitable for early planting in NW plains, this experiment was designed to evaluate performance of Kufri Surya *vis-a-vis* Kufri Pukhraj. Treatments consisted of three dates of planting *viz.*, 5th, 12th and 24th September and three dates of harvesting 60, 67 and 74 days after planting. Plot size was 3 X 3 m and spacing was 60 X 20 cm. Recommended fertilizer dose and other cultural practices were followed for raising the crop. Design was split plot with three replications. There was severe hopper burn in Kufri Pukhraj while K. Surya had negligible damage on this account. Tuber yield increased in both the varieties with advancing date of planting as well as date of harvesting. Kufri Surya out-yielded K. Pukhraj at first date of planting and all harvesting dates. On second date of planting Kufri Surya had little yield advantage. At third date of planting Kufri Pukhraj out yielded Kufri Surya at all dates of harvest. The proportion of small non-marketable tuber was low in Kufri Surya at first and second date of planting and at par with K. Pukhraj at third date of planting. Kufri Surya had yield advantage over Kufri Pukhraj if planted early in September (Fig. 10). As the planting is delayed this advantage is reduced and ultimately lost during late September planting.

Performance of advance stage genotypes at Ladol (Gujarat) and Pune (Maharashtra) 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

Fig. 10. Tuber yield of Kufri Surya and Kufri Pukhraj at 60 DAP during early planting

highest total tuber yield (27.3 t/ha) which was significantly higher than controls, Kufri Surya (21.9 t/ha), Kufri Badshah (23.8 t/ha) and Kufri Lauvkar (18.6t/ha). Foliage maturity was late in all the hybrids compared to controls. At Pune four advanced hybrids were evaluated along with three controls varieties in replicated under *Kharif* planting season at 90 DAP. None of the hybrid and control found to be promising however, advance hybrid HT/6-97 produced highest total tuber yield (9.3 t/ha). At this location, seven parental lines were also evaluated in duplicate row trial and CP1765 (22.62 t/ha) and CP3379 (21.69 t/ha) were found to be promising.

Screening for drought tolerance

A total of 30000 seed from 25 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., 880 clones each with 3-5 tubers were selected in WS 2011 series.

Evaluation of potato hybrids for drought tolerance

Four hybrids (WS/2005-108, WS/2005-152, WS-2005-146 and WS/2005-137) selected for drought tolerance were evaluated along with three control varieties viz., K. Lauvkar, Kufri Pukhraj, K. Arun under water stress. Control plots (T1) were irrigated when evaporation in the open pan reached 20 mm and stress treatment was (T2) was irrigated at 35 mm. One stress treatment was given at 60 DAP. Before and after stress treatment all the plots were irrigated at 20 mm open pan evaporation. The crop was harvestedat 90 DAP. There was 9-27% reduction in yield due to water stress. Two hybrids WS/2005-108 and 137 yielded better than all the three controls under control as well stress treatments. Yield reduction due to stress in these hybrids was 19-26% compared to 13-24% for controls. These hybrids were also evaluated at Modipuram at three moisture regimes viz. 0.20-0.25, 0.40-0.45 & 0.60-0.65 bars soil moisture tension at 15 cm soil depth. WS 108, 119, 137, 146 and 152 produced higher yield at all irrigation levels in comparison to popular variety Kufri Pukhraj. Based on the performance of hybrids at two locations WS/05-146 and WS/05-108 were selected for further studies.

Variety specific minimum thresh-hold water requirement of potato

Twelve potato varieties were evaluated at 15, 20, 25 and 30mm CPE irrigation. The effect of irrigation levels and varieties was significant on yield and tuber numbers. Potato cultivars viz. Kufri Bahar, Kufri Pukhraj, Kufri Anand, Kufri Khyati, Kufri Sadabahar, Kufri Surya, Kufri Chipsona-1, Kufri Chipsona-3 & Kufri Pushkar produced significantly higher yield at 15 mm CPE (468 ha-mm total water applied) in comparison to 20, 25 & 30 mm CPE water levels tried. But statistically, the potato yields produced at 15 mm CPE were at par with the produce of 20 mm CPE water level (368 ha-mm water applied). The potato var. Kufri Sutlej, Kufri Ashoka and Kufri Jawahar gave higher yield at 15 mm CPE in comparison to other water levels applied. However, the total yields decreased with the decrease in water levels from 15 to 30 mm CPE, the significant differences in yields being observed when irrigations applied at 30 mm CPE water level. Similar trend was also observed in case of large and medium grade tuber yields and numbers. However, the small size tuber yield was non significant under all irrigation methods. The potato cultivars Kufri Khyati, Kufri Sadabahar, Kufri Anand and Kufri Pukhraj produced significantly higher tuber yields as compared to other varieties. The water use efficiency (WUE) was also higher in case of Kufri Khyati (1.18 q tubers), Kufri Sadabahar (1.03 q tubers), Kufri Anand (0.99 q tubers) and Kufri Pukhraj (0.98 q tubers), in comparison to others varieties. The water requirement of Kufri Khyati (0.849 mm/q tubers), Kufri Sadabahar (0.975 mm/q tubers), Kufri Anand (1.008 mm/ q tubers) and Kufri Pukhraj (1.026 mm/q tubers) was less than other potato varieties.

Evaluation of potato genotypes for drought tolerance (Physiological parameters)

Genotypes WS/07-159 (15.2°C), WS/07-138 (16.0°C) and WS/06-073 (16.3°C) were able to maintain lower mean crop canopy temperature during crop growth period under mild water stress conditions, which was superior over all four controls (17.4-21.0°C). Hybrid WS/07-111 recorded highest mean canopy temperature (20.6°C) among hybrids under test, which was comparable to one of the control K. Lauvkar (21.0°C). Water stress distinctly increased mean canopy temperature (18.5°C) over normal irrigation (16.3°C). Interactions of genotypes and water application were also promising for this parameter (Fig 11).

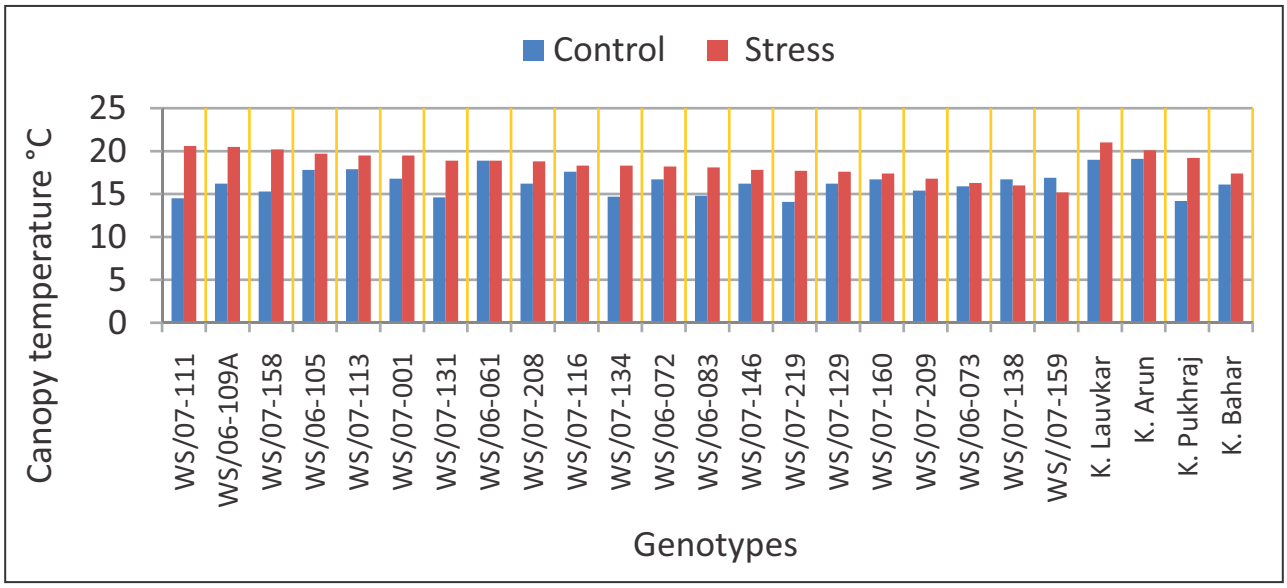


Fig. 11. Mean crop canopy temperatures (°C) of drought tolerant hybrids

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 no. of stems was measured at 50, 70 and 90 days after planting. Tuber number and weight was recorded at harvest. All the transgenic lines were shorter than the control plants in Kufri Surya. Tuber number per plant was similar in both transformed and untransformed plants. Four out of seven transgenic lines of Kufri Surya yielded better than control with KS 8 yielding 349 g/plant compared to 251 g/plant for untransformed controls. In Kufri Himalini, two transgenic lines KH.79 and KH 90 had plant height similar to control plants. The third transgenic line KH.65 was shorter than the controls bill maturity. Tuber number was higher KH.65 than the control and other two transgenic lines. Two transgenic lines of K. Himalini yielded better than untransformed controls with KH79 yielding 373 g/plant compared to 283 g/plant for untransformed control. The dwarf line KH.65 yielded lower than the controls.

Division of Seed Technology

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

Potato seed tuber is vegetatively propagated and most essential input in successful potato cultivation and accounting for about 50% of the total cost of cultivation. Degeneration of potato seed stocks due to virus diseases is most limiting factor in potato seed production. Therefore, seed stocks should be free from viral and other seed-borne diseases. To maintain the higher productivity as well as yields, it is essential to have a scientifically sound proper seed production mechanism through which high degree of health standard of the seed potato 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 program entitled "Production of breeder seed through conventional and high-system" was started under revolving fund scheme. The nucleus and breeder seed production is being monitored by the Scientists of the division at five different regional stations located in different regions of the country. The division has also started several seed technological research activities on emerging problems in conventional and high-tech seed production system to increase the quality of nucleus and breeder seed in the country. The seed production and supply status of breeder seed for hills in 2012-13 and supply of plains during 2011-12, while seed research of current year is summarized as below.

Seed Production

I. Conventional Seed Production System:

i) Tuber indexing: A total no. of 17,736 tubers of different commercial potato varieties were indexed at Modipuram (6264), Jalandhar (2920) Gwalior (6528), Patna (964) and Kufri/Fagu (960).

ii) Stage-I: A total production of 216.57 quintals was achieved in stage-I from an area of 2.1 hectare in plains and hills (table-1). During 2012-13, the average production was 117.96, 135.65, 62.47, 90.0 and 201.4 q/ha at Modipuram, Jalandar, Gwalior, Patna and Kufri respectively (Fig.1).

iii) Stage-II: A total production of 1016.84 quintals was achieved in stage-II from an area of 7.04 hectare in plains and hills (table-1). The average production

Fig: 1 Nucleus crop in Stage-1.

was 130.4, 157.72, 163.59, 143.75 and 178.86 q/ha at Modipuram, Jalandar, Gwalior, Patna and Kufri respectively.

iv) Stage- III: A total production of 4051.77 quintals was achieved in stage-III from an area of 22.66 hectares in plains and hills (table-1). The average production in stage-III was 144.34, 249.87, 216.12, 204.03 and 154.50 q/ha at Modipuram, Jalandar, Gwalior, Patna and Kufri respectively.

v) Stage-IV: A total production of 17852.84 quintals of breeder seed was achieved in stage-IV from an area of 86.61 hectares in plains and hills. The average production in stage-IV was 196.29, 243.40, 210.08, 212.85 and 93.86 q/ha at Modipuram, Jalandar, Gwalior, Patna and Kufri respectively (table-1).

II. Hi-Tech Seed production Technology:

i) Production of microplants, microtubers and minitubers: .A total number of 31,972 *in vitro* culture tubes of 26 varieties and 81,376 microtubers of 18 varieties were produced at CPRI, Shimla. A total of 5,077 test tubes and 25 bottles of 16 varieties were

Table 1: Station & variety wise area and production in conventional system

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	0.24	3.24	1.22	200.25	6.0	835	17.50	3391.90	24.96	4430.39
2	K. Pukhraj	0.03	6.03	0.35	50.90	1.2	202	0.70	136.65	2.28	395.58
3	K. Anand	0.03	1.03	0.15	20.0	0.5	93.6	2.00	469.3	2.68	583.93
4	K. Surya	0.03	8.03	0.3	20.8	0.6	110.3	4.0	1090	4.93	1229.13
5	K. Chip-1	0.03	9.03	0.20	23.3	0.4	70.2	1.40	383.1	2.03	485.63
6	K. Chip-3	0.04	10.04	0.18	18.25	0.5	57.2	0.40	77.1	1.12	162.59
7	K. Badshah	0.01	2.01	0.08	9.3	0.5	42.3	1.5	208.04	2.09	261.65
8	K. Himsona	-	-	-	-	0.2	25.2	0.63	113	0.83	138.2
9	K. Sadabahar	0.04	7.04	0.49	66.9	1.5	176.7	2.8	184.14	4.83	434.78
10	K. Frysona	0.06	12.06	0.13	12.85	0.3	51.2	1.9	403	2.39	479.11
11	K. Sutlej	-	-	-	-	0.2	25.2	0.5	43.12	0.7	68.32
12	K. Chip-4	0.05	11.05	0.25	28	0.1	24.35	1.6	357	2	420.4
13	K. Khyati	0.08	8.95	0.47	46	0.7	119.9	-	-	1.25	174.85
14	K.Garima	0.06	4.06	0.08	12.0	-	-	-	-	0.14	16.06
Total		0.70	82.57	3.90	508.55	12.7	1833.15	34.93	6856.35	52.23	9280.62
Jalandhar											
1	K. Jyoti	0.30	44.31	0.60	110.5	1.9	427.5	10	2222.2	12.8	2804.51
2	K. Pushkar	0.02	0.08	-	-	-	-	-	-	0.02	0.08
3	K. Pukhraj	0.02	4.33	0.05	9.94	1.2	324.0	2.5	831.5	3.77	1169.77
4	K. Badshah	0.01	2.38	0.04	4.34	0.15	37.88	0.4	130.2	0.6	174.8
5	K. C. M	0.01	0.9	0.04	5.3	0.2	43.61	0.75	163.8	1.00	213.61
6	K. Chip-3	0.02	0.6	0.05	0.38	0.2	45.5	-	-	0.27	46.48
7	K. Surya	0.01	0.6	0.05	4	-	-	1	220.30	1.06	224.9
8	K. Khyati	0.01	1.06	0.05	4.33	0.15	63.75	-	-	0.21	69.14
9	K. Himalini	-	-	-	-	0.02	2.85	0.03	5	0.05	7.85
10	K. Shailja	-	-	-	-	0.01	11.9	0.01	2.49	0.02	14.39
Total		0.40	54.26	0.88	138.79	3.83	956.99	14.69	3575.49	19.8	4725.53

Gwalior											
1	K. Sindhuri	0.14	7.45	0.25	49.90	0.98	243.5	5.72	1301.55	7.09	1602.4
2	K. Jyoti	0.23	10.11	0.30	44.90	0.90	166	4.27	1024.45	5.70	1245.46
3	K. Chip-1	0.09	7.16	0.31	49.85	0.85	197	5.56	1202.5	6.81	1456.51
4	K. CM	0.12	7.01	0.21	32.5	0.20	31	2.49	477.50	3.02	548.01
5	K. Chip-2	-	-	-	-	-	-	0.70	87.5	0.70	87.5
6	K. Lauvkar	0.12	9.62	0.30	42.5	1	213	3.88	622.25	5.30	887.37
7	K. Arun	-	-	-	-	-	-	0.70	152.80	0.70	152.80
8	K. Chip-3	0.11	9.25	0.26	47	0.25	52.9	-	-	0.62	109.15
9	K.Chip-4	-	-	-	-	-	-	1.03	205.5	1.03	205.5
10	K. Surya	-	-	-	-	-	-	1.90	440.5	1.90	440.5
Total:		0.81	50.60	1.63	266.65	4.18	903.40	26.25	5514.55	32.87	6735.2
Patna											
1	K. Jyoti	0.036	3.10	0.12	16.75	0.30	76.65	1.65	285.25	2.106	381.75
2	K. Arun	0.032	2.65	0.08	10.5	0.40	56.23	0.80	193.10	1.312	262.48
3	K. Surya	-	-	-	-	-	-	-	-	-	-
4	K. Pukhraj	0.032	3.25	0.08	13.00	0.45	101.75	5.1	1128.7	5.662	1246.7
	Total	0.10	9.00	0.28	40.25	1.15	234.63	7.55	1607.05	9.08	1890.93
	G. Total Plains (A)	2.01	196.43	6.69	954.24	21.86	3928.17	83.42	17553.44	113.98	22632.28
Kufri											
1	K. Jyoti	0.045	8.15	0.18	32.50	0.30	42.50	1.40	152.30	1.925	235.45
2	K. Himalini	0.02	4.85	0.07	11.70	0.20	24.00	0.65	54.75	0.94	95.3
3	K. Kanchan	0.007	2.23	0.03	3.00	0.06	18.50	0.23	16.80	0.327	40.53
4	K. Shailja	0.004	0.98	0.010	1.70	0.06	11.00	0.07	07.00	0.144	20.68
5	K. Giriraj	0.002	0.39	0.005	0.30	0.05	6.50	0.19	12.60	0.247	19.79
6	K. Girdhari	0.02	3.25	0.05	12.20	0.12	19.50	0.60	54.80	0.79	89.75
7	K. Himsona	0.002	0.29	0.005	1.20	0.01	1.60	0.05	01.15	0.067	4.24
G. Total Hills (B)		0.10	20.14	0.35	62.60	0.80	123.60	3.19	299.40	4.44	505.74
Grand total (A+B)		2.11	216.57	7.04	1016.84	22.66	4051.77	86.61	17852.84	118.42	23138.02

supplied to different regional stations for further multiplication. A total number of 7,17,974 minitubers have been produced from microplants, microtubers and < 3 g mintubers (table-2). In some culture such as Kufri Pukhraj up to 35 minitubers were produced per microplant (fig-2). A total no. of 43,985 (132.89 kg) aeroponic minitubers was produced comprising 30,241 at Modipuram and 14,144 at Shimla.

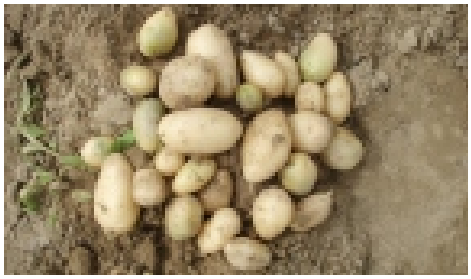


Fig : 2 Minituber production/ plant.

Table 2: Production status of microplants, microtubers, , <3 grams and aeroponic minitubers

Station	Planting material (Type)	Planted No.	Establishment (No.)	No. of minituber produced (wt. in kg.)
Modipuram	Microplants	55384	52244	230384 (5725)
	Microtubers	7082	4532	33026 (475)
	Minitubers (<3 g)	59420	NA	169070 (4150)
	Aeroponic tubers	2448	2366	30241 (94.91)
Jalandhar	Microplants	27300	20256	123700 (1652)
	Minitubers (<3 g)	7762	7762	42270 (1037)
Kufri	Microplants	4260	NA	11402 (82.62)
	Minitubers (<3 g)	2468	1893	4204 (68.3)
Gwalior	Microtubers	19840	10303	70221 (440.87)
Patna	Microplants	5420	4425	12775 (110)
	Microtubers	15350	7830	19435 (200)
Shimla	Microplants	510	377	1370
	Microtubers	30	30	117
	Aeroponic tubers	2912	2571	13744 (37.98)
Total Microplants		**92874**	**77302**	**379631 (7569.62)**
Total Microtubers		**42302**	**22695**	**122799 (1115.87**
Total Minitubers (<3 g		**69650**	**9655**	**215544 (5255.3)**
Aeroponic minitubers		**5360**	**4937**	**43985 (132.89)**

ii) Generation-1: A total production of 1394.4 quintals was achieved in generation-1 from an area of 9.12 hectare in plains and hills (table-3). The average production in this generation was 156.10, 143.9, 126.5, 183.15 and 90.5 q/ha at Modipuram, Jalandar, Gwalior, Patna and Kufri respectively.

iii) Generation-2: A total production of 6973.1 quintals of breeder seed was achieved in generation-2 from an area of 31.64 hectare in plains and hills. The average production in G-2 was 202.03, 279.67, 225.28, 229.46 and 135.14 q/ha at Modipuram, Jalandar, Gwalior, Patna and Kufri respectively (Table-3).

Table 3. Station & variety wise area and production in high-tech system

S.No	Variety	Generation-I		Generation -II		Total	
		Area (ha)	Production (q)	Area (ha)	Production (q)	Area (ha)	Production (q)
Modipuram							
1	K. Bahar	2.50	384.00	7.50	1394.5	10.0	1778.50
2	K. Chipsona-3	0.50	86.4	2.30	442.0	2.80	528.40
3	K. Surya	0.40	65.7	1.50	402.1	1.9	467.8

4	K. Sutlej	0.05	6.00	0.10	7.50	0.15	13.5
5	K. Anand	-	-	0.05	11.8	0.05	11.8
6	K. Chipsona-4	0.50	87.5	0.25	55.9	0.75	143.40
7	K. Himsona	0.04	8.10	0.17	30.6	0.21	38.7
8	K. Pukhraj	1.38	174.8	3.80	735.0	5.18	909.80
9	K. Himalini	0.05	8.20	0.20	38.5	0.25	46.7
10	K. Khyati	0.80	132.5	2.90	721.6	3.70	854.10
11	K. Sadabahar	0.08	9.50	0.40	28.50	0.48	38.0
12	K. Frysona	0.50	98.80	0.60	126.1	1.10	224.90
Total		6.80	1061.50	19.77	3994.10	26.57	5055.6
Jalandhar							
1	K. Pukhraj	0.20	45.60	1.60	480.00	1.8	525.60
2	K. Chandramukhi	0.15	4.03	0.75	141.95	0.9	145.98
3	K. Badshah	0.10	23.44	1.30	413.13	1.4	436.57
4	K. Himsona	-	-	0.10	17.43	0.10	17.43
5	K. Jyoti	0.10	15.67	0.20	47.00	0.30	62.67
6	K. Chipsona-3	-	-	1.20	295.00	1.20	295.00
7	K. Pushkar	0.10	7.50	0.20	41.50	0.30	49.0
8	K. Khyati	0.10	9.31	0.75	282.95	0.85	292.26
9	K. Chipsona-1	-	-	0.05	5.04	0.05	5.04
10	K. Surya	-	-	0.40	107.85	0.40	107.85
11	K. Himalini	0.02	5.25	-	-	0.02	5.25
Total		0.77	110.80	6.55	1831.85	7.32	1942.65
Gwalior							
1	K. Lauvkar	0.43	46.0	0.66	172.0	1.09	218
2	K. Sindhuri	0.13	23.0	0.28	75.0	0.41	98
3	K. Chandramukhi	0.04	6.90	0.05	12.20	0.09	19.1
4	K. Chipsona-1	-	-	0.02	7.00	0.02	7.00
5	K. Chipsona-3	-	-	0.07	12.75	0.07	12.75
6	K. Jawahar	-	-	0.02	4.00	0.02	4.00
7	K. Surya	-	-	0.48	73.00	0.48	73.00
Total		0.60	75.90	1.58	355.95	2.18	431.85
Patna							
1	K. Pukhraj	0.20	56.0	1.15	283.50	1.35	339.5
2	K. Kanchan	0.06	5.50	0.25	51.60	0.31	57.1
3	K. Ashoka	0.15	22.85	0.55	113.3	0.70	136.15
4	K. Surya	0.04	1.00	-	-	0.04	1.00
5	K. Jyoti	0.07	11.00	0.60	156.0	0.67	167
6	K. Chipsona-3	0.01	2.20	0.13	28.65	0.14	30.85
7	K. Pushkar	-	-	-	-	-	-
8	K. Sindhuri	-	-	0.15	19.60	0.15	19.60
9	K. Khyati	0.02	7.00	0.20	42.6	0.22	49.6
10	K. Arun	0.10	13.50	-	-	0.10	13.50
Total		0.65	119.05	3.03	695.25	3.68	814.3
G. Total plains (A)		8.82	1367.25	30.93	6877.15	39.75	8244.4
Kufri							
1	K. Jyoti	0.04	2.00	0.10	12.50	0.14	14.50
2	K. Himalini	0.12	12.30	0.25	39.50	0.37	51.80
3	K. Giriraj	0.01	1.35	0.06	05.00	0.07	6.35
4	K. Kanchan	0.01	0.80	0.02	01.50	0.03	2.30
5	K. Shailja	0.02	1.70	0.18	18.95	0.20	20.65
6	K. Girdh ari	0.10	9.00	0.10	18.50	0.20	27.50
G. Total hills (B)		0.30	27.15	0.71	95.95	1.01	123.10
Grand total (A+B)		9.12	1394.4	31.64	6973.1	40.76	8367.5

III) Production of nucleus and breeder seed during 2012-13.

A total production of 31505.52 quintals nucleus and breeder seed was achieved in both conventional and hi-tech seed production system from an area of 159.18 hectares in plains and hills. This includes 24825.94 quintals breeder seed produced in 118.25 ha area. A total of 412.10 quintals of breeder seed was supplied from Kufri/Fagu hiulls during the current season (table-4). During this year, 73.44% nucleus and breeder seed was produced from 74.39% area in conventional system and remaining was in hi-tech system. The percentage of breeder seed from conventional system was 71.94% while 28.08% through hi-tech system.

Table 4: Agency & variety wise supply of breeder seed during 2012-13 from hills

Agency	K. Jyoti	K. Girdhari	K. Giriraj	K. Shailja	K. Himalini	K. Himsona	K. Kanchan	Total
Himachal Pradesh	20.00	20.00	15.00	-	35.00	-	-	90.00
HPKV	1.50	2.50	-	2.00	2.00	-	-	8.00
J&K	30.00	2.00	-	-	5.00	-	-	37.00
Arunachal Pradesh	16.00	-	-	-	-	-	4.00	20.00
Sikkim	5.00	-	-	5.00	-	-	20.00	30.00
Uttaranchal	10.00	20.00	5.00	10.00	20.00	-	-	65.00
Meghalaya	20.00	-	-	-	-	-	-	20.00
Manipur(Indexed tubers)	0.80	0.38	-	-	0.45	-	0.25	1.88
ICAR/ CPRI	22.87	9.50	0.50	3.50	19.00	0.50	0.50	56.37
Private/Framers	36.45	19.50	2.70	6.55	14.55	1.00	3.10	83.85
Total	162.62	73.88	23.20	27.05	96.00	1.50	27.85	412.10

IV) Total supply of breeder seed during 2011-12 cropping season.

A total of 24268.20 quintals breeder seed were supplied to various government and private agencies during 2011-12 from plains and hills which includes both pre- (21535.19 quintal) and post-cold storage (2214.15 quintal) as well as 518.86 quintals supplied from hills (table-5).

V) Maintenance and multiplication of virus free buffer stocks:

Disease-free buffer stock tubers as 182 lots of 25 varieties were aseptically produced under controlled conditions in the poly house (fig-3). During its growth period samples were tested against 17 viruses by ELISA. Out of this material, positives and phenotypically different plants were discarded. About 46 individual tubers of 23 varieties of virus-free, true to type in uniform size and genetically pure tubers were selected and aseptically maintained at 4ºC as basic material as well as used for nodal cutting. Finally germinated culture from nodal cut was further tested with PCR and healthy samples were taken forward for in-vitro multiplication (fig-4).

VI) Revenue generated in Revolving Fund Scheme (RFS-I):

During the financial year 2011-12, a total of Rs. 3,96,95,409 was generated from the sale of breeder seed of potato. The sale of potato breeder seed was worth Rs. 2,27,93,502, 60,90,145, 63,94,863, 36,64,424 and 7,52,475 at Modipuram, Jalandhar, Gwalior, Patna and Kufri respectively. The total

Fig: 3 Basic material maintenance

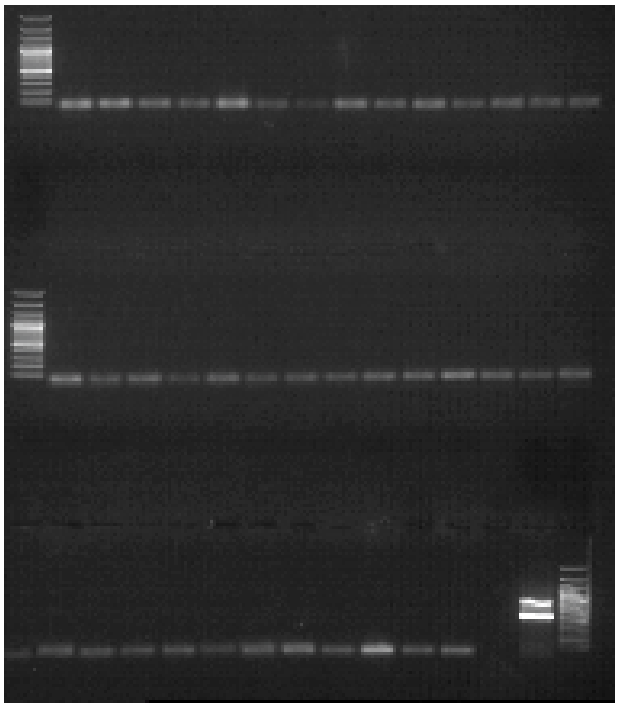


Fig: 4 PCR test of basic material.

recurring expenditure was Rs.2,46,06,444 under RFS as per the record of audited balance sheet and the centre wise expenditure was 1,14,78,728, 62,33,346, 34,92,646, 15,14,311, 17,18,214 and 1,69,199 at Modipuram, Jalandhar, Gwalior, Patna, Kufri and Shimla respectively.

VII) Production and supply of quality seed:

A total production of 1318.60 q was achieved in 9.49 ha area at Ooty with the average productivity of 138.95 q/ha and the revenue generated was approximately rupees 20.28 lakhs. A total production of 183.73 q was achieved in 2.46 hectare area at Shillong with average productivity of 77.38 q/ha. A total number of 37934 minitubers have been produced (21787 minitubers from 10037 microplants, 1196 minitubers from 1000 microtubers and 14951 minitubers from 3997 less than 3 g minitubers). The average productivity of quality seed at Shillong was 77.38 q/ha and the revenue generated approximately rupees 2.51 lakhs.

Seed Research

1. Comparison of crop raised with tissue culture vs conventional seed tubers.

The average germination, number of leaves and stems per plant was almost same in both the system of seed crop but plant height was more in conventional system than hi-tech system at Modipuram. The average yield of test varieties in terms of no. of tubers per hectare was maximum in conventional system than tissue culture raised seed crop and record of maximum 616.3 q/ha yield was recorded in K. Pukhraj in stage-3 at Jalandhar. Virus incidence in visual rouging as well as ELISA was comparatively less in hi-tech seed production. At Gwalior, higher number of stem and leaves were recorded in Stage-IV (5.12 and 47) and Stage-F1 (4.7 and 47) than their respective counterparts G-2 (4.0 and 42) and G-3 (4.6 and 40). In G-2 and G-3 total number of seed tubers were higher than their counterpart Stage-III and IV (fig-5).

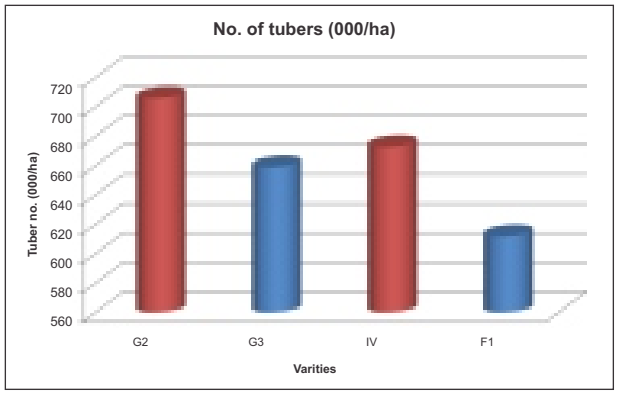


Fig.5. Comparative tubes yield

2. Phenotypic changes during hi tech seed potato production system (G0, G1& G2)

The elongated tubers from G-I of K. Bahar after planting yielded about 29.5% long shaped tubers by number while normal tuber after planting further yielded 48.2% long shaped tubers in G-II. The long shaped tuber was maximum in >125 g grade tubers in both the planting material. At Shimla, 20.9% elongated tubers were observed in K. Jyoti and 54.5% in K. Girdhari in G-0 raised by microplants. The elongated and normal tubers of these varieties were kept for planting and expression of phenotypic change in next cropping season. At Gwalior, highest deshaped tuber percentage by weight and number was observed in K. Surya in both shaped and deshaped planted tubers. The number of tuber per plot ($5M^2$) was highest in K. Sindhuri followed by K. Bahar in both shaped and deshaped planted tubers (fig-6). Weight of tuber per plot ($5M^2$) was at par in all the varieties and both type of tubers. Higher percent disease incidence in ELISA test was recorded in deshaped tuber than normal shaped tubers; among varieties it was higher in Kufri Surya.

Table 5. Variety and agency wise supply (quintal) of breeder seed during 2011-12

	K. Bahar	K. Jyoti	K. Pukhraj	K. Chip.3	K. Chip.1	K. Badshah	K. Sindhuri	K. Surya	KCM	K. Anand	K. Himsona	K. Kanchan	K. Lauvkar	K. chip.2	K. Sadabhar	K. Arun	K. Sutlej	K. Himalini	K. Ashoka	K. Girdhari	K. Pushkar	K. Shailja	K. Giriraj	K. Khyati	K. Frysona	K. Jawahar	TOTAL
UP	4930	-	400	950	502	241	400	422	50	210	50	174	-	-	-	-	135	-	-	-	-	-	-	-	200	-	8664
Punjab	50	123	300	100	-	90	50	-	100	-	-	-	100	-	-	50	28	-	-	-	-	-	-	90	50	1	1132
Haryana	-	-	70	-	-	50	-	70	-	40	56	-		-	-	-	29	-	-	-	15	-	-	54	-	-	384
H.P	-	615	-	-	-	-	-	-	50	-	-	-	-	-	-	-	-	20	-	10	-	-	10	-	-	-	705
M.P	-	364	-	150	262	-	-	-	106	-	-	-	413	-	-	-	-	-	-	-	-	-	-	-	25	-	1320
W.B	-	515	-	-	-	-	-	133	52.5	-	-	-	-	-	-	-	-	-	24	-	5	-	-	-	37	0.5	767
J&K	-	115	-	-	-	-	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	195
Bihar	-	26.5	406	20	-	-	-	-	-	-	-	-	-	-	-	120	-	-	10	-	-	-	-	-	-	-	582.5
Chattisgarh	-	-	230	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34	-	-	-	-	-	-	-	414
Arunachal Pradesh	-	20	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
Nagaland	-	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24
Sikkim	-	22	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
Uttaranchal	-	53	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	30	-	-	-	3	-	-	-	-	95
Meghalaya	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
NSC	150	450	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600
SFCI	25	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	85
NHRDF	-	200	200	100	-	-	100	174	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	774
FOC/ICAR	8.5	97.07	164.3	98.62	2.42	14.12	1.74	117.41	5.3	0.62	73.35	0.5	-	50.8	16.72	-	-	16.78	1	7.75	4.41	7.21	2	25.14	0.02	-	715.76
University	-	2.7	72.35	4	-	1.6	-	6.45	0.3	-	26.15	-	-	3	-	13.5	-	1	18	1	-	0.25	-	0.25	3	-	153.55
PVt./Farmers	1084	558	667.7	404.86	148	130.85	798.75	485.55	117.31	33.4	346.4	9.7	75.1	5.5	293	7.5	4	31.8	14.85	39.85	-	2.55	1.2	99.22	145	-	5504.09
Auction/Market	920.5	1.4	125	226.6	29	52.4	-a	64.1	0.4	29.5	316.9	-	-	17.2	190.7	-	25.2	0.7	-	-	0.1	-	-	35.6	28	-	2063.3
Total:	7168	3217	2635	2204.1	943	579.97	1430.49	1472.51	481.81	313.52	877.8	202.2	588.1	76.5	500.42	191	221.2	100.28	101.85	58.6	24.51	13.01	13.2	304.21	548.02	1.5	24268.2

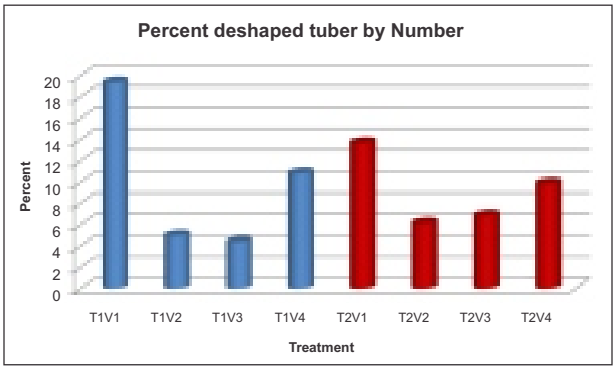


Fig: 6 Tuber deshaping

3. Standardization of planting date for seed production in Gwalior region

At Gwalior, early planted seed crop (10th Oct) took longer time for emergence and 50% emergence (12.2 and 18.1 day respectively). With delay in planting date there was increasing trend in final germination percent. K. Sindhuri performed better for growth attributing parameters followed by K. Chipsona-1 and K. Chandramukhi. There was increasing trend for tuber number and yield with delay in planting date except 31st Oct (fig-7). Among varieties, highest tuber number and yield was recorded in K. Sindhuri.

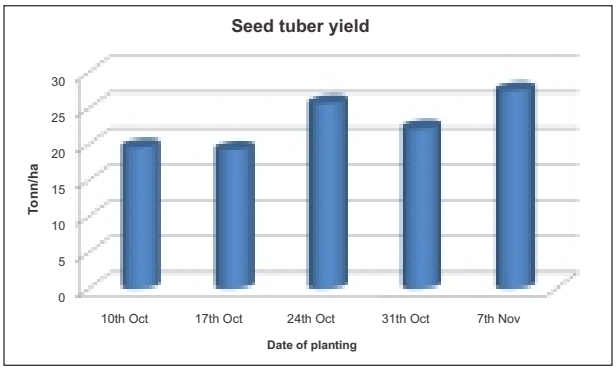


Fig: 7 Yield variations

4. Monitoring of aphid population build up in seed crop of Shillong and Ooty

Aphid population was monitored during crop season (February to June) in K. Girdhari, K. Himalini, K. Jyoti, K. Megha, K. Giriraj at Shillong and 24 to 93 aphid /100 compound leaves were recorded from the 4th week of April up to 2nd week May. Thirteen observations were recorded after 25th day of planting with weekly interval in 10 locations of The Nilgiri district and there was no appearance of aphid population in the potato crop during crop season in all the varieties.

5. Virus profiling in potato growing regions of Punjab, Karnataka, Tamil Nadu and H.P.

Virus profiling of district Jalandhar, Hoshiarpur and Kapurthala in 35 farmer's fields revealed that mild mosaics were most predominant being prevalent in 91.4% fields with maximum of 8.0% incidence, severe mosaic in 77.1% fields with 6%, leaf roll in 51.4% field with 12.3% incidence and PALCV in 40% fields with 4% incidence. Plants exhibiting bright yellow spots caused by potato aucuba mosaic virus and the other unidentified viruses were noticed in 48.6% fields and their incidence varied from 0 to 10%. Out of 198 samples of Kufri hills 96 were found infected with PVX, 80 with PVS, 31 with PLRV, 25 with PVY, 20 with PVM and 1 with PVA. Out of 40 samples from 14 villages of Hassan, Chickmagalur and 6 villages of Kodaikanal the number of infected samples were PVX (3), PVY(1), PLRV (6) in Karnataka while 3 samples infected with each virus of PVX, PVY, PVA, PVM and 4 samples with PLRV in Kodaikanal.

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

The experiment was conducted in experimental field of lower laboratory in summer season at Shimla. Out of 11 treatments of bio-pesticides and fungicides as tuber dipping just before planting, commercial formulation of Pseudomonas flourescens (1%) and Boric acid (3%) was equally effective with minimum of 13.9 and 14.1% black scurf incidence respectively as compared to control (36.7%) (fig-8).

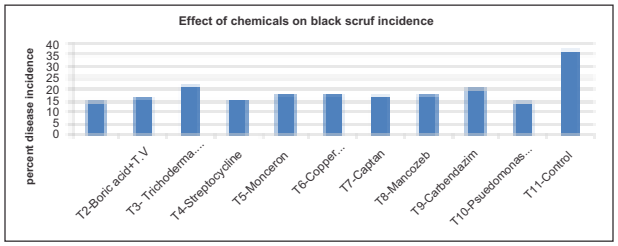


Fig: 8 Black scurf management

7. Growth and Production performance of potato minitubers through aeroponics

The planting of eight potato cultivars viz. Kufri Bahar, Kufri Surya, Kufri Pukhraj, Kufri Chipsona-3, Kufri Chipsona-4, Kufri Frysona, Kufri Himalini and Kufri Khyati was done in the last week of October at Modipuram. Rooting initiated within 3 to 4 days in all the varieties. Sequential harvesting of about 3 g was done at the interval of three days and minimum no. of days taken for first harvest in Kufri Bahar was 38 days

and in Kufri Chipsona-3 was 57 days. Maximum number (36.9) and weight (81.5 g) of minitubers/plant was obtained from Kufri Frysona and minimum number from Kufri Khyati (13.1), whereas minimum weight in Kufri Himalini (36.0 g). Mean tuber weight was maximum in Kufri Khyati (3.4 g) and Kufri Bahar (2.9 g). Planting of aeroponic minitubers on raised bed in three rows and 20 cm distance was better for total tuber yield in field but other growth parameters were not significant.

Performance of six potato cultivars viz. Kufri Himalini, Kufri Lauvkar, Kufri Sindhuri, Kufri Girdhari, Kufri Jyoti and Kufri Khyati was evaluated in aeroponic system at Shimla during winter season (fig.9). Rooting was initiated between 4 to 6 days in hardened plants while 12 to 22 days in microplants of all the varieties. The plant establishment varies from 93.4 to 99.5% after 30 days of planting. Tuber initiated between 12 to 17 days in hardened plants and 7 to 32 days in microplants. Among the varieties, maximum time for root and tuber initiation was taken by K. Jyoti. The first harvesting of aeroponic minituber was carried out after 55 to 59 days of planting while in K. Jyoti about 90 days. The aeroponic minituber weight varied from minimum of 2.3 g in K. Himalini to maximum of 3.8 g in K. Khyati. The maximum no. of leaves & plant height per plant were observed in K. Sindhuri while minimum in K. Himalini. The loss of undersize minitubers due to driage after grading varied from 0.32 to 7.26% with minimum in K. Sindhuri and maximum in K. Girdhari (table-6). Very long, numerous, thick stolon with pale leaf primordia was observed in K. Jyoti, K. Khyati, K. Girdhari and K. Sindhuri.

Fig: 9 Aeroponic production performances during winter season in Shimla

Table 6: Growth and yield parameters of aeroponic microplants in Unit-1at Shimla till date

S. No.	Varieties	Percent establishment (30 days)	No. of leaves/ plant (115 DAP)	Plant height (cm)	Mean wt. of minitu ber (g)	No. of mini tubers plant	No. of mini tubers harvested	No. of mini tubers stored	Percent loss of minitubers
1.	K. Himalini	99.45	15.0	29.2	2.31	12.08	2357	2273	3.57
2.	K. Khyati	95.92	20.4	74.2	3.81	14.29	2688	2583	3.90
3.	K. Girdhari	99.4	21.4	56.9	2.88	14.02	2342	2172	7.26
4.	K. Sindhuri	93.37	26.0	75.1	3.02	21.77	3985	3972	0.32
5.	K. Lauvkar	97.54	15.5	35.3	2.78	15.14	13232	13141	0.69
6	K. Jyoti	94.64	17.8	38.7	3.15	33.83	1793	1746	2.63
	Total/average	**96.72**	**19.35**	**51.57**	**2.99**	**18.52**	**26397**	**26038**	**3.06**

8. Effect of harvesting interval on minituber production in aeroponic.

Experiment conducted with four harvesting intervals (3, 7, 10 and 14 days) on cultivar Kufri Bahar under aeroponic system at Modipuram. In case of the fifth harvest, the picking was done when it appeared that the minituber will drop if left further. Maximum number of minitubers/plant (17.1) was obtained from minimum harvesting interval (3 days). However, maximum weight of minituber/plant (120 g) was obtained from fifth picking.

9. Effect of spacing on minituber production in aeroponic system

The effect of five spacing on K. Bahar at Modipuram during October showed that maximum number of

minitubers/plant (28.8) in 20x20 cm spacing and minimum (16.3) in 10x10 cm. The highest minituber yield/plant (95.3 g) was also observed in 20x20 cm spacing. Similarly maximum mean minituber weight (3.3 g) was also obtained in geometry with lowest density (table-7).

Table 7: Effect of spacing on minituber production in aeroponic system at Modipuram

S.N	Spacing (cm)	No. of tuber/plant	Wt. of tuber/plant (g)	Mean tuber wt. (g)
1.	10x10	16.34	44.41	2.72
2.	15x15	20.58	53.18	2.58
3.	20x10	17.36	53.13	3.06
4.	20x15	21.58	68.27	3.16
5.	20x20	28.78	95.30	3.31

The aeroponic minituber was stored in cold chamber at 4ºC for 6 months followed by 2 month at ambient conditions at Shimla in perforated plastic bags. The average weight was recorded maximum 3.1 gm in K. Khyati while minimum 2.4 g in K. Surya. The sprout length was minimum 0.82 cm in K. Sadabahar while maximum 2.8 cm in K. Himalini (2.5 cm). The percent decrease in weight and increase in sprout length was recorded after 35, 40, 53 and 67 days of storage at ambient conditions. The weight loss was gradually increasing in all the varieties from the days of packing to 67 days in all the packing material. In K. Sadabahar, the weight loss was varying between 24 to 39.8%. The maximum sprout length increase was 278% in paper box followed by 217.1% in brown paper bag while minimum (70.7%) in gunny bag, plastic bag (fig-10). Among different storage material, the maximum weight loss was almost similar in butter paper bag, paper box, plastic bag and gunny bag. Paper box and brown paper bag was not suitable by any means due to very long, lanky and pale sprouts of all the test varieties.

11. Effect of different packing material on storage behavior of 3 grades of microtubers at Shimla.

Three different grades of microtubers of K. Chandramukhi were kept for 8 months in refrigerator at 4ºC temperature in perforated polythene bags and then 3 months in 5 different packing materials at ambient conditions. The weight loss ranges from 23.7 to 73.3% in different packing material in all the three grades (fig-11). In 4 mm grade of microtuber, maximum weight loss was recorded of about 43.7% in paper box and minimum of 30.6% in butter paper bag for KCM (table-8). The weight loss of K. Megha varied from 43.5 to 68.3% in 5 months storage in refrigerator and 3 months in ambient conditions. In general plastic bag and butter bags have minimum weight loss in all grades of microtubers in all the varieties.

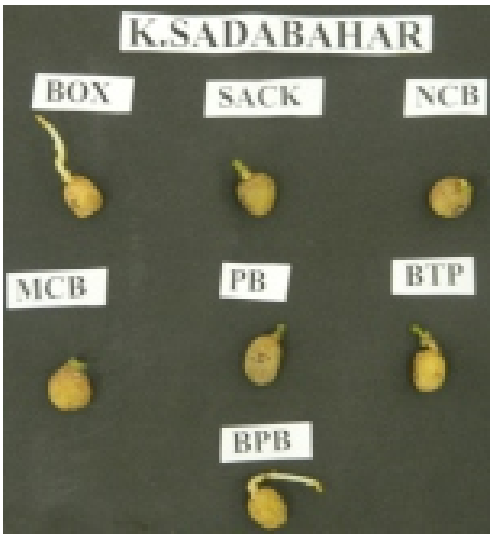


Fig: 10 Comparative sprouting

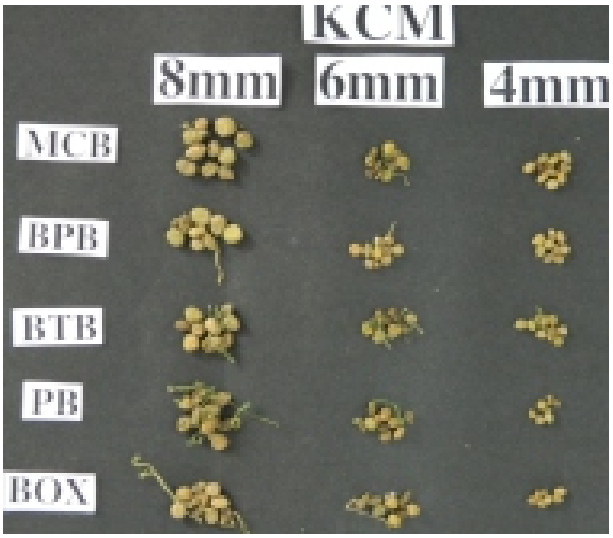


Fig: 11 Comparative driage and sprouting

Table 8: Effect of packing materials on periodical shrinkage behavior of 3 grades of microtubers of KCM

Date of Reading	Weight of microtubers (grams)														
	Plastic Bag			Butter Paper			Muslin Cloth			Brown Paper			Paper Box		
	8mm	6mm	4mm	8mm	6mm	4mm	8mm	6mm	4mm	8mm	6mm	4mm	8mm	6mm	4mm
11.10.2012	0.32	0.11	0.03	0.24	0.10	0.05	0.36	0.13	0.07	0.30	0.25	0.06	0.23	0.15	0.05
23.10.2012	0.28	0.11	0.03	0.23	0.09	0.05	0.34	0.12	0.06	0.27	0.17	0.05	0.21	0.14	0.05
6.11.2012	0.27	0.10	0.03	0.22	0.08	0.05	0.32	0.17	0.06	0.25	0.10	0.05	0.20	0.13	0.04
6.12.2012	0.22	0.08	0.03	0.18	0.06	0.04	0.28	0.10	0.05	0.22	0.09	0.05	0.17	0.10	0.03
6.1.2013	0.16	0.06	0.02	0.14	0.04	0.04	0.27	0.06	0.04	0.17	0.07	0.04	0.16	0.10	0.03
Wt. loss (g)	0.49	0.51	0.34	0.42	0.57	0.31	0.24	0.56	0.39	0.44	0.73	0.41	0.31	0.34	0.43
Wt loss (%)	48.7	50.8	34.0	41.6	56.7	30.5	23.6	55.7	39.3	44.2	73.2	40.5	30.8	33.9	43.2

12. Effect of different storage containers and conditions on microtuber storage at Gwalior

At Gwalior, percent weight loss was higher in conical flask with cotton plug and least in polythene without ventilation after 45 days of storage (fig-12). Among conditions, weight loss was higher in control followed by refrigerator and growth chamber. Among varieties, K. Chandramukhi recorded higher weight loss followed by K. Lauvkar. Conical flask with plastic cap, control conditions and K. Lauvkar recorded highest percent driage in storage container, storage condition and variety respectively.

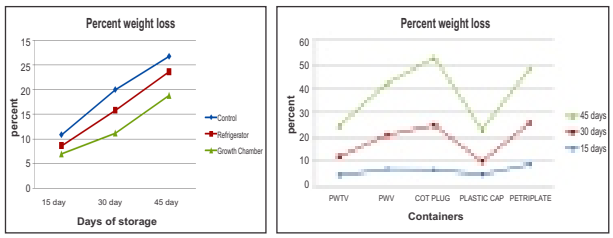


Fig: 12 Weight losses of microtubers

13. Effect of different storage conditions and containers on weight loss of microtubers at Shimla

Three different grades of microtuber of K. Chandramukhi were stored for 8 months at 4ºC in perforated poly bags and then kept for 3.5 months in plastic petriplates, ventilated culture bottles and perforated plastic bags under ambient conditions, non-hermatic and hermetic culture rooms at Shimla. The effect of hermetic and non-hermetic culture room was almost same for weight loss with maximum in 4 mm as compared to 6 & 8 mm. The moisture loss varied from 14.9 to 75.3%. Minimum loss was recorded in room temperature for all grades and in all packing materials. There was no difference in hermetic and non-hermatic culture rooms. The weight loss in ventilated bottles was almost constant for both the grades of microtubers and seems to be better than petriplates and polythene bags (fig-13).

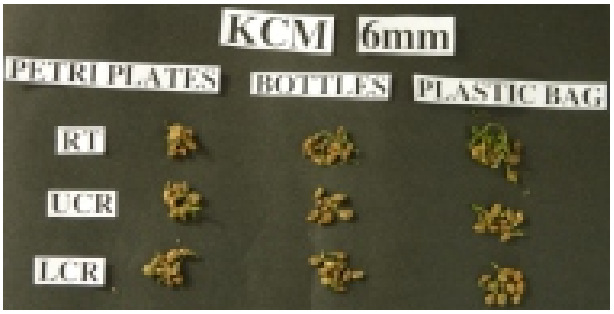


Fig: 13 Weight loss and germination

14. Effect of different antibiotics on growth parameters of in-vitro microplants

The liquid formulation of three antibiotics (streptomycin, amphotericin, antimyotic) tested at different concentrations (1 to 4%) while gentamycin dry formulation was tested (10 to 100 ppm) by adding it in MS medium for growth of microplants and its contamination status. Gentamycin (10 ppm), amphotericin (1%) and antimyotic (1%) at lowest test concentration was inferior to control for most of the growth parameters of microplants in variety K. Lauvkar, K. Sindhuri, K. Sadabahar and K. Jyoti (fig-14). The in-vitro growth of K. Jyoti for most of the

parameters was better than control between 1 to 2% in streptomycin.

Fig: 14 Antibiotic effects on growth

15. Effect of different types of MS media on in-vitro growth of microplants

Two types of readymade MS media having vitamins and without CaCl2 of Hi-media and two types of salt based synthetic MS media prepared in laboratory with gelrite and agar were tested for growth of microplants. The MS media solidified in gelrite (0.2%) for K. Chipsona-3 found better for in-vitro growth parameters of microplants in comparison to agar (0.7%) for K. Khyati (fig-15).

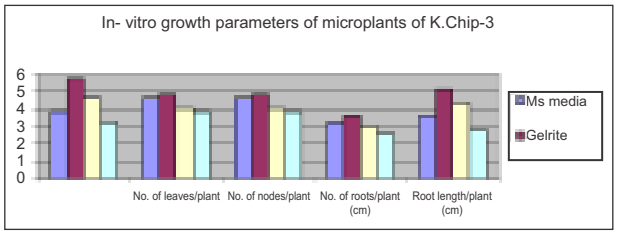


Fig: 15 MS media effect on growth

16. Effect of no. of nodes and its orientation on growth of different varieties.

Microplant height was more in single node in comparison to double node at vertical insertion in the MS media in varieties Kufri Bahar, Kufri Jyoti and K. Lauvkar. Similarly, single node was better than double node when placed horizontally for all the test varieties(fig-16). The orientation of microplant for vertical placing in MS media was always better than horizontal placing for multiplication of all the test varieties (table-9). The no. of roots was more or less similar in all the treatments. The root length was slightly more in single node in comparison to double node in most of the varieties except K. Chandramukhi.

Fig: 16 Growth of vertical single node

Table 9: Performance of number of nodes and its orientation in MS media of different varieties

Variety	Microplant height (cm)				No. of leaves			
	Double node (vertical)	Double node (horizontal)	Single node (vertical)	Single node (horizontal)	Double node (vertical)	Double node (horizontal)	Single node (vertical)	Single node (horizontal)
K. Bahar	12.7	8.77	13.2	10.7	6.1	5.53	5.9	5.9
K. Jyoti	5.87	3.87	9.13	6.67	4.4	4.0	4.37	3.4
K. Lauvkar	4.1	4.3	5.37	4.0	3.6	5.1	3.6	3.1
K. Sindhuri	6.2	3.63	5.9	4.9	4.4	3.1	4.76	4.0
KCM	8.63	7.4	7.1	7.4	6.1	4.3	4.0	4.5

17. Effect of different media on microplantlets height and number of leaves of different potato cultivars.

Four synthetic media was evaluated for in-vitro growth of 5 varieties to find out the substitute of ammonium nitrate. The mean microplant height of all the test varieties was maximum (8.3 cm) in Gamborg's (B5) modified medium. K. Bahar was fastest growing variety in the test medium (table-10). White's medium was not supporting any growth parameters of *in vitro* microplants of the varieties. In general, Gamborg's (B5) modified medium may be suitable alternate medium for potato micropropagation as it at par/significantly better results as compared to MS medium with respect to different morphological characters.

Table 10: Effect of different media on microplantlets height and number of leaves on *in vitro* growth

Variety/media	Height (cm)					Number of leaves				
	Modified Gamborg's	Modified MS	White's	MS	Mean	Modified Gamborg's	Modified MS	White's	MS	Mean
Kufri Sindhuri	9.30	9.54	2.68	7.42	7.24	4.8	4.6	2.2	3.9	3.9
Kufri Bahar	11.72	11.30	5.82	8.74	9.40	4.6	5.2	3.5	5.1	4.6
Kufri Khyati	5.14	2.70	2.48	6.66	4.25	2.3	0.9	1.7	2.5	1.9
Kufri Girdhari	11.22	7.88	0.18	7.88	6.79	3.7	3.5	0.2	4.5	3.0
KCM	7.04	6.02	0.50	8.02	5.40	3.9	2.9	0.6	3.7	2.8
Kufri Jyoti	5.54	3.64	0.14	3.10	3.11	2.3	1.5	0.2	2.0	1.5
Mean	8.33	6.85	1.97	6.97		3.6	3.1	1.4	3.6	
	Factor	V	M	VM		Factor	V	M	VM	
	SED	0.28	0.23	0.56		SED	0.16	0.13	0.32	
	CD	0.56**	0.46**	1.12**		CD	0.31**	0.26**	0.63**	

18. Effect of dormancy breaking chemicals on microtuber establishment and yield

At Gwalior, 1ppm Gibberllic acid + 1% Thiourea performed best for growth attributing parameters like emergence and plant height, No. of stems and compound leaves at 50 and 75 days. Among tuber size, > 8mm performed best followed by >6mm and >4mm for above said parameters. Among varieties, K. Sindhuri performed better over other two varieties. 0.5 ppm gibberllic acid gave highest tuber yield and number per plot in all grades and total tuber per plot. Among dip duration, 30 min gave highest tuber yield followed by 45 min and 60 min.

19. Effect of fungicides on in-vitro establishment of microplants

At Jalandar, the effect of azoxystrobin as root dip of the microplants for 10 minute before planting of Kufri Jyoti revealed that azoxystrobin @ 0.125% (1.25ml/l) was another option available to the treatment with carbendazim (0.2%) and resulted in 80% establishment of the microplants in comparison to carbendazim (87%) and produced maximum number of tuber (465/m2) and yield (14.8 kg/m2).

20. Standardization of priming technique for storage and germination of micrtubers

At Gwalior, highest weight loss after 60 days of

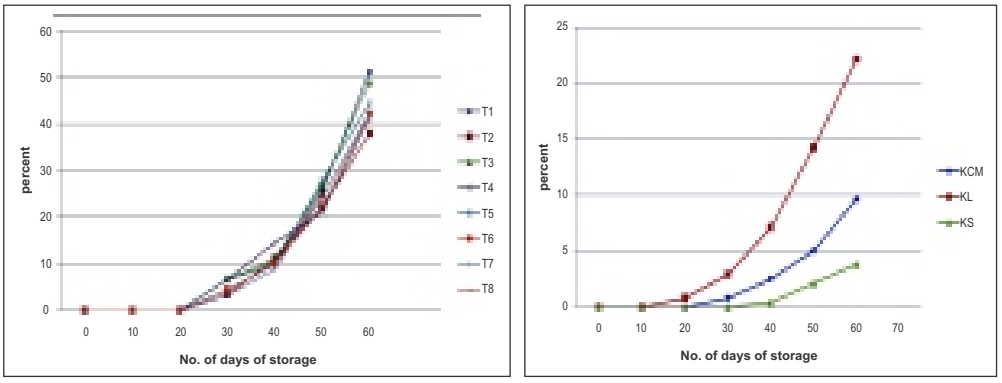


Fig: 17 Biopriming effect on microtubers

storage was recorded in B-5 treatment (46.54%) and least in control (36.13%). Among varieties, K. Lauvkar recorded higher weight loss over the storage period. Highest tuber sprouting was in control (51.1%) followed by B-5 treatment and least was in water control (fig-17). Among varieties, K Sindhuri recorded higher sprouting followed by K. Lauvkar and K. Chandramukhi. Percent tuber rottage was highest in water control (17.8%) and least in control and A. niger treated tubers (5.6%) with maximum rottage in K. Lauvkar.

The treated microtubers with Gelatin performed better in terms of establishment, microtuber number as well as yield in nethouse and produced significantly superior yield over other treatments and control. Chitosan was better than control but chitin did not perform well except 0.25% concentration (fig-18). No sprouting was observed in the Carbon-di-sulphide and Rendite treated microtubers irrespective of duration of soaking and concentration of chemicals. GA3 and thiourea combinations when treated without insertion on the microtubers, all the sprouted well (100%) with good establishment in net house. These microtubers treated both GA3 or Thio urea alone and also combination with insertion did not establish well. GA 3 @1 ppm + Thio urea @1% with 45 and 60 min soaking registered better performance in terms of yield than other treatments.

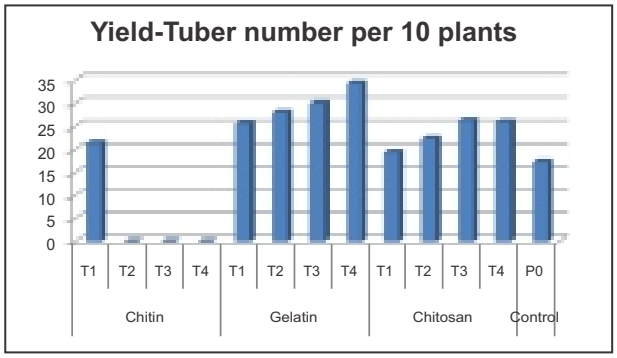


Fig: 18 Polymers effect on minituber yield

Division of Social Sciences

Impact of potato production technologies developed by the institute

Project 1: Seed potato marketing system in India and Its impact on farmer's profitability.

Seed Potato Utilization in UP State of India

Uttar Pradesh (UP) is the largest potato producing state of India. As per the statistics of National Horticulture Board, Gurgaon, UP produced 32.07% of potatoes from 29.87% area at national level during 2010-11. The state produced 13.58 million t potatoes during 2010-11 which was higher than the national potato production of Germany (11.06 million t; FAO) which is the sixth largest potato producer in the world. UP produces seed, processing grade and specialty potatoes in addition to the table purpose at 24.4 t/ha productivity compared to 22.7 t/ha at national level. The state consumes on an average 1.3 million t seed potato every year, which is nearly 35% of total seed potato used at national level. Availability of healthy seed has largely been reported as the principal cause for lower potato productivity in the country. This comprehensive study was conducted to find real problems and seed potato utilization pattern of the potato growers in UP during 2011-12.

UP being the largest potato producing state was selected for this study. The state was stratified into four potato producing zones. One district from each zone was randomly selected. The selected districts were Meerut, Farrukhabad, Jaunpur and Agra. Seed potato utilization pattern and constraints of potato growers in selected districts were studied through primary data. Problems of potato growers were quantified in terms of severity and relative importance (RI) of each problem in overall potato farming situation was estimated.

Variety wise potato area

Variety wise potato area was assessed and it was found that Kufri Bahar was the predominant potato variety occupying 68.63% potato area followed by K. Pukhraj (19.71% area). All other potato varieties constituted only 11.66% potato area in the state. Out of total production, 16.29 per cent of Kufri Bahar and 10.66 per cent of K. Chipsona varieties were sold as seed potato. Other varieties were mostly sold as table potato. Overall, it was found that 14 per cent of total potato production was sold as seed potato in UP.

Seed potato utilization pattern

It was found that farm saved seed potato was the major source of seed contributing more than 80 per cent followed by other progressive farmers (9.4%) and seed from government farms (3.61%). A further analysis of variety wise seed utilization pattern revealed that in case of K. Jyoti and K. Pukhraj, farm saved seeds contributed to the extent of 88.93 and 80.07 per cent respectively. Maximum contribution from other farmers was in case of K. Lauvkar (17.07%) and K. Badshah (11.62%). Government farms supplied mostly seeds of K. Pukhraj and K. Jyoti. Private companies and traders were major source of seed after farm saved seeds of K. Chandramukhi and they contributed 10.65 per cent and 13.02 per cent of seeds of KCM variety.

Seed replacement rate

Variety wise seed replacement rate was also studied and it was found that seed replacement rate was highest in K. Chandramukhi (31.95%) followed by K. Chipsona varieties (24.00%) and K. Lauvkar (21.14%). The reason behind higher seed replacement rate in KCM was due to higher seed supply from private companies and traders. The seed replacement rate was lowest in case of K. Jyoti (11.07%). Overall seed replacement rate in UP was found to be 19.35 per cent which is lower than optimum rate of 33 per cent. Therefore, there is a need to increase the rate of seed replacement in potato in Uttar Pradesh.

Effect of seed quality on farmers' profitability

Effect of seed potato quality on farmers' profitability was assessed considering expenditure on seed as proxy to its quality. Overall, it was found that 50% respondents with higher seed potato expenditure invariably has higher potato yield, cost of cultivation, net income and benefit-cost ratio compared to the 50% respondents with lower expenditure on seed potato.

Constraints in seed potato cultivation

Constraints of potato farmers were studied in terms of their severity and relative importance. Expensive inputs was found to be the severest problem for potato farmers with relative importance of 20.41% followed by shortage of fertilizers (RI=17.81%), electricity failure (RI=15), expensive cold storage (RI=9.65%). Hence, infrastructure and logistics

related constraints dominated the problem matrix of the farmers in UP. Healthy seed potato availability of other (exotic and less popular) varieties was the most difficult for UP farmers followed by Kufri Pukhraj, Kufri Lauvkar, Kufri Badshah, Kufri Chipsona 1 and 3, Kufri Jyoti and Kufri Bahar.

Project 2: Analysis of adoption pattern and technology gap in important potato growing areas

Adoption of improved potato varieties and technology in Himachal Pradesh: A Survey of 100 potato growers was carried out in three districts of HP namely Shimla, Mandi and Kangra. Analysis of data revealed that average land holding under potato cultivation was found to be 0.25 ha in shimla which is less than Mandi (0.53 ha) and Kangra (0.41 ha). Out of total area under agriculture, potato contributed 18.72 % in Shimla, 38.72% in Mandi and 45.17% in Kangra district. The varietal adoption pattern observed in these three district and it was found that K. Jyoti was most predominant variety in all three districts covering 48.25%, 84.5% and 80.62% area in Shimla, Mandi and Kangra district respectively. K. Himalini (33%) and K. Girdhari (16.4%) were other two popular varieties grown in Shimla district. Application of NPK fertilizers in Shimla and Mandi was found to be 126:64:44 and 30:61:26 Kg/ha against the recommended dose of 120:100:100 Kg/ha. In Mandi almost 100% of farmers used IFFCO fertilizer 12:32:16 while CPRI recommends a mixture of CAN, SSP and MOP. Hundred percent of farmers applied all fertilizer at the time of planting in Mandi while 15% of farmers used second dose of urea fertilizer in Shimla district. Farmers reported 40-45% crop damage due to late blight in Shimla and Kangra. Most of the famers used Diathane-M45 and ridomil @ 2-3 g/lt. of water to control this disease but reported that it could not be controlled effectively. This may be due to incorrect timing of spray and faulty doses. Potato tuber moth and cutworm were main pests of potato in Kangra district causing 50-60% damage. White grub and cut worm were major pests in Mandi district but most of the farmers were not using any management practices due to lack of knowledge. The average yield of potato recorded was maximum 16.16 t/ha in Kangra district while it was only 13.3 t/ha in Shimla and 11.9 t/ha in Mandi district. Higher yield in Kangra may be attributed to irrigated field condition and better management of diseases and pests by farmers.

Another survey regarding adoption of potato variety and technologies was carried out in Patna, Nalanda and Muzaffrapur districts of Bihar. Tabulation and analysis of data is under process.

Assessment of improved potato varieties and technologies at different locations

Overall, 57 demonstrations were laid out in different locations of HP, Bihar, UP and Meghalaya to assess the performance of potato varieties and technologies at farmer's field.

In Himachal Pradesh, three improved varieties of potato i.e. Kufri Himalini, Kufri Shailja and Kufri Girdhari were provided to 17 farmers in four villages of district shimla, namely Koti, Bekhalti, Talai and Shoghi during 2012-13. These varieties were raised using recommended package of practice of the potato developed by CPRI under the observation of CPRI scientists. Farmers planted Kufri Jyoti as control plot using their own practices. Data revealed that incident of early blight was observed in controlled plot of Kufri Jyoti to the extent of 10-20% while none of the three varieties of demonstration plot showed any symptom of early blight. The incident of late blight was observed on control plot of kufri Jyoti to the extent of 30% while none of demonstration plots showed any symptom of late blight. In case of the white grub infestation, it was found in kufri Girdhari, Kufri Himalini and Kufri Shailja to the extent of 5-10% while in kufri jyoti it was 20-25% infestation of white grub. Thus new varieties of CPRI performed better and showed less symptoms of diseases and pests. Yield levels of Kufri Himalini, K. Girdhari and K. Shailja were found to be 24.1, 23.0 and 23.4 t/ha respectively. Control variety K. Jyoti yielded 16.5 t/ha. Thus Kufri Himalini has 46% yield advantage over K. Jyoti. Similarly other two demonstrated varieties K. Shailja and K. Girdhari were also having yield advantage of 41.8% and 39.3% respectively over farmer's check K. Jyoti. Thus it can be said that new varieties of potato released by CPRI is doing far better than traditional variety K. Jyoti. Therefore farmers should use new varieties in Shimla hills.

In UP, 10 demonstrations, 5 each on late blight and cutworm management were conducted on farmer's field at various locations in districts Baghpat, Hapur and Bulandsher of UP during 2012-13. Results from demonstration on late blight management revealed that disease did not appear in the main crop due to unfavourable weather conditions for disease appearance. Therefore losses of tuber yield due to disease incidence was not observed in demonstration plots. While total of 14.7**%** tuber rotting at harvest was observed due to heavy rains during crop growing in demonstration plot at all five locations. Kufri Khyati variety gave 21.1% higher yield than local variety K. Bahar. Observations from demonstrations conducted on cutworm management showed that farmers did not apply any chemical in their crops in control plot for managing cutworm while recommended practices were applied i.e. 2 spray of Chloropyriphos (drenching on ridges) @ 0.20 % at 20 and 50 DAP on all demonstration plot. Tuber damage to the extent of 2.24 % was observed at control plot at harvest due to cutworm. No cutworm damage was observed in sprayed crop under the recommended practices. On an average 9.62% yield increase was recorded under recommended practices over the control variety.

The average tuber yield from 10 demonstrations was observed as 362 q/ha in Kufri Khyati, 274.32 q/ha in Kufri Sadabahar, 269.30 q/ha in Kufri Bahar and 264.71 q/ha in Kufri Anand.

In Bhojpur district of Bihar, 15 varietal demonstrations were laid out at Farhangpur. The performance of heat tolerant potato variety K. Surya was assessed on farmer's field against the local variety C-40. All the recommended package of practices was used in demonstration plot of K. Surya. It was observed that all the farmers of were 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 for Surya. It was also observed that the incidence of late blight in K. Surya was negligible (0.3%) while average intensity of this disease in C-40 was found to be nearly 2%. Farmers used Indofil M-45 for control of late blight but their dose of this chemical was only 1.0 Kg/ha which is very less than recommended dose of 2.5 Kg/ha. Because of these differences, K. Surya gave an yield of 202 q/ha which is 21.8% higher than local variety C-40 (165 q/ha).

In Shillong and nearby villages of Meghalaya, a total of 15 demonstrations, 5 each on varietal yield, white grub management and late blight management were laid out. The yield of CPRI varieties like K. Himalini, K. Giriraj and K. Girdhari were in the range of 21-22 t/ha while local variety gave yield of only 10-11 q/ha. Thus there was an increase in yield to the tune of more than 100% with use of CPRI varieties. Recommended dose of phorate was applied on demonstration plots and results were compared with farmer's practice. There was 15-25% increase in yield of demonstration plot as compared to farmer's practice. Similarly, in case of late blight management, with the application of recommended chemical Indofil M-45/Curzate, the demonstration plots yield was found to be 120-130% higher than farmer's practice.

In addition to above mentioned activities, a survey of potato growers in three districts of Bihar namely Patna, Nalanda and Muzaffarpur was also conducted under this project in which 120 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: An eight days model training course sponsored by Directorate of Extension, Govt. of India, was organized on "**Technology for quality seed potato production and certification**" from November 30- December 7, 2012 at CPRI Shimla to improve the knowledge and skill of extension officers working in state departments of agriculture/horticulture. This training course was attended by 13 participants from 7 states. A variety of methods of training such as lecture-cum discussion, practical sessions, field visits and video film shows etc. were applied during this programme. To assess the impact of training, pre and post training evaluation was conducted and it was found that after the training, the overall knowledge of the participants was improved by 32.4%. The training was rated as excellent by 46.2 per cent of the participants as very good by 53.8 per cent of them and almost 95 % of the trainees were satisfied with boarding, lodging, classroom, transport facilities etc.

Transfer of Technology

Technology Transfer activities organized by CPRI, Shimla

CPRI organizes many activities every year to disseminate potato technologies to farming communities. These technology transfer activities includes trainings, demonstration, kisan mela, awareness camp, live phone in programmes on AIR and Doordarshan, Shimla etc. These activities helps in creating awareness and diffusion of knowledge regarding potato technologies among farmers & other stakeholders.

A. **Organization of Trainings**: Various training programmes for farmers, extension functionaries as well as other stakeholders were organized at CPRI, Shimla. All the aspects of potato cultivation from planting to harvesting, storage and marketing were thoroughly covered during these training programmes. The participants were exposed to a series of lectures on varietal selection for their respective areas, time and method of panting, disease and pest management, water management, harvesting, processing, storage and marketing. In these lectures multimedia presentations were used by the faculty 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. The details of the trainings and other extension activities conducted during the period are given in the table below.

Sr. No.	Title of Training Course	Date & Duration	No. of Farmers Officers	Sponsoring Agency
1.	आलू उत्पादन, फसलोतर तकनीक एवं प्रसंस्करण	18-22 May 2012 (5 days)	20	परियोजना निदेशक, आत्मा, समस्तीपुर, बिहार
2.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	13-14 Aug., 2012 (2 days)	15	निदेशक, केन्द्रीय आलू अनुसंधान संस्थान, शिमला
3.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	16-17 Aug., 2012 (2 days)	20	निदेशक, केन्द्रीय आलू अनुसंधान संस्थान, शिमला
4.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	23-25 Aug., 2012 (3 days)	20	कृषि प्रौद्योगिकी प्रबन्ध अभिकरण, आत्मा औरंगाबाद
5.	बीज आलू उत्पादन तकनीकी एवं विपणन प्रबंधन	27-31 Aug., 2012 (5 days)	25	राज्य कृषि प्रबंधन संस्थान, रहमानखेड़ा लखनऊ, उत्तर प्रदेश
6.	विधायन हेतु आलू उत्पादन एवं मूल्यावर्धन	18-20 Oct., 2012 (2 days)	20	निदेशक, केन्द्रीय आलू अनुसंधान संस्थान, शिमला
7.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	10-11 Nov., 2012 (2 days)	20	निदेशक, केन्द्रीय आलू अनुसंधान संस्थान, शिमला
8.	MTC on technology for quality seed potato production and certification	30 Nov.-7 Dec., 2012 (8 days)	13	Directorate of Extension, Govt. of India, New Delhi
9.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन	22-24 Aug., 2013 (5 days)	5	श्री प्रवीन भारद्वाज 16, कृष्णापुरी मथुरा–281001

B. Organization of Awareness Camp/*Kisan Mela* cum Workshop: The institute organized three *kisan mela* under Tribal Sub Plan (TSP) and two awareness camp for a large no. of farmers to create awareness about modern techniques of potato cultivation. The list of these programmes are given in following table

List of kisan mela and awareness camp

Sr. No.	Title / Vanue of awareness camp	Date	No. of Farmers/ participants
1.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन, उदयपुर, (लाहौल स्पीति)	31 Oct., 2012	164
2.	आदिवासी कृषक मेला एवं प्रशिक्षण, KVK, जिला सरगुजा अम्बिकापुर (छतीसगढ़)	13-14 Feb., 2013	3500
3.	आदिवासी कृषक मेला एवं प्रशिक्षण, KVK, जिला मयूरभंज (उड़ीसा)	22-23 Feb., 2013	2500
4.	आदिवासी कृषक मेला एवं प्रशिक्षण, मांडला (मध्य प्रदेश)	18-19 March, 2013	1800
5.	आधुनिक तकनीक द्वारा बीज एवं भोज्य आलू उत्पादन, रामपुर (शिमला)	26 March, 2013	200

C. Live phone in programme/Agricultural talk on AIR and Doordarshan: Expert scientists from different fields of potato research and development from CPRI Shimla participated in various agricultural talk show and live phone in programmes on different topics. They answered the queries from potato growers on aspects like planting, water management, disease and pest management, storage practices etc. A list of these programmes is given in following table.

Agriculture talk on Doordarshan, Shimla

Sr.No.	Date	Topic	Name of Expert
1	April, 2012	Seed preparation and planting of potato in higher hills of HP	Dr. NK Pandey Dr. Ashwani Sharma
2	May, 2012	Earthing up, fertilizer application and potato disease management in higher and mid hills of HP	Dr. VK Dua Dr. Sanjeev Shrama
3	June, 2012	Harvesting and post harvest operation and mid hills of HP	Dr. KK Pandey Dr. Brajesh Singh
4	July, 2012	Fungal, boil borne disease and insect pest in potato in higher hills	Dr. Sanjeev Sharma Dr. Ravinder Kumar

5	August, 2012	Care of seed crop rouging, haulm cutting & drainage in seed potato	Dr. SS Lal Dr. Ashwani Sharma
6	September, 2012	Harvesting and post harvest operation of seed potato in higher hills of HP	Dr. Vinod Kumar Dr. Brajesh Singh
7	October, 2012	Post harvesting operation and Marketing	Dr. NK Pandey Dr. RK Rana
8	November, 2012	Planting and fertilizer application in lower hills of HP	Dr. VK Dua Dr. MK Jatav
9	December, 2012	Disease management in Potato in lower hills of HP	Dr. VK Chandla Dr. Malkhan Singh Gujjar
10	January, 2013	Planting of potato in mid hills of Shimla and other district of HP	Dr. SS Lal Dr. PM Govinda Krishnan
11	Feburary, 2013	Earthing up and potato disease management in mid hills of HP	Dr. Sanjeev Sharma Dr. VK Chandla
12	March, 2013	Seed preparation and precaution in planting of seed potato in higher hills of HP	Dr. Vinod Kumar Dr. Ashwani Sharma

Radio talk / Live phone in programme on AIR Shimla

Sr. No.	Date	Topic	Name of Expert
1	09April, 2012	Potato cultivation/ practices	Dr. NK Pandey
2	10April, 2012	Disease and pest management in Potato in mid hills of Himachal Pradesh	Dr. Sanjeev Sharma
3	14 May, 2012	आलू में कृषि सामयिक कार्य	Dr. VK Dua
4	2 July, 2012	Disease in potato & their management in higher hills of Himachal Pradesh	Dr. Sanjeev Sharma
5	27 August, 2012	Harvesting & Storage of Potato in high hills of Himachal Pradesh	Dr. Brajesh Singh
6	06 Sept., 2012	कृषि तकनीक को किसानों तक पहुचाने के लिए विभागीय प्रयास	Dr. Dhiraj K. Singh
7	01 Dec., 2012	Potato Cultivation in Himachal Pradesh	Dr. NK Pandey
8	27 Dec., 2012	आलू के प्रमुख रोग एवं उनका प्रबंधन	Dr. Ravinder Kumar
9	03 January, 2013	आलू की खेती में सावधानियां	Dr. NK Pandey

D. Participation in Agricultural fair/ Exhibition: CPRI participated in many exhibitions and agricultural fairs organized in different parts of the country through ATIC at CPRI, Shimla and other regional stations. A stall was put to showcase new potato varieties and production technologies of potato. Large no. of farmers benefitted from these exhibitions. List of these exhibitions are given in following table.

Extension activities at CPRI Campus Modipuram

Sr.No.	Particular	Dated	Venue
1	Mushroom Mela at Directorate of Mushroom Research	10 September, 2012	Solan (HP)
2	National Exhibition in Global Conference on Horticulture	28-31 May, 2012	OUAT, Bhubaneshwar
3	Farm innovators Day	18 September, 2012	PDCSR, Meerut (UP)
4	Kisan Mela at SVBP University of Agri. & Technology (The CPRI stall got first award in ICAR group)	8-10 November, 2012	Meerut (UP)
5	Exhibition in Agro-Expo	28-31 May, 2012	OUAT, Bhubaneshwar
6	Exhibition in Agri-Expo-2012	11-13 October, 2012	ICAR, RCER Patna
7	3rd North East Agri Expo	15-17 November, 2012	4th Mile, Dimapur, Nagaland
8	Exhibition during National Sciences Day	28th February, 2013	Ooty (Tamilnadu)
9	IX Agricultural Science Congress Conference	6-7 February, 2013	Bhubaneswar (Orissa)
10	Exhibition in Farm Innovators	1st March, 2013	CSWCRTI Regional Centre, Teettukkal, Ooty

Extension activities at CPRI Campus Modipuram

- Two Days training programme on “Improved Techniques of Table and Potato Seed Production for Plain areas” was organized during 19-20 December, 2012. A total number of 100 farmers from 23 districts of UP, MP, Rajasthan and Haryana participated in the training programme.

Aloo Krishi Pathshala on AIR, Delhi

- 15 episode of "Aloo krishi pathshala" was organized from 28 December, 2012 to 12 March, 2013.

Visitors and phones attended

- Total 388 farmers and 50 students from various districts of UP, Haryana and MP visited CPRIC Modipuram. A total number of 20 quarries were answered through Phone.

Front Line Demonstration of Kufri Himsona in UP

- Five FLD of Processing variety K. Himsona was conducted in Lucknow, Moradabad, Raiborrelly, Sitapur and Kanpur district of UP through respective KVKs. Average yield of K. Himsona was found to be 360 q/ha against the local variety which yielded only 314 q/ha only. Therefore K. Himsona yield was 14.6% higher than local variety.

Farm trial in hooghly (WB):- Two potato varieties namely K. Shailja & K. Himalini were planted in farmer's field in Hooghly district of WB. Yield of K. Himalini (320 q/ha) was slightly than K. Shailja (300t/ha) in these filed trials.

Extension activities at CPRS Patna

- Farmers Training cum work Shop Programme was organized on 20th January 2013. The programme was participated by 100 farmers from different parts of the Bihar.
- Participation in demonstration of harvester implement for potato from 8-11 February, 2013 in Mechanization in Agriculture Fair organized by govt. of Bihar.

Extension activities at CPRS Jalandhar

- A field day-cum-Training programme was organized on 29th November, 2012.
- Farmer Training-cum workshop on “Potato Seed Production Techniques” held on 11th December, 2012.
- One day refresher course on “Identification of Morphological Character of different Varieties of Potato Disease and their control” was organized on 14th December, 2012.

Extension activities at CPRS Gwalior (MP)

- One day training programme for farmers was organized on 7th December, 2012 at village Jalalpur.

- One day training programme for farmers was organized on 28th December, 2012 at village Girvai.
- One day training programme for 29 KVK and Horticulture Officer's were organized on "Potato Production Techniques" on 9th January, 2013.
- One day kisan mela organized at CPRS Gwalior on 4th February, 2013.

Extension activities at CPRS Shillong (Meghalaya)

- Nine trainings for famers on different dates were conducted under MM-I on "Improved Potato Production and protection technology".
- One day training programme for 40 farmers was organized on 11th February, 2013.

Extension activities at CPRS Ooty

- One day training programme for 25 Horticulture Officer's and 10 Agriculture officers from Udhagamandalam were trained on "Technologies for Potato Cultivation" organized on 12th October, 2012.
- One day training programme for 30 tribal farmers were trained on "Problems and Solutions for Potato Cultivation" on 2nd February, 2013.
- A farmer's day was organized on 9th July, 2012 at CPRS, Ooty. 25 farmers from Appukodu village of the Nilgiris district participated in the programme.

Activities of Agriculture Technology Information Centre (ATIC)

Sale and distribution of CPRI technical and extension bulletins: A total of 3647 technical bulletins were sold through ATIC. Moreover, a number of free Extension bulletins, CPRI brochures, Potato Crop Calendar and several leaf-lets related to modern potato technologies were distributed to the Scientist, Extension workers and Farmers. Specially developed CDs of PPM (Potato Pest Manager)-4 Nos. and CAAPS (Computer Aided Advisory System for Potato Crop Scheduling)-3 Nos. were also sold through ATIC. Altogether this generated revenue of Rs. 1,26,070.00 for the institute, an increase over the last year's sale.

Dissemination of knowledge to visitors: A museum has been set up in which the technology 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 were benefited by strengthening their knowledge about potato cultivation. A total of 1460 stake holders visited in the institute during the said period it included 1242 B.Sc./M.Sc. student of various universities of different states, 416 farmers from different states of the country and 156 scientist/extension worker/state level agriculture and horticulture officer.

Film Shows: The visitors were made aware of the activities being undertaken in the institute by means of documentary films viz CPRI in tune with time of 21 minutes duration, farm mechanization (15 minute duration), Pahari Kshetro me Aaloo ki Kheti and documentary on storage of potato.

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 the kits were developed for the detection of PVX and PVA using colored polystyrene beads. The coat protein of PVX was found in inclusion bodies and inclusion bodies were purified from the induced E. coli culture by using Bugbuster Protein extraction reagent, solubilized using 6M urea and refolded by dialysis. Then the coat protein was purified using Ni-NTA His bind resin. Western blotting analysis and dot-blot assay was performed with PVX Specific polyclonal antibody for further confirmation. Document for commercialization of dipstick assay kit has been prepared and submitted for commercialization.

In the processing component, water requirement of Kufri Frysona was standardized under micro-irrigation systems. In drip irrigation, maximum and significantly better French fry grade tuber productivity (31.4 t/ha) was observed with 75% CPE level and this level also had improved Fry colour (2.0). In sprinkler irrigation, highest and statistically superior French fry grade tuber yield (30.2 t/ha) was achieved with 125% CPE treatment, which also had best fry colour (2.0). French fries chain was strengthened in Gujarat in association with associate partner M/s. McCain's Food India Pvt. Ltd., Mahesana (Gujarat).

Apart from M/s. McCain's Food India Pvt. Ltd., another venture M/s HimalyaSimplot (P) Ltd. (a joint venture of Himalya International Pvt. Ltd. Paonta Sahib and JR Simplot, USA) has started their French fry plant at Vadnagar, Distt. Mehsana, Gujarat and they have found CPRI French fry variety Kufri Frysona quite suitable for commercial production.

In the Speciality component, evaluation of two crops of 'baby potatoes' in a season revealed that hybrid HT/03-704 achieved statistically better baby grade tuber number (812 '000' ha^{-1}) that also tended to improve baby grade yield (11.5 t ha^{-1}) in main season. While in late season, K. Himsona recorded statistically higher baby grade tuber yield (7.07 t ha^{-1}) and maximum total baby grade tuber yield of both crops (18.5 t ha^{-1}) was with hybrid HT/03-704 and cv. K. Himsona raised consecutively. The N-P-K dose of 25% of recommended for processing varieties (270-80-150 kg ha^{-1}) were sufficient due to shorter crop duration Hybrid HT/03-704 was accessed for baby potatoes and under both the NPK levels (25 and

50%), it retained. The glycoalkaloid contents were very low in HT/03-704 (3.5±0.2 mg 100g FW^{-1}) which were comparable to K. Himsona (2.8±0.2 mg) and much below the acceptable limit of 20.0 mg 100g FW: Superior nutritive values were recorded in HT/03-704 (as baby potato) than Kufri Himsona at 25% NPK as shown by higher ascorbic acid and total carotenoids values.

Performa to get feedback on impact assessment of technology of making cattle feed from potato waste has been prepared in Hindi and English. Leaflet prepared on compound cattle feed using potato waste. A video film was prepared on the technologies developed under this project i.e. to develop processes for making animal feed from potato wastes and extraction of dietary fibre from potato peel. Technology for animal feed with potato waste has been commercialised. Technology was trans-

ferred to Mr. D. S. Oberoi (President, Dairy Association Ludhiana), 28-A, Dairy Complex, Tajpur Road, Ludhiana-141008 on 2nd Feb 2013. Technology has been also transferred to eight progressive farmers through NABARD on 11th Feb, 2013. Discussions with foreign client, Mr. Steenekamp from South Africa is under consideration as licensing of process knowhow has been demanded by the client.

Project 2: Suitability of potato cultivar "Kufri Surya" for early planting under warmer condition in the Sone riverbed of Patna district in Bihar (Funded by Agricultural Technology Management Agency, Patna, Bihar)

Ten progressive farmers spread over four villages in the Sone river bed area of Patna district were selected through ATMA, Patna for conducting demonstration trails on their fields. Results revealed that the heat tolerant variety Kufri Surya though recorded higher emergence percentage as compared to traditional variety but still it was lower due to heavy rains immediately after planting. The variety Kufri Surya also recorded significantly taller plants and increased number of leaves per plant and the maximum plant height and number of leaves was recorded under the recommended management practice. The total dry matter production followed similar pattern.

Kufri Surya produced significantly more marketable tubers (90.5%) yield as compared to Lal Gulab which produced only 79% marketable yield out of the total tuber yield. The marketable tuber yield increased from 11.38 t/ha (Farmers practice) to 21.67 t/ ha (Kufri Surya at farmers management) and further increased to 23.14 t/ha (Planting Kufri surya as per improved recommended practices by CPRS, Patna). The increase in marketable tuber yield was 56.5 and 67.2% with Kufri Surya at farmers management and improved recommended practices over traditional farmers practice. The cost of cultivation was more with improved practice but at the same time the gross return and net return also increased with cultivation of Kufri Surya. The gross return (Rs.1,57,352 /ha) as well as net return (Rs. 60,352/ha) and B:C ratio (1.62) were maximum with cultivation of Kufri Surya at improved management practices as recommended by the CPRI.

Project 3: Sustainable livelihood improvement through need based integrated farming system models in disadvantaged districts of Bihar, Sub - project: Scientific cultivation of seed potato (Funded by NAIP, ICAR)

Production of quality seed was accomplished by adopting seed plot technique, improved agronomic practices and using high yielding variety Kufri Pukhraj, Kufri Khyati, Kufri Sadabahar and Kufri Himsona. During 2012-13 which was fifth year of this project, a group of seventy two farmers were selected. These farmers were provided with breeder seed of above mentioned high yielding varieties to produce foundation seed at their fields. In the beginning, farmers were imparted training on seed plot technique and other improved agronomic practices.

70 farmers spread over four villages, grew the seed crop covering an area of 2.4 ha. The agronomic practices were supervised at farmer's fields by the scientists and technical staff at regular intervals. In the farmers' fields the crops were fully protected against late blight. The seed crop were got certified by the seed certification agency of state government. A total of 41.55 t seed was produced. Farmers sold 2.55 t of their produce @ Rs. 8000/t. Out of a total of 41.55 t, a quantity of 39.0 t was kept in cold store for further sale or use for planting in the next season. Among the four varieties tested, Kufri Khyati performed reasonably well and the average yield was about 26.38% higher than the most popular variety Kufri Pukhraj. The viral disease incidence was also comparatively lower in Kufri Khyati as compared to Kufri Pukhraj.

The project was implemented in an area where potato was not grown earlier as popular crop. Farmers have been fully convinced that potato can be successfully grown there. Farmers have been immensely benefited through the programme and have earned handsome income through the sale of produce as seed.

Project 4: Refinement of technology for potato crop management through botanicals and their effect on soil pest dynamics, crop growth and soil health (Funded by Mini-Mission-1 Project)

Monitoring of soil pests of potato was done with the help of light traps to formulate effective management schedule against target pests. Liquid formulations of effective botanicals *viz. Melia azedarach* (dharek), *Sapindus mukorossi* (reetha), *Urtica diocia* (bhichu butti), *Azadirachta indica* (*neem*) and *Alium sativus* (garlic) prepared by fermentation in cow urine and in solvent (methanol) proved very effective against cutworm and white grubs as compared to talc powder formulation and formulation prepared in different manures under control conditions. The extracts of *Melia azedarach* (*dharak*) and *Azadirachta indica* (*neem*) gave maximum protection of potato crop from the attack of cutworms (0.33-0.67% damage with 0.33 number of cutworm/plot as compared to 7.67 cutworms in control plots). The extracts of *Melia azedarach* (dharek) and *Azadirachta indica* (neem) gave maximum protection of potato crop from the attack of white grubs (0.33-1.00 % damage with 0.33-0.67 number of white grubs/plot as compared to 10.7 white grubs in control plots at the time of potato harvesting). Three awareness programmes were organised, one at Kandaghat, one at Baculty (Fagu) and one at Shakrodi (Seoni) potato growing areas to impart knowledge to the farmers about importance of the botanical pesticides for potato soil pests management.

Project 5: Farmer Participatory Action Research Programme (FPARP) 2nd Phase (Funded by Ministry of Water Resources, Govt. of India, New Delhi)

The programme involved field demonstrations of the technologies developed by the institute *viz.,* rainwater harvesting farm ponds, use of poly mulch/organic mulch in vegetable crops, raise bed technology for *in situ* soil moisture conservation to achieve higher crop yields. A total of 75 rain water harvesting dug-out farm ponds (30-50 cubic meter capacity) were constructed and lined with 250 micron meter black HDPE (High density poly-ethylene Geomemberane) sheet. During the drought period at the sowing time of summer and off -season vegetables, seeding irrigation was given from rainwater harvesting ponds which ensured quick emergence and establishment of these crops (tomato, potato, capsicum, ginger, French bean, garlic and spinach). These crops were further covered with poly mulch of 30 micron thickness sheet having silver/black colour for further conservation of soil moisture, which resulted in to 15-25 % increase in yield of these crops. Raised bed technology under pea, garlic, capsicum and tomato also resulted in higher yield. The crop growth was always higher under raised bed plots with increase in 10-15% higher crop yield. Use of micro irrigation was also demonstrated under potato crop which resulted in 25-30% increase in potato yield.

Project 6: Phytophthora, Fusarium and Ralstonia diseases of horticultural and field crops

Phytophthora infestans population was characterized using both biological and molecular markers. Variation in the metalaxyl tolerance has been recorded in the population both in the hills and plains of India. In the hills, A_2 mating type has completely replaced A_1 mating type and almost stabilized while in the plains A_1 mating type has established itself. Beside, more complex (9-11 genes) races have been reported from across the country. Mitochondrial DNA (mt DNA) analyses of the pathogen population revealed that the new population (Ia type) has displaced the old population (Ib type) in most of the locations. SSR analysis of the pathogen population revealed that primers Pi04 & Pi63 showed better polymorphism but could not establish any relationship with origin of isolates, metalaxyl sensitivity, racial spectrum and mating types. Real time PCR protocol for detection & quantification of *P. infestans* in host tissues was standardized. SCAR marker based on RAPD sequence was developed for detection of *P. infestans* and which showed specificity to *P. infestans* only. Bioassay and qRT-PCR analysis of siRNA and amiRNA positive transformed lines of Kufri Pukhraj and Kufri Khyati confirmed the resistant nature of siRNA and amiRNA transgenic lines against late blight. Identified two QTLs located on chromosomes IX and X of diploid mapping population of *Solanum spegazzinii* x *S. chacoense* which explained 14.70 and 3.40% variation, respectively Fig. 1. To

investigate the late blight resistance *R* genes in the wild/semi-cultivated *Solanum* species by sequencing based allele mining approach using known primer pairs, a total of 44 *Solanum* species were screened for late blight resistance, out of which 18 were found highly resistant. Hybridization was attempted to combine *R1* and *R3a* genes in single host background and about 15 clones were identified possessing both R1and R3a genes through MAS. Besides, 20 genotypes with PVY resistance (*Ryadg* gene), 10 genotypes with PCN resistance (*HC*, *H1*genes) were also identified. The biosurfactant compound has been characterized as rhamnolipid from *Pseudomonas aeruginosa* and formulation based on rhamnolipid has been prepared. Decision support system for the management of late blight in western Uttar Pradesh has been developed.

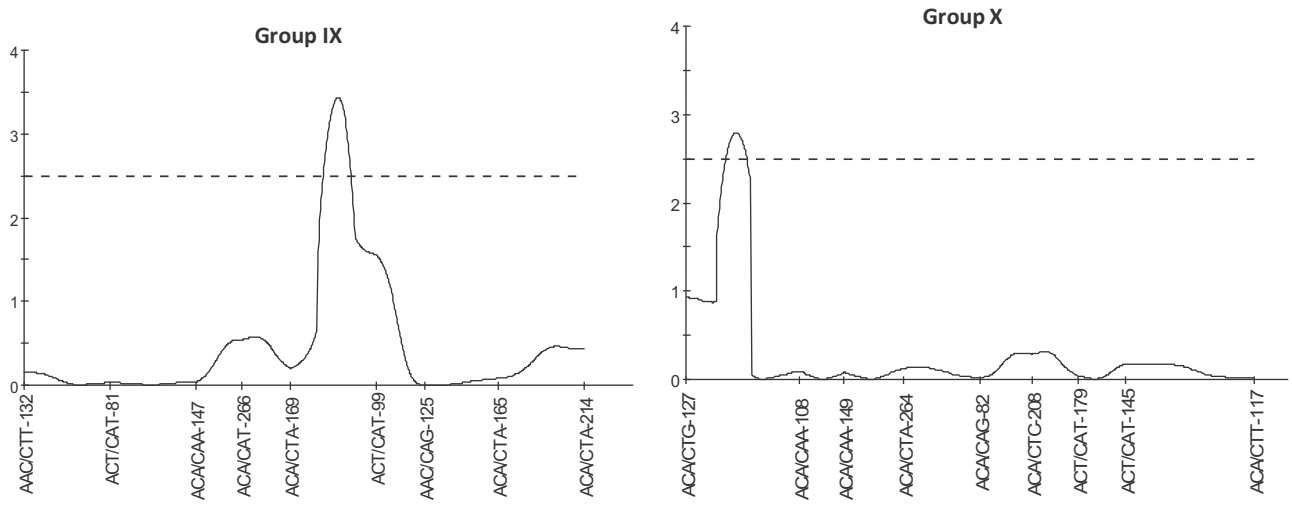


Fig.1: Late blight resistance QTL mapping on linkage group IX and X in the 126 progenies of cross between Solanum spegazzinii × S. chacoense

Project 7: Engineering late blight resistance in susceptible Indian potato cultivars (ICAR/ABSP II collaboration)

Genome walker studies confirmed the integration of right and left border of RB gene cassette in the SP951 parental line. All the clones of right border sequence matches ~99% whereas left border sequence matches along with potato genome, which reconfirmed the integration of whole T-DNA region of RB cassette in the parental line. Quantitative real-time (qRT)-PCR analysis was used to investigate a possible relationship between the amounts of RB transcript level in leaf and tuber tissues and disease severity. The expression of elongation factor gene was used to normalize the relative abundance of the RB gene as well as SGT transcript level in SP951 line (**Fig.2**) and hybrids. Expression of RB gene was static from the point of inoculation to 120 hrs after inoculation (hri) in leaf tissues. Expression of R genes was gradually up regulated (10 fold in KJ 16, 20 fold KJ 21 and 8 fold in KJ 66 over non hybrid line) in correlation with the level of infection in Kufri Jyoti hybrid lines. This reveals that expression patterns of R gene are dependent on genetic background of the genotypes. The expression of other defense related gene like SGT transcript found to be 7 fold after 24 hri (0% infection) and this level of expression maintained up to 120 hri (35% infection). Expression level of RB transcript correlated with the % infection of *P.infestans.* Similarly, expression of RB and SGT genes was studied in tubers of SP951 (**Fig**.3). In tubers no expression of RB transcript was recorded while its downstream defense gene SGT transcript expression level accumulated in very negligible amount (0.2 fold to 0.9 fold, at 24, 72 and 120 hr) confirming that there is no expression of RB gene in tubers.

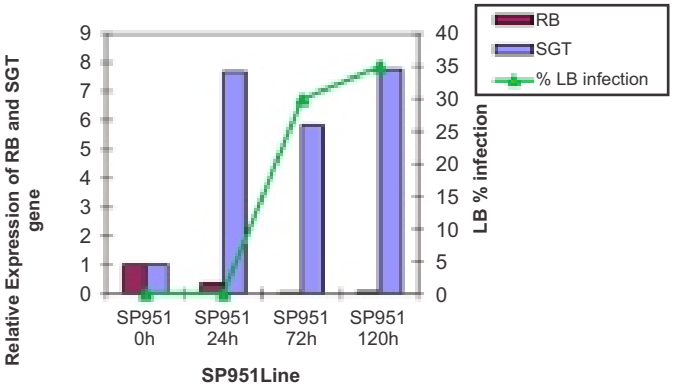


Fig.2: Relative expression of RB and SGT transcript in leaves in relation to P. infestans interaction

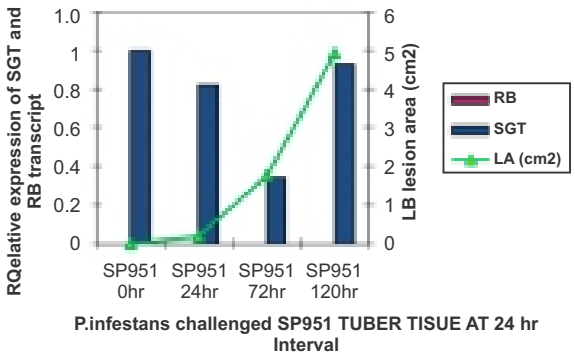


Fig.3: Relative expression of RB and SGT transcript in tuber tissue in relation to P. infestans interaction

Project 8: Development of transgenic potato with resistance to major viruses (ICAR network project on transgenics in crops)

Tubers of transgenic lines of Kufri Pukhraj *viz.,* KPYS-1, KPYS-9, KPYS-10, KPYS-13, KPYS-18, KPYS-20, KPYS-21, KPYS-24, KPYS-26 and KPYS-36 (CP in sense orientation) and KPYNT-2, KPYNT-3, KPYNT-4, KPYNT-9 (non translatable CP) were multiplied under glass house and planted for second year screening for PVY resistance through challenge inoculation. Transgenic lines of Kufri Badshah (2 lines- GTLC2-90, GTLC2-127) and Kufri Pukhraj (5 lines -KPLC2-30, KPLC2-37, KPLC2-53, KPLC2-54 and KPLC2-44) carrying hairpin replicase constructs which were found resistant to ToLCNDV-potato were planted in containment facility and the tubers have been harvested for studying the tubers and other characters.

Project 9: *Training Entrepreneurial Skills to Farmers in Potato Based Farming System of Himachal Pradesh*

The Project "Training Entrepreneurial Skills to Farmers in Potato Based Farming System of Himachal Pradesh" under centrally sponsored scheme Technology Mission for Integrated Development of Horticulture in Himachal Pradesh (MM-I) was started in October, 2010. The project duration is of three years and under this project 5 districts has been selected on the basis area under potato cultivation and production i.e. Shimla, Mandi, Kangra, Sirmour and Una. As per the target of the project about 10 on farm training and 2 on campus training will be conducted per year for the farmers of the selected 5 districts.

During the year 2012-13, 10 On-farm trainings were conducted at Kangra, Mandi, Una, Sirmour, Shimla district where about 424 farmers participated. Out of these 262 were male and 162 women farmers. These vegetables growers were trained in commercial cultivation of potato, pea and other vegetables. They were trained in different aspects like plant protection,

water management, storages and marketing of these vegetables. 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 5 districts (Kangra, Mandi, Una, Sirmour, and Shimla) showed that there was overall 25.7% increase in knowledge level of farmers after trainings.

Two On-campus trainings were also conducted at CPRI, Shimla. A total of 42 farmers participated in these trainings 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 there was an improvement of 28.3% in the knowledge and skills of farmers after trainings.

Project 10: *Central Sector Scheme for PPV & FR legislation*

- **Varieties/numbers under maintenance breeding:** Reference collection of 162 varieties/numbers was maintained both *in vitro* at Shimla and *in vivo* at Kufri and Modipuram. These include 46 CPRI released varieties, 7 state varieties, 18 exotic varieties in cultivation in India, 62 indigenous varieties/numbers and 29 UPOV example varieties.
- **Varieties under DUS test:** Two potato varieties of PepsiCo Limited are under DUS testing in the category of 'new varieties'. The vegetative parameters of both the varieties were recorded at CPRS, Jalandhar and CPRIC, Modipuram stations, respectively along with reference varieties.
- **Human Resource Development initiatives:** Three 'one day' training cum awareness camp were organised at three different districts (Solan, Shimla and Mandi) of Himachal Pradesh for creation of awareness among farmers and common mass about Protection of Plant Varieties and Farmer's Rights Act 2001 on 26th November, 2012, 10th January, 2013 and 28th February, 2013, respectively. More than 100 participants took active participation in each of the training and got benefitted from it.

Table: 1- List of training under PPV & FRA

Districts	Date of training	No. of participants
Solan	26th November, 2012	128
Shimla	10th January, 2013	95
Mandi	28th February, 2013	133

Project 11: Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology scheme (Up-scaling of existing components i.e. Intellectual Property Right (IPR)

CPRI is committed to generate technologies leading to enhanced potato productivity and its utilization. Till date, CPRI has developed more than 50 potato varieties suitable for different agro-ecological regions of the country. The institute aims to act as a centre for training in research methodologies and technology for up-grading scientific manpower in modern technologies for potato production and to provide consultancy in potato research and development. So far CPRI has developed more than **89** technologies including **50** potato varieties for different agro-climatic zones, registered **19** germplasms and **20** technologies. So far **2** technologies have been patented and **2** more patents filed and **1** technology have been commercialized.

Achievements:

- Information regarding Commercialisation of **2** technologies i.e. 'Heap Storage Technology' and 'Dipstick Technology for detection of potato viruses' has been submitted to ZTMC-New Delhi.
- **Two** MOU are in process i.e MOU with Anand Agricultural University, Gujarat and MOU with Rajdeep Agri Products Pvt. Ltd, New Delhi.
- One industry interface meeting was organised with participants.

❖ Other initiative taken for commercialisation:

Possible buyers for three technologies have been identified and initiatives for their commercialisation have been taken. These technologies are:

I. Aeroponic Technology.

II. Heap Storage Technology.

III. Dipstick Technology for detection of potato viruses.

Project 12: Refinement of rapid multiplication technique for recalcitrant potato cultivar suitable for Himachal Pradesh (MM-I)

Kufri Girdhari, Kufri Bahar and Kufri Chandramukhi produced maximum microplant height and number of leaves in the medium supplemented with ammonium nitrate 10mM. Kufri Jyoti produced significantly maximum microplant height, number of leaves and nodes in the medium supplemented with ammonium nitrate 25mM. Kufri Bahar produced maximum number of nodes on the medium containing 10-20mM ammonium nitrate whereas Kufri Girdhari at 10mM. Kufri Chandramukhi produced maximum number of nodes in the medium supplemented with 15-25mM ammonium nitrate. Almost all the cultivars except Kufri Girdhari produced more number of roots in the medium supplemented with lesser ammonium nitrate as compared to standard MS medium whereas, Kufri Girdhari (5.7) produced higher number of roots in the standard MS medium. Kufri Girdhari, Kufri Bahar and Kufri Jyoti recorded maximum fresh weight in the medium containing 10-15mM ammonium nitrate. However, Kufri Chandramukhi recorded maximum fresh weight on the standard MS medium. Kufri Girdhari recorded maximum dry weight in the medium containing 10mM ammonium nitrate, Kufri Bahar and Kufri Chandramukhi in 20mM whereas, Kufri Jyoti in 15mM.

Minituber production

Project 13: Production of planting material of potato through hi-tech system of seed production for the hills of Himachal Pradesh

A total of 12,000 microplants and 4,720 minitubers in G-0 were produced at Shimla. A total of 694 (17.5 kg) tubers of K. Girdhari in G-1was produced at HAREC Dhaulakuan during Rabi 2012 season supplied from 200 minitubers of Kufri Girdhari by CPRI Shimla. About each of 100 minitubers (G-0) of each Kufri Jyoti and Kufri Girdhari was supplied by CPRI Shimla to KVK, Kandaghat in May 2012 for further multiplication in G-1 by which 70 tubers of K, Jyoti and 129 Tubers of Kufri Girdhari was produced but severely infected with root knot nematode hence decided to discard and stop the multiplication in that field. A total number of 1012 tuber of Kufri Jyoti and 1630 of Kufri Girdhari was produced in G-2 at Jadhari farm of KVK, Kandaghat and harvested in July. No yield in G-2 in Dhaulakuan and Una center because most of the G-1 materials is either rotted during storage or not germinated after planting.

Project 14: Refinement of technology for improvement of potato microtubers and aeroponic minitubers production, vigour and survivability

Effect of different packing material on periodical storage behaviour of aeroponic minitubers at ambient conditions of Shimla.

In K. Himalini, percent weight loss increased from 35 days to 60 days of storage at ambient conditions in most of the packing material. Maximum 50.3% weight loss was observed in muslin cloth while minimum (29%) in net cloth within 2 months of storage at ambient condition of Shimla. Most of the packing material resulted in weight loss of >40% during the storage period at ambient condition. The sprout length of aeroponic minituber increased to maximum of 307% in paper box while lowest was 7.1% in gunny bags. The sprout length was at par in plastic bag and net cloth bag. Sprout length increased only upto 40 days of storage in paper box and then remained constant in subsequent observations upto 60 days. Sprout length was decreased in gunny bag and net cloth bag from 53 and 60 days. In K. Surya, the % weight loss increased in all packing material from 35 to 60 days. Maximum weight loss was 33.7% in paper box while minimum

(20.3%) in plastic paper bag. The weight loss ranges from 20.3 to 33.7% and more or less similar in all the packing material. The maximum of 166.3% sprout length increase was observed in paper box. The decrease in sprout length was recorded in plastic bag, muslin cloth bag, gunny bag and net cloth bag from 40 days to 60 days of storage while almost constant in remaining packing material.

Effect of different storage conditions and laboratory storage containers on weight loss of microtubers.

Microtubers of K. Megha were stored for 5 months at 4ºC and then for 3.5 months in the ambient conditions. The weight loss varied from 33.5-60.9%. Almost similar weight loss was observed in all the conditions, grades and packing materials. Weight loss was more in 4 mm than 6 mm in all storage containers i.e. petriplates, ventilated bottles and plastic bags. In K. Kanchan, the weight loss varied from 11.6 to 52.9%. The weight loss was more in 4 mm than 6 mm in most of the storage conditions. Among the containers, ventilated bottles were better than petriplates and plastic bag.

Effect of bio-pesticide treatment on microtuber germination and vigour of K. Sindhuri.

The microtubers of K. Sindhuri were stored in polybags at 4ºC temperature for 9 months. These microtubers were dipped for 30 minutes and then plated on moist blotter paper for incubation at ambient conditions. Germination, rottage and vigour in terms of shoot and root length was recorded after 11 days of plating revealed that the shoot length was maximum in carbendazim (0.2%), *P. flourescens* (3%) and *T. viride* (3%) in comparison to control (fig-4). Rooting was maximum in *T. viride* (3%) as compared to all the treatments. The higher dose of biopesticides was not toxic to sprouting behavior of microtubers.

Effect of bio-pesticide priming as dry dressing of mycoflora on germination of microtubers.

Microtubers of 4 mm grades coated with *T. virde* (1%) and *P. flourescens* (0.8%) was comparatively better for sprouting after 13 days of planting in comparison to control in K. Sindhuri and K. Kanchan. Combination of *T. virde* (0.6%) + *P. flourescens* (0.6%) was very good for increase in germination, vigour and suppression of mycoflora. No any adverse effect of captan and carbendazium on germination after 35 days of incubation in any of the varieties and any grade of microtubers. The maximum germination was recorded in captan (0.25%) and carbendazim (0.25%) with maximum vigour and minimum mycoflora (fig-5). *Aspergillus, Penicillium, Fusarium, Rhizopus, Mucor* and one unidentified fungus producing fruiting body were observed on germinated microtubers in the control.

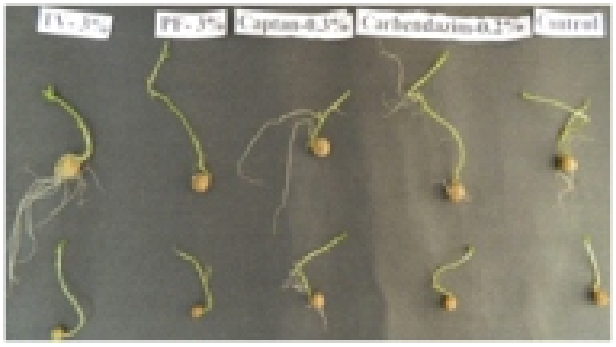


Fig. 4: Comparative growth of sprout & roots

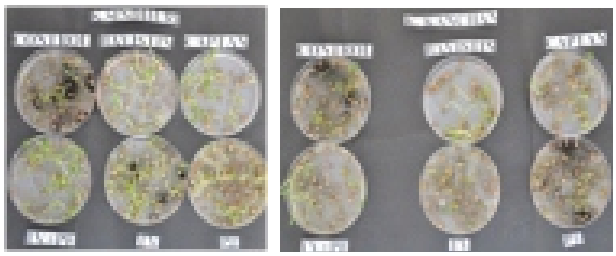


Fig: 5 Mycoflora and germination in biopriming

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 64 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 clearing house 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 1205 documents were purchased, procured and added to library resources. The total collection at Shimla stand at 37544 documents comprised of 14966 books, 15164 back volume of journals, 2547 serials, 2162 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 27401 books; journals back volumes and other documents i.e. AR/Reprints and Bulletins etc as per the details below (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	4414	5576	1534	11624	23
2	CPRS, Jalandhar	3107	1401	1216	5724	20
3	CPRS, Patna	1977	1280	-	3257	11
4	CPRS, Gwalior	957	4	59	1020	-
5	CPRS, Ooty	1592	1888	540	4020	12
6	CPRS, Shillong	1448	–	164	11612	2
7	CPRS, Kufri	144	–	-	144	-
	TOTAL	**13639**	**10249**	**3513**	**27401**	**68**

Periodicals and Serials Management

Sixteen serials title i.e. advances, annual reviews, reference annuals, yearbooks and statistical data publications etc. were purchased. A total of 183 current journals comprising of 30 foreign and 153 Indian have been subscribed at Shimla. Out of which 19 foreign and 136 Indian journals were subscribed on payment basis and rest on exchange or gratis. In all 1099 issues of such journals were received, marked and kept in library for use. Besides **68** titles of different journals were subscribed at CPRS libraries. 653 entries of library documents were made in Library Automation Software and 573 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, 30 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 2203 documents were circulated (borrowed and returned) for home studies and 5537 readers consulted 29529 (includes reshuffling of documents in lower and upper hall) documents within the library. Besides 32 outside scientists and research scholars of various research organizations consulted the library resources. 11 new members were enrolled and 7 old members withdrew their library membership due to their transfer or retirement. At present 152 readers are active members of library including RAs/SRFs. Library received 8150 reference queries from the users of the library and responded to them satisfactorily. Besides, 711 job requests were received for 2,39,766 copies of photocopying and printing work of different scientific and administrative documents.

Documentation and Information Services

1099 issues of journals (813 issues of national and 286 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 List of New Additions (Monthly) were brought out regularly and updated for library users.

Resource Generation and utilization

The library has generated the revenue of Rs. 3,02,607.00 which include the amount charged on account of rendering CDROM searching & photocopying services (Rs. 14,488.00), IGNOU computer practical (Rs. 18,560.00) and library discount (Rs.2,69,559.00) in addition to normal 10% GOC discount saved on purchase of library books and journals through CPRI Book store. A total of Rs. 39,51,856.00 was spent (under Plan Rs. 35,25,899.00 and Non-Plan Rs. 4,25,957.00) on purchase of library resources like books (Rs.20,65,127.00), and subscription of journals (Rs.14,02,049.00) at HQ library Shimla and Rs 4,84,680.00 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 19th Aug – 4th Sept 2012 for 9 MLIS and 14 BLIS students of IGNOU Study Center, Shimla.

Infrastructure Development

One high end HP Server and “LIBERTY” web enabled library automation software has been procured and installed to facilitate digital content storage, searching and downloading of scientific documents.

Institute Research Council Meeting, 2012

The Institute Research Council Meeting, 2012 was held at CPRI, Shimla on 10th -11th August, 2012. It was attended by 62 scientists from the Headquarters and Stations. The basic objective of this meeting was review of the achievements of 2011-12 and finalize the work plan for 2012-13 of different research programmes. The main decisions taken during the meeting are given below:

1. Quarantine records of the imported germplasm will be maintained by the Division of Plant Protection.
2. *Aphis gossipii* should be targeted pest at Modipuram and all entomologists should discuss and develop methodology to quantify whitefly on field level per unit arpea.
3. The performance of advanced hybrids likely to be introduced in AICRP (P) multi-location trials will be examined by respective Station Heads and Director, CPRI (if possible) at the time of harvest. The PI of the project will submit the proposal in the prescribed proforma to Director, CPRI through respective Head of Stations.
4. The ploidy status of the existing 11 dihaploids should be confirmed by flow-cytometry/ chromosome count.
5. Germplasm, particularly the parental lines for processing should be evaluated for early bulking. Besides, additional characters to be evaluated in germplasm should be identified in consultation with all the breeders.
6. Reviewing the current status of molecular markers for PVX, PLRV, PVA, PALCV resistance genes needs to be done.
7. Pre-breeding for the selected traits *i.e*. late blight, low cold induced sweetening, heat tolerance should be carried out through protoplast fusion and production of diploid lines and these should be further utilized in breeding programmes.
8. Wild species database will be shared with all the breeders so as to identify the promising available clones by the respective breeder. The suitable clones suggested by the breeders will be planted in the polyhouse/ glass house at Kufri for utilization in the respective breeding projects. Firstly these clones shall be checked for the frequency of 2n gamete production and if found >1% then the same will be utilized for crossing with widely adapted commercial cultivars.
9. Promising wild clones will be used for somatic hybridization. Somatic hybrids will be further improved for agronomic traits by crossing with commercial cultivars.
10. In early maturing cultivars, the data on glyco-alkaloid content should be recorded in the advanced hybrids at 60 days crop duration.
11. Division of Social Science should take up the issue based survey for i) Reasons for Kufri Surya not being adopted by farmers of early growing regions, ii) Identification of nitche areas for new varieties/hybrids and their region specific requirements.
12. The storage data of advanced hybrids should be presented with temperature and relative humidity data and the data should be verified by Head of Stations.
13. Development of combined RNAi constructs for late blight resistance besides, identification of new resistant genes through microarray approach. Promising wild clone (s) having consistently high late blight resistance should be used in microarray experiments.
14. Efforts should be made to identify novel genes from promising somatic hybrids through biotechnological approaches.
15. Front-line demonstrations for popularization of Kufri Surya and Kifri Himalaini at Hassan and Dharwad may be conducted. Front-line demonstrations for popularization of Kufri Garima and Kufri Gaurav at Jalandhar and Modipuram may also be conducted at farmer's field.
16. Interaction between late blight pathogen and temperature, pathogen and genotype may be studied in all combinations of temperature and genotypes.
17. Irrigation should be given based on available soil moisture in screening of water efficient germplasm/hybrids.
18. Rubberized material may be used in combine harvester to reduce the bruising of potato tubers. Cleaning system should also be

incorporated in potato combine harvester.

19. The experiment on "Effect of temperature on the efficacy of fungicides" studied on detached leaves needs to be repeated on whole plants in growth chamber.

20. Screen *Solanum pimpinellifolium* against all strains of *Ralstonia solanacearum*. If *S. pimpinellifolium* proves to be susceptible, then the Director, IIHR, Bengaluru be contacted for providing resistant sources against *R. solanacearum*.

21. The analysis of 1,4-DMN should be done in more number of varieties for establishing its relation with dormancy.

22. The previous plant extracts found effective for sprout suppression may first be characterized before working on new sprout suppressants.

23. Basic studies on enzymes related to physiological ageing during potato storage may be done on priority.

24. The high glycoalkaloid content in peels of varieties like Kufri Lauvkar should be correlated with the taste of varieties. The possibility of increasing the firmness in low oil French fries should be explored.

25. Possibilities for improving the aeration in the insulated culture rooms should be explored and implemented at the earliest to bring down the CO_2 content in-order to improve the vigour of microplants.

26. Experiment on comparative performance of conventional *vs* hi-tech seed production system should be carried out up to three generations starting with breeder seed (Stage IV vs Generation-II) mainly at Gwalior and Patna in the experimental area.

27. More number of front line demonstrations of newly released varieties should be conducted in their respective suitable/potential areas.

Publications

A. Research papers published in referred journals

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73. Minhas, J.S., Mehta, A., Charaya, P. and Singh, B.P. (2012) Chipping and nutritional quality of potato processing varieties harvested at different maturity dates in North-Western plains. In: Abstracts: 5th Indian Horticultural Congress 2012, p 519. Held at PAU Ludhiana November 6-9, 2012.

74. Minhas, J.S. 2012. Potato Production in India: Present Scenario and Future Prospects. Invited lecture, New Frontiers and Future Challenges in Horticultural Crops (NFFCHC-2012). Held at PAU Ludhiana 15-17th March 2012.

75. Minhas, J.S. and Kumar, D. 2012. Screening of potato germplasm for water use efficiency and transpiration rate based on carbon and oxygen stable isotope ratios. -ibid-, Bhubneshwar conference, pp140.

76. Mehta, A., Ezekiel, R., Singh, B. and Minhas, J.S. 2012. Processing quality of potato varieties stored under different conditions. In: Abstracts: 5th Indian Horticultural Congress 2012, p 488. Held at PAU Ludhiana November 6-9, 2012.

77. Luthra, S.K., Gupta, V.K. and Rawal, S. 2012. MS/6-1947: A promising drought tolerant advanced potato hybrid. -ibid-, Bhubneshwar conference, pp. 99.

78. Mehta, A., Bhagwati, P.C., Satpathy, P.C., Konar, A., Gupta, Y.K., Naik, P.S. and Singh, B.P. 2012. On-farm heap storage of potatoes: Evaluation in north-eastern plains of India. -ibid-, pp. 86.

79. Singh, B., Mehta, A. and Ezekiel, R.2012. Possibilities of enhancing dormancy of seed potatoes under diffused light storage in Hills. -ibid-, pp. 138.

80. Singh, D. K. and Pandey, N. K. and Rana, R. K. 2012. Utilization pattern of agricultural information sources by potato growers of Himachal Pradesh. -ibid-, pp. 98.

81. Rana, R. K., Singh, D. K., Pandey, N.K. and Singh, B.P. 2012. Dynamics of seed potato utilization in UP state of India (Poster presentation), -ibid-, pp. 134.

82. Tomar, S., Malik, K., and Singh, B.P. 2012. Field testing of diafenthiuron for the management of *Bemisia tabaci* (Gennadius) non-B type population. -ibid-, pp. 148-149.

E. Misc. Publications

1. *Extension Bulletin* No.39 (Revised) entitled "Cultural Management of crops in potato based cropping systems in India".
2. *Technical Bulletin* No.95 entitled "Potato cultivation in North-western Himalaya".
3. *Aaloo Fasal Calendar* (Hindi) Potato Crop Calendar.
4. *Technical Bulletin* No.96 entitled "Integrated Management of potato pests".
5. *Extension Bulletin* No.44 'Certification of Potato for Seed & Export".
6. *Quinquennial Review Team Report*. *Extension Bulletin* No.23 entitled "पठारी क्षेत्रों में भोज्य एवं बीज आलू की उत्पादन तकनीक".

Institute Activities

Important meetings and Visitors

Parliamentary Standing Committee on Agriculture visited CPRI, Shimla

Parliamentary Standing Committee on Agriculture visited CPRI, Shimla during 16-17 June, 2012. The Committee had a total of 13 members along with 5 other important officials from the Parliament. Discussions on Evaluation of National Agricultural Research System was held during their visit. The Committee was headed by Shri Basudev Acharya. The role of potato in National Agricultural Research was discussed by MPs at length with the Director. During the meeting, utilization of fresh potato waste as animal feed was also discussed. The Chairman and Members of the Committee lauded the efforts of CPRI towards achieving self sufficiency in potato production in the country.

Director General, ICAR visits CPRS, Muthorai, Tamil Nadu

Dr. S. Ayyappan, Secretary, DARE and DG, ICAR visited CPRS, Muthorai on 14th June, 2012. An interaction with scientists was held about the research project undertaken at the Station and suggestions for the future line of work were given by him. He showed keen interest and apprised the potato production problems in the Nilgiris. Dr Ayyappan also inaugurated the newly constructed potato store and planted a sapling in the station premises.

QRT Team visited CPRI, Shillong and Shimla

The Quinquennial Review Team (2006-10) comprising Dr RP Ray, Vice Chancellor, OUAT, Bhubaneswar as Chairman of QRT, and other Members viz. Dr ML Chadha, Dr AK Singh, Dr HC Pathak, Dr GC Srivastava and Dr R. Ezekiel, Member Secretary visited Central Potato Research Station, Shillong on 12th June, 2012 to review the progress of work at this station and also at the centres of AICRP on potato in CAU, Pasighat, Arunanchal Pradesh and Assam Agricultural University, Jorhat, Assam. They also interacted with the Scientists of participating centres and CPRS, Shillong during the meeting. Further the Quinquennial Review Team visited CPRI during 16-

18, October to review the progress of work at the Institute and give future guidelines to the scientists associated with different projects etc.

Foundation Day of CPRI

CPRI, Shimla celebrated its Foundation Day on 9th August, 2012. The occasion was graced by Shri Suresh Bhardwaj, Hon'ble MLA of Shimla constituency. In this function Dr NM Nayar, Former Director of CPRI and a renowned Agricultural Scientist delivered IPA Ramanujam Memorial lecture award. Dr Rakesh Pandit from Department of Ayurveda, HP State Government also delivered a lecture on "Life style related health problems in office workers and remedial measures" . Approximately 250 persons including scientists and farmers attended this function. On this occasion a Workshop-cum-Exhibition was also organized for the benefit of potato farmers and training was given to farmers on "Improved Method of Potato Production " by the experts.

Parliamentary Committee on Official Language Implementation visits CPRS, Muthorai

Review meeting of the second Sub-Committee of Committee of Parliament on Official Language Implementation was held on 6th October, 2012 at Ootacamund. Hon'ble Members of Parliament were

welcomed by Dr TA Joseph, Head, CPRS, Ooty and the various activities of the station, current status of official language implementation at the station were highlighted. The future strategies to be undertaken to implement the official language in the day today functioning of the station was also discussed. Dr SK Malhotra, Principal Scientist, Horticultural Division, ICAR, New Delhi Shri Praveen Chandla, Assistant Director, Official Language, CPRI, Shimla alongwih the station scientists participated in this review meeting.

Stakeholders meet held at CPRS, Jalandhar

A meeting of the stakeholders on potato research and development was held at CPRS, Jalandhar on December 10, 2012 under the chairmanship of Dr Birpal Singh, Director, CPRI, Shimla. A total of forty nine persons including representatives from private companies like Sygenta India Limited, Pune, Technico, Chandigarh, Haldiram Snacks Pvt. Ltd., Noida, Satnam Agriculture Products, Jalandhar, Transgenic Bioplants Pvt. Ltd., Ropar, Cold Store Owners, Agricultural Implement Manufacturers, Area Manager, National Seed Corporation (NSC), Jalandhar, executives of Jalandhar Potato Growers Association, executives of POSCON Jalandhar, scientists of CPRS, Jalandhar and CPRIC, Modipuram and many progressive farmers attended this meet. Discussion on improvement of machine like haulm cutter, combine harvester, popularization of new potato varieties, involving progressive

farmers in potato breeding, ways to enhance potato consumption and involving farmers in certified seed production was held. To suggest ways and means to popularize newly released varieties a committee of 14 persons from companies/ progressive farmers and CPRI was constituted.

RAC Meeting

The Institute Research Advisory Council meeting was held at CPRI, Shimla on 26-27 July, 2012 under the chairmanship of Dr KR Dhiman, Vice Chancellor, Dr YS Parmar University of Horticulture & Forestry, Nauni, Solan, HP. Important decisions were taken to guide the research agenda of CPRI during the meet.

IRC Meeting

The Institute Research Council meeting was held on 10-11 August, 2012 at CPRI, Shimla. The meeting was attended by 62 scientists from Shimla and Regional Station of the Institute. The main objective of the meeting was to review the progress made in different research programmes of the Institute. The programme leaders presented the achievements made during 2011-12 under various research programmes of the Institute and were also guided by the experts about the further plan of action during his meeting.

Dr. N. Krishna Kumar, DDG (Hort.) ICAR visiting CPRI

Visit of Hon'ble Dr Charan Dass Mahant Hon'ble Dr Charan Dass Mahant, State Minister of Agriculture & Food Processing Industries

Hon'ble Dr Charan Dass Mahant, State Minister of Agriculture & Food Processing Industries, Govt. of India visited CPRI, Shimla during 31 December, 2012 to 2nd January, 2013. During his visit he visited various labs of the Institute and inquired about the research being undertaken. He also inaugurated the newly started Aeroponic facility : An Innovative Method of Potato Seed Production created at CPRI, Shimla. He addressed the entire CPRI Staff and praised the work being done in the Institute. He also emphasized upon to find the possibilities of setting up more and more processing facilities in the State and Country. He also visited CPRS, Kufri and planted a sapling at the Aramgha premises of the station as a mark of remembrance.

Institute Joint Staff Council Meeting

During the period three meetings with IJSC were held on 13 August, 2012 at CPRIC, Modipuram, 11 December, 2012 at CPRS, Jalandhar and 30th March, 2013 at CPRI, Shimla. The meetings were chaired by Dr BP Singh, Director, CPRI. In these meetings the grievances of the staff were taken up and were solved through discussions. From the Chair the Director also requested the staff members to work in harmony and mutual cooperation for the progress of the Institute.

Group meeting of AICRP (Potato)

The 30th Group Meeting of AICRP (Potato) was organized at OUAT, Bhubaneswar, Odisha during September 23-25, 2012. The meeting was attended by delegates from Indian Council of Agricultural Research, Central Potato Research Institute, State Agriculture Universities and representatives from the Industries. During the workshop the action taken on the recommendation of 29th Group Meeting were reviewed in the presence of Dr Umesh Srivastava,

ADG (Hort-II), ICAR, New Delhi. Further the results of the trials conducted at different centres were reviewed and 11 crop production and 4 crop protection recommendations were brought out. The technical programme for the next year was also formulated at the meeting.

National Consultation Meet

A national consultation meet on potato research and development was held at Odhisa University of Agriculture & Technology, Bhubaneswar on 26th September, 2012. The meet was jointly organized by Central Potato Research Institute, Shimla, Indian Potato Association, Shimla and Odhisa University of Agriculture & Technology, Bhubaneswar. In this meeting panel discussions on i) research strategies to break the yield barriers ii) Concernes of industrial sector regarding post harvest handling, marketing and marketing issues in case of surplus and shortages, iii) issues in seed production – farmers perspectives and concerns of the seed industry and iv) status and prospects of international trade issues of licenses GAP and other policies were held at length during the day. The meeting was attended by 107 delegates representing different concerned sectors. In the evening the Annual General Body meeting of the IPA was held, thereby utilizing the whole day to the full.

Hindi Chetna Maas

CPRI celebrated Hindi Chetna Maas from 14 September to 13 October, 2012. Dr OP Sarswat, renowned poet of Himachal Pradesh inaugurated this celebration. During this celebration various competitions were held in which all the staff members of the Institute were covered. Along with headquarters Hindi Divas was also celebrated at CPRI Stations viz. Modipuram, Jalandhar, Patna, Gwalior, Ooty and Shillong. The winner of these competitions were honoured with prizes. Dr BP Singh, Director, CPRI presided over the concluding function. He emphasized on the maximum use of Hindi in the day-to-day work of the Institute.

Foreign visits by CPRI Scientists

1.	Dr. Bir Pal Singh, Director, CPRI, Shimla for participation in the 8th World Potato Congress at Edinburgh, U.K. during May 27-30, 2012.
2.	Dr. Brajesh Singh, Sr. Scientist, CPRI, Shimla for attending training programme "Gene expression studies related to tuberisation and heat stress tolerance in potatoes and signalling pathways underlying heat stress tolerance" Madrid, Spain from 10th May 2012 to 9th July 2012.
3.	Dr. Shashi Rawat, Sr. Scientist, CPRI, Shimla for participation in the training programme in "DNA Sequencer" at Asia Pacific Support Centre, Shanghai, China during November 01-08, 2012.
4.	Dr.(Ms.) Jeevalatha, Scientist, CPRI, Shimla for participation in the training programme in "Micro-Array System" at Asia Pacific Support Centre, Shanghai, China during November 01-08, 2012.
5.	Dr. Bir Pal, Singh, Director, CPRI, Shimla for participation in the meeting of Board of Trustees of CIP to be held at CIP, Lima, Peru during November 19-23, 2012.
6.	Dr. Bir Pal, Singh, Director, Dr. Sanjeev Sharma, Sr. Scientist & Dr. Surendresha Scientist, CPRI, Shimla for participation in the Workshop on "Biotechnology for Food Security and Farmer Prosperity and ABSP-II Potato Partners Meeting" to be held at Dhaka, Bangladesh during 28-29 November, 2012.

Krishi Sansthan Samman Award 2013

Education, Training, Awards & honours

Conference/Seminar/Symposium and Workshop

Sl. No.	Name & Designation	Training Programe	Date & Venue
1.	Dr. Devendra Kumar, CPRIC, Modipuram	National conference on climate change and agriculture	April 10, 2012 at CCR(PG) College, Muzaffarnagar (UP)
2.	Dr. PM Govindakrishnan, and Dr. SK Yadav	XXBiennial workshop of "All India Coordinated Research Project on Weed Control"	Kerla Agriculture University, Thrissur w.e.f. April 19-20, 2012
3.	Dr. Sanjay Kumar Yadav, Scientist, CPRS, Shillong	Biennial conference of Indian Society of Weed Science on "Weed threat to Agriculture, Biodiversity and Environment"	Kerla Agricultural University, Thrissur w.e.f. April 19-20, 2012
4.	Sh. AS Negi, AO and Sh. Jeet Ram, AAO, CPRI, Shimla	Training course on "Purchase Management in Govt. for Gazetted Officers"	ISTM, New Delhi w.e.f. 21-25 May, 2012
5.	Dr. AK Srivastava, Scientist, CPRS, Shillong.	National Seminar on "Plant Genetic Research for Eastern and North-Eastern India"	ICAR Research Complex for NEH Region, Umiam, Meghalaya w.e.f. 11-12thMay, 2012
6.	Dr. Sanjay Rawal, Scientist, CPRIC, Modipuram	Zonal Workshop	May 20-21, 2012 at SVBPUAT, Meerut
7.	Dr. G. Ravichandran, Sr. Scientist, CPRS, Ooty	Collaborative workshop on "Export opportunities for value added agro based products from Tamil Nadu and Punducherry"	Punducherry, w.e.f. 28-29 May, 2012
8.	Dr. SK Kaushik, Dr. R.K. Singh, Dr. Rahul R. Bakade, Dr. EP Venkatasalam and Dr. Dhruv Kumar	Global Conference on "Horticulture for food, nutrition and livelihood options"	OUAT, Bhubaneswar w.e.f. 28-31st May, 2012.
9.	Dr. Bir Pal Singh, Director, CPRI, Shimla	One day workshop on "Disposal of Appeal under RTI"	ISTM, New Delhi on 8.6.2012
10.	Dr. NC Upadhyay, PS, CPRIC, Modipuram	National Seminar on "Organic and Biological Inputs- New Innovations and quality control"	Ghaziabad w.e.f. 18-19 July, 2012
11.	Dr. VK Gupta, Sr. Scientist, CPRIC, Modipuram	Training course on "Conventional and biotechnology approaches in crop improvement"	PAU, Ludhiana w.e.f. 7-27 August, 2012
12.	Dr. Sanjay Rawal, Sr. Scientist, CPRIC, Modipuram	Short course on "Application of Nanotechnology in soil science and plant nutrition research"	IISS, Bhopal w.e.f. 18-27 September, 2012
13.	Dr. Jeevalatha, Scientist, CPRI, Shimla	Seminar on "Millennium Alliance"	Shimla on 21st September, 2012
14.	Dr. Shashi Rawat, Sr. Scientist, CPRI, Shimla	Workshop cum training on "Computational genome analysis techniques in discovery of agronomically important crops genes"	NBPGR, New Delhi w.e.f. 24-29 September, 2012

Sl. No.	Name & Designation	Training Programe	Date & Venue
15.	Sh. Dinesh Kumar, TO, CPRIC, Modipuram	Training programme on "Information and communication technologies (ICs) for Agricultural Knowledge Management"	NAARM, Hyderabad w.e.f. 3-17 October, 2012
16.	Dr. NK Pandey, Head, Division of Social Sciences, CPRI, Shimla	National workshop on " Scientific report writing and presentation"	NAARM, Hyderabad w.e.f. 20-23 November, 2012
17.	Dr. SK Kaushik, Dr. SS Lal, Dr. AnujBhatnagar, Er. Manjit Singh, Dr. Jagesh Kumar Tiwari, Dr. Rajesh Kumar Rana, Dr. VU Patil, Dr. Name Singh, Dr. (Ms) Bandna, Dr. VK Dua, Dr. Sundrsha S., Dr. Devendra Kumar, Dr. SP Trehan, Dr. Raj Kumar, Er. Sunil Gulati, Dr. TA Joseph, Dr. KK Pandey, Dr. (Ms.) Dalamu, Dr. Murlidhar J Sadawarti, Dr. R Muthuraj, Dr. Sanjeev Sharma, Dr. NK Pandey, Dr. VinaySagar, Dr.(Mrs.) Ashiv Mehta, Dr. Vinay Bhardwaj, Dr. JS Minhas, Dr. NC Upadhayay, Dr. A. Jeevalatha, Dr. Vinay Singh, Dr. RK Arora, Dr. SK Singh, Dr. VK Gupta, Dr. Shambhu Kumar, Dr. (Mrs.) Kamlesh Malik, Dr. Umamaheswari, Dr. TK Bag, Dr. AK Srivastava, Dr. MS Gurjar, Dr. Pinky Raigond and Dr. Rakesh Mani Sharma,	National Consultation on "Potato Research and Development: Way Forward"	OUAT, Bhubaneswar, Odisha on 26th September, 2012
18.	Dr. JS Minhas, Dr. SP Trehan, Dr. (Mrs.) Ashiv Mehta and Er. Manjit Singh, CPRS, Jalandhar	5th Indian Horticulture Congress 2012	Punjab Agricultural University, Ludhiana w.e.f. November 6-9, 2012
19.	Dr. Baswaraj R., Scientist, CPRI, Shimla	XXI National Conference on "Immunobiology and Management of Viral Diseases in 21st Century"	IVRI, Mukteswar, Nainital, Uttarakhandw.e.f. 8-10th November, 2012
20.	Dr. VK Dua, Dr. SK Yadav, Dr. SK Singh, Dr. SP Singh and Sh. Kapil Kumar Sharma	Third International Agronomy Congress on "Agriculture Diversification, Climate Change Management and Livelihoods"	IARI, New Delhi w.e.f. 26-30 November, 2012
21.	Dr. Shashi Rawat, Sh. Islam Ahmad and Sh. Dhraminder Verma	Training on "Web based (Dot Net) technology"	DOEACC, Shimla w.e.f. 26th November, 2012 to 22nd December, 2012
22.	Dr. (Ms.) A. Jeevalatha, Dr. Baswaraj R. and Dr. (Mrs.) Pinky Raigond, CPRI, Shimla	Focal theme on "Nanotechnology creating better tomorrow for India and for the world"	Bangalore w.e.f. 5-7 December, 2012
23.	Dr. Vinay Sagar, Dr. Baswaraj R. and Dr. A. Jeevalatha, CPRI, Shimla	National Symposium on "Blending Conventional and Modern Plant Pathology for Sustainable Agriculture"	Bangalore w.e.f. 4-6 December, 2012

Sl. No.	Name & Designation	Training Programe	Date & Venue
24.	Dr. VK Dua, Sr. Scientist, CPRI, Shimla	Training programme on "Two days workshop on RTI Act - 2005"	Istm, New Delhi w.e.f. December 17-18, 2012
25.	Dr. Rajesh Rana, Pr. Scientist, CPRI, Shimla	Training workshop on "Modeling Agricultural Research Priority Setting and Polity Communications"	NASC Complex, Pusa, New Delhi w.e.f. January 7-9, 2013
26.	Dr. MA Khan, Sr. Scientist, CPRIC, Modipuram	Chemist conclave meet	IARI, New Delhi w.e.f. January 14 -15, 2013
27.	Dr. KK Pandey, Head, Division of Seed Technology, CPRI, Shimla	34th Annual Conference & Symposium of ISMPP on "Crop Disease Management: Advances and Challenges"	NAU, Navsariw.e.f. 21-23 January, 2013
28.	Dr. Vinay Bhardwaj, Act. Head, Div. of CI, Dr. Sanjeev Sharma, Act. Head, Div. of PP and Dr. Sundresha, Scientist CPRI, Shimla	Third "Global Biosafety Management Programme (GBMP): Approach to Product Development and Regulation" and the "LBR Potato Partner's meeting"	Hyderabad w.e.f. January 21-23 and January 23-24, 2013
29.	Dr. Anuj Bhatnagar, Principal Scientist, CPRIC, Modipuram	International Congress on "Insect Science"	UAS, Bangalore w.e.f. February 14-17, 2013
30.	Dr. Malkhan Singh Gurjar, Scientist, CPRS, Shillong	Training programme on "Exploitation of microbial and genomic resources for plant disease management"	USA, Dharward w.e.f. 29th January - 18th February, 2013
31.	Dr. RK Singh Scientist (SS), CPRS, Patna	Training programme on "New dimensions in quality seed production technology with special reference to hybrid seed production of field and vegetable crops"	GB Pant University of Agric. & tech. Pantnagar, Uttrakhand w.e.f. February 18-27, 2013 (Re -scheduled)
32.	Sh. Rahul R. Bakade, Scientist, CPRS, Patna	National workshop on "foresight and future pathways of agricultural research through youth in India"	NASC Complex, New Delhi w .e.f. March 1-2, 2013
33.	Dr. SS Lal, Head, Div. of CP, CPRI, Shimla and Dr. MJ Sadawarti, Scientist, CPRS, Gwalior	State level seminar cum workshop on Potato, Onion and Garlic	Indore on 9th March, 2013
34.	Sh. Rahul R Bakade, Scientist, CPRS, Patna	National training programme on "Polyphasic Microbial identification: Methods and applications"	Mau, Uttar Pradesh, w.e.f. March 5-14, 2013
35.	Dr. Devendra Kumar, Pr. Scientist CPRIC, Modipuram	05th Annual Workshop NAIP (component-2)	March 11-12, 2013 at NASC, Pusa Campus, New Delhi.
36.	Er. Manjit Singh, PS, CPRS, Jalandhar	RashtriyaSangosthi in Hindi 2013	CSSRI, Karnal w.e.f. March 13-14,

Awards & honours

2011	Sadar Patel Outstanding ICAR Institution Award 2011	CPRI, Shimla
2013	Krishi Sansthan Samman Award 2013	CPRI, Shimla

Other Awards and Honours

- **Post Doctoral Fellowship-** Dr. K Manorama, Sr. Scientist (Agronomy), CPRS, Ooty completed NIAS at II Sc. Campus, Bangalore Post Doctoral Fellow for a period of six months on Sabbatical leave (w.e.f. 28.9.2012) under the DST sponsored programme "Agricultural Innovation Systems in India – An Analysis".
- **Best Poster Award-** Manorama K, Govindakrishnan PM, Ravichandran G and Lal, SS. 2013. "Potato Crop Scheduling for Nilgiris – Development of DSS" was presented with best poster award in the International Conference "Increasing Agricultural Productivity and Sustainability – The Future We Want" organized by National Institute of Advanced Studies, Bangalore and MSSRF, Chennai during 8th and 9th January, 2013.
- **Best poster paper award**- for paper "Molecular diversity of begomovirus associated with apical leaf curl disease in potato" by A. Jeevalatha, S. K. Chakrabarti, Sanjeev Sharma, Vinay Sagar, Kamlesh Malik and B.P. Singh. In: National Symposium on Blending conventional and modern plant pathology for sustainable agriculture held during December 4-6th, 2012 at Indian Institute of Horticulture Research, Bangalore. p86.
- **Second best poster paper award**- for paper "RT-PCR standardization for detection of viruses in apple" by Santosh Watpade, Baswaraj R, K K Parmanik, Y P Sharma, P D Thakur, Anil Handa, Satish Kumar and Ankush Katoch. National Symposium on "Emerging Issues in Plant Health Management" during September 28-29, 2012 at Y S Parmar University of Horticulture and Forestry, Nauni, Solan.
- **Second best poster paper Award-** for paper **"**Current profile of potato viral diseases in Punjab" by Arora, R.K., Singh, A.K. and J.S.Minhas. National Consultation on Potato Research and Development:Way Forward. CPRI, IPA and OUAT, Bubaneswar September 26, 2012.
- **Third best poster paper Award** for paper **"**Anastomosis grouping of *Rhizoctonia solani* associated with black scurf disease of potato based on ITS -5.8 RDNA region by Vinay Sagar, A.Jeevalatha, Shravan Singh Parmar, R.K.Arora, Rahul Bakade, Sanjeev Sharma, S.K. Chakrabarti and B.P.Singh. National Consultation on Potato Research and Development: Way Forward. CPRI, IPA and OUAT, Bubaneswar September 26, 2012.

Dr. B P Singh, Director, CPRI receiving The ICAR Best Institute Award for the year 2011

Classified abstract of expenditure (Non-plan and Plan) and Receipt

Annexure - B
(Amount in Rs.)

Details of Institute Non Plan Expenditure for the year

Head Expenditure	Allocation Govt. Grant Resource+Additional	Allocation Internal Total amount provided by HQ out of Council's share		Expenditure Allocation	Expenditure Govt. Grant)	Total Generation)
1	2	3	4	5	6	7
		Grants in Aid - Capital Works				
A.1 Land	0	0	0	0	0	0
B.1 Office Buildings	0	0	0	0	0	0
B.2 Residential Buildings	0	0	0	0	0	0
B.3 Other works	0	0	0	0	0	0
Total: Works	0 Other Capital Expenditure	0	0	0	0	0
C. Equipments	1785000	0	1785000	1496350	0	1496350
D. Information Technology	0	0	0	288637	0	288637
E. Library Books and Journals	426000	211000	637000	214957	211000	425957
F. Vehicles and Vessels	0	0	0	0	0	0
G. Livestock	0	0	0	0	0	0
H. Furniture & fixtures	289000	289000	578000	56	289000	289056
I. Others000000						
Total:other Capital Expenditure	2500000	500000	3000000	2000000	500000	2500000
Grants in Aid - Capital	2500000	500000	3000000	2000000	500000	2500000
Grants in Aid - Salaries						

Contd.....

Head Expenditure	Allocation Govt. Grant Resource+Additional	Allocation Internal Total amount provided by HQ out of Council's share		Expenditure Allocation	Expenditure Govt. Grant	Total Generation
	Establishment Expenses					
A.1 Establishment Charges	242098000	0	242098000	242098247	0	242098247
A.2 Wages	69020000	690200	0	6901628	0	6901628
A.3 Overtime Allowance	0	0	0	0	0	0
Establishment Expenses	249000000	0	249000000	248999875	0	248999875
Grants in Aid - Salaries	249000000	0	249000000	248999875	0	248999875
	Grants in Aid - General Pension and Retirement Benefits					
A. Pension & Other Retirement Benefits	98000000	0	98000000	97998496	0	97998496
Pension and Retirement Benefits	98000000	0	98000000	97998496	0	97998496
	Travelling Allowances					
A. Domestic TA / Transfer TA	1600000	0	1600000	1599914	0	1599914
B. Foreign TA	0	0	0	0	0	0
Travelling Allowances	1600000	0	1600000	1599914	0	1599914
	Research and Operational Expenses					
A. Research Expenses	13330000	5000000	18330000	8330420	5000000	13330420
B. Operational Expenses	5025000	2000000	7025000	3024599	2000000	5024599
Research and Operational Expenses	18355000	7000000	25355000	11355019	7000000	18355019
	Administrative Expenses					

Contd.....

Head Expenditure	Allocation Govt. Grant Resource+Additional	Allocation Internal Total amount provided by HQ out of Council's share		Expenditure Allocation	Expenditure Govt. Grant	Total Generation
A. Infrastructure	8023000	0	8023000	8023213	0	8023213
B. Communication	455000	0	455000	453613	0	453613
C.1 Repairs/Maintenance - Equipments, Vehicles & Others	2973000	2000000	4973000	1272546	2000000	3272546
C.2 Repairs/Maintenance - Office building	4404000	2000000	6404000	2165230	2000000	4165230
C.3 Repairs/Maintenance - Residential building	2263000	2000000	4263000	502603	2000000	2502603
C.4 Repairs/Maintenance - Minor Works	516000	0	516000	516188	0	516188
D. Others (excluding TA)	6726000	2675000	9401000	3750794	2675000	6425794
Administrative Expenses	25360000	8675000	34035000	16684187	8675000	25359187
	Miscellaneous Expenses					
A. HRD	560000	300000	860000	260350	300000	560350
B. Other Items (Fellowships, Scholarships etc.)	0	0	0	0	0	0
C. Publicity & Exhibitions	0	0	0	0	0	0
D. Guest House – Maintenance	0	0	0	0	0	0
E. Other Miscellaneous	0	0	0	0	0	0
Miscellaneous Expenses	560000	300000	860000	260350	300000	560350
Grants in Aid - General	143875000	15975000	159850000	127897966	15975000	143872966
Grand Total : Capital + Revenue	395375000	16475000	411850000	378897841	16475000	395372841
(Salaries)+						
B. Loans and Advances	0	1000000	1000000	0	838500	838500

Details of Institute Plan Expenditure for the year 2012-13 (Amount in Rupees)

Head	RE Allocation	Expenditure
Grants in Aid - Capital Works		
A.1 Land	0	0
B.1 Office Buildings	12406000	12406000
B.2 Residential Buildings	0	0
B.3 Other works	0	0
Works **Other Capital Expenditure**	12406000	12406000
C. Equipments	1651000	1187206
D. Information Technology	0	463794
E. Library Books and Journals	3526000	3525899
F. Vehicles and Vessels	0	0
G. Livestock	0	0
H. Furniture & fixtures	634000	634000
I. Others	0	0
Other Capital Expenditure	5811000	5810899
Grants in Aid - Capital	18217000	18216899
Grants in Aid - Salaries		
Establishment Expenses		
A.1 Establishment Charges	0	0
A.2 Wages	0	0
A.3 Overtime Allowance	0	0
Establishment Expenses	0	0
Grants in Aid - Salaries	0	0
Grants in Aid - General		
Pension and Retirement Benefits		
A. Pension & Other Retirement Benefits	0	0
Pension and Retirement Benefits	0	0
Travelling Allowances		
A. Domestic TA / Transfer TA	2500000	2499716
B. Foreign TA	0	0
Travelling Allowances	2500000	2499716

Contd.....

Head	RE Allocation	Expenditure
Research and Operational Expenses		
A. Research Expenses	48458000	48458452
B. Operational Expenses	5238000	5238404
Research and Operational Expenses	53696000	53696856
Administrative Expenses		
A. Infrastructure	3669000	3668513
B. Communication	294000	293701
C.1 Repairs/Maintenance - Equipments,Vehicles & Others	2192000	2188534
C.2 Repairs/Maintenance - Office building	8812000	8811630
C.3 Repairs/Maintenance - Residential building	0	0
C.4 Repairs/Maintenance - Minor Works	596000	596280
D. Others (excluding TA)	2304000	2306625
Administrative Expenses	17867000	17865283
Miscellaneous Expenses		
A. HRD	3720000	3719830
B. Other Items (Fellowships, Scholarships etc.)	0	0
C. Publicity & Exhibitions	0	0
D. Guest House – Maintenance	0	0
E. Other Miscellaneous	0	0
Miscellaneous Expenses	3720000	3719830
Grants in Aid - General	77783000	77781685
Grand Total : Capital + Revenue (Salaries)	**96000000**	**95998584**

	Receipt (Rs.)	
1	Sale of Farms Produce	12251023
2	Sale of Fish & Poultry	0
3	Sale of Land	0
4	Sale of Building	0
5	Sale of Vehicle, Other Machine Tools	351000
6	Sale of Livestocks	0
7	Income from Royalty, Sale of Publications and Advertisement	128110
8	Licence Fee	1315969
9	Interest earned on Loans and Advances	1130435
10	Leave Salary and Pension Contribution	0
11	Receipts from Schemes	0
12	Analytical and Testing Fee	0
13	Pre-shipment Fee	0
14	Application fee from candidates	127020
15	Diploma Charges	0
16	Receipts from Services Rendered	0
17	Unspent Balance of Grants	0
18	Interest earned on short term deposits	5410600
19	Income generated from Internal Resource Generation	0
20	Net profit in Revolving Funds	21358792
21	Recovereies of Loans and Advances	1426544
22	Miscellenous Receipts	6052351
	Grand Total	**49551844**

Contd.....

Promotions / Retirements / Transfers / Deaths

Scientific Category

Appointments

Dr. PM Govindakrishnan, Principal Scientist has assumed the charge to the post of Project Coordinator, CPRI, Shimla with effect from 17th May, 2012.

Promotion

1. Dr. Brajesh Singh, Sr. Scientist to the post of Principal Scientist w.e.f. 20.2.2010.
2. Dr. Raj Kumar, Sr. Scientist to the post of Principal Scientist w.e.f. 1.1.2009.
3. Dr. SK Luthra, Sr. Scientist to the post of Principal Scientist w.e.f. 1.1.2009
4. Dr. Anuj Bhatnagar, Sr. Scientist to the post of Principal Scientist w.e.f. 1.1.2009.
5. Dr. Dhruv Kumar, Sr. Scientist to the post of Principal Scientist w.e.f. 20.5.2011.
6. Dr.Vijay Kumar Dua, Sr. Scientist to the post of Principal Scientist w.e.f. 1.1.2009.
7. Dr. Sanjay Rawal, Sr. Scientist to the post of Principal Scientist w.e.f. 12.9.2011.
8. Dr. Sidharth Kumar Singh, Sr. Scientist to the post of Principal Scientist w.e.f.24.12.2011.
9. Dr. Manoj Kumar, Sr. Scientist to the post of Principal Scientist w.e.f. 17.3.2009.
10. Dr.Vinay Singh, Sr. Scientist to the post of Principal Scientist w.e.f. 11.5.2010.
11. Dr. RK Rana, Sr. Scientist to the post of Principal Scientist w.e.f. 1.1.2009.
12. Dr. SK Kaushik, Sr. Scientist to the post of Principal Scientist w.e.f. 1.1.2009

Transfers

1. Sh. Earadsappa E. , Scientist (Plant Breeding), CPRS, Patna relieved with effect from 4.4.2012 (AN) to join at Directorate of Cashew Research, Puttur.
2. Dr. EP Venkatasalam, Scientist relieved from CPRI, Shimla from 10.12.2012 to join at IARI, Wellington Centre, Ooty, Tamilnadu.
3. Dr. R. Muthu Raj, Sr. Scientist, CPRS, Ooty joined his duty at CPRI, Shimla with effect from 24.12.2012.
4. Dr. (Mrs.) TC Kumari Sugitha, Scientist has joined her duty at CPRI, Shimla with effect from 12.9.2012.

Retirements

1. Dr. AK Somani, Head, CPRS, Gwalior on 30.9.2012
2. Sh. Rambir, PS, CPRIC, Modipuram on 31.10.2012.
3. Dr. TA Joseph, PS, CPRS, Ooty on 31.12.2012.

Technical Category

Promotion through assessment

1. Shri AMR Sawale, CPRS, Gwalior, promoted T-9 in the pay scale of Rs. 15600-39100 + GP 7600/-, with effect from 5.4.2010.
2. Dr. Ashok Kumar, CPRIC Modipuram, promoted T-7-8 in the pay scale of Rs. 15600-39100 + GP 6600/-, with effect from 8.5.2011.
3. Shri Mahipal Singh Bharti, CPRIC Modipuram, promoted T-7-8 in the pay scale of Rs. 15600-39100 + GP 6600/-, with effect from 1.7.2010.
4. Shri Harvir Singh, CPRIC Modipuram, promoted T-7-8 in the pay scale of Rs. 15600-39100 + GP 6600/-, with effect from 30.3.2011.
5. Shri Arun Kumar Singh, CPRS, Patna, promoted T-7-8 in the pay scale of Rs. 15600-39100 + GP 6600/-, with effect from 16.7.2010.
6. Shri Yogesh, CPRI, Shimla, promoted to T-6, with effect from 1.2.2012, in the pay scale of Rs. 15600-39100+5400 GP
7. Sh. Parvesh Jassal, CPRI, Shimla, promoted to T-6, with effect from 1.1.2012, in the pay scale of Rs. 15600-39100+5400 GP
8. Shri Yogesh Kumar Gupta, CPRS, Jalandhar, promoted to T-6, with effect from 10.04.2012, in the pay scale of Rs. 15600-39100+5400 GP
9. Shri Satander Kumar, CPRIC, Modipuram, promoted to T-6, with effect from 03.02.2012, in the pay scale of Rs. 15600-39100+5400 GP
10. Shri Murari Lal, CPRIC, Modipuram, promoted to T-6, with effect from 16.01.2012, in the pay scale of Rs. 15600-39100+5400 GP
11. Shri Santosh Kumar, CPRIC, Modipuram, promoted to T-6, with effect from 17.06.2011, in the pay scale of Rs. 15600-39100+5400 GP

12. Shri Kundan Singh, CPRIC, Modipuram, promoted to T-5, with effect from 03.02.2011, in the pay scale of Rs. 9300-34800+ 4600 GP

13. Shri Mool Chand, Tractor Driver (T-4) CPRIC, Modipuram, promoted to T-5, with effect from 01.01.2009, in the pay scale of Rs. 9300-34800+ 4600 GP

14. Shri Naresh Kumar Sharma, CPRI, Shimla, promoted to T-4, with effect from 16.06.2012, in the pay scale of Rs. 9300-34800+ 4200 GP

15. Shri Harbans Lal, CPRS, Jalandhar, promoted to T-4, with effect from 06.05.2012, in the pay scale of Rs. 9300-34800+ 4200 GP

16. Shri Agre Nand Singh, Driver (T-3) CPRS, Patna, promoted to T-4, with effect from 29.06.2011, in the pay scale of Rs. 9300-34800+ 4200 GP.

17. Shri Ranjesh Bhardwaj, CPRI, Shimla, promoted to T-3, with effect from 07.06.2012, in the pay scale of Rs. 5200-20200 +2800 GP

18. Shri Naresh Kumar, CPRI, Shimla, promoted to T-3, with effect from 15.04.2012, in the pay scale of Rs. 5200-20200 +2800 GP

19. Shri Pawan Kumar , CPRIC, Modipuram, promoted to T-3, with effect from 24.12.2011, in the pay scale of Rs. 5200-20200 +2800 GP

20. Shri Lal Babu Das , Driver (T-2), CPRS, Patna, promoted to T-3, with effect from 29.6.2011, in the pay scale of Rs. 5200-20200 +2800 GP

21. Shri Bhag Singh, Driver (T-2), CPRS, Jalandhar, promoted to Driver (T-I-3), with effect from 29.6.2011, in the pay scale of Rs. 5200-20200 +2800 GP

22. Shri Onkar Singh, Driver (T-2), CPRI, Shimla, promoted to T-3, with effect from 01.01.2011, in the pay scale of Rs. 5200-20200 +2800 GP

23. Shri Atma Ram, CPRS, Kufri, promoted to T-2, with effect from 28.09.2011, in the pay scale of Rs. 5200-20200 +2400 GP

24. Shri Mohan Lal, CPRS, Kufri, promoted to T-2, with effect from 11.07.2012, in the pay scale of Rs. 5200-20200 +2400 GP

25. Shri Dev Raj, CPRI, Shimla, promoted to T-2, with effect from 11.07.2012, in the pay scale of Rs. 5200-20200 +2400 GP

26. Shri Ram Dayal, CPRI, Shimla, promoted to T-2, with effect from 11.07.2012, in the pay scale of Rs. 5200-20200 +2400 GP

27. Shri Anil Kumar Dube, CPRI, Shimla, promoted to T-2, with effect from 11.07.2012, in the pay scale of Rs. 5200-20200 +2400 GP

Promotion under 33.33% Departmental Promotion Quota from Skilled Support Staff

1. Shri Bijendra Singh, SSS, CPRS, Gwalior, promoted as T-1, w.e.f. 6.8.2012

2. Shri Pawan Kumar, SSS, CPRS, Jalandhar, promoted as T-1, w.e.f. 6.8.2012

3. Shri Tara Chand, SSS, CPRS, Gwalior, promoted as T-1, w.e.f. 6.8.2012

4. Shri Sita Ram, SSS, CPRI, Shimla, promoted as T-1, w.e.f. 6.8.2012

5. Shri Sat Pal Singh, SSS, CPRIC, Modipuram, promoted as T-1, w.e.f. 6.8.2012

6. Shri Pravesh Kumar, SSS, CPRS, Patna, promoted as T-1, w.e.f. 6.8.2012

7. Shri Laiq Ram, CPRI, Shimla, promoted as T-1, w.e.f. 7.8.2012

8. Shri Surinder Pal, CPRI, Shimla, promoted as T-1, w.e.f. 16.11.2012

Retirements

1. Shri Jagat Ram, Technical Officer (T-5), on 30.04.2012

2. Shri Kuldeep Singh, Technical Asstt. (T-3), on 30.04.2012

3. Shri SK Awasthi, Technical Officer (T-5), on 30.04.2012

4. Shri Tarlochan Singh, Technical Officer (T-5), on 30.04.2012

5. Shri AMR Sawale, Technical Officer (T-9), on 31.05.2012

6. Shri Abdul Rasheed, Technical Officer (T-5), on 31.05.2012

7. Shri Satnam Singh, Technical Officer (T-5), on 30.06.2012

8. Sh. T. Selvraj, T-2, (Trac.-cum-Jeep Driver) CPRS, Muthorai, retired on 31.08.2012

9. Shri Atma Ram,T-2, CPRS, Kufri on 31.10.2012

10. Shri Shivi Kant Arya, T-3 (Tractor Driver), CPRS Patna, on 31.10.2012

11. Shri Ram Nath Vishwakarma, T-3 (Tractor Driver), CPRS Patna, on 31.1.2013

Transfer wihin Institute

1. Shri Munna Lal, Technical Officer (T-6), from CPRS Jalandhar to CPRS Gwalior, on 1.5.2012
2. Shri Munna Lal, Driver (T-4), from CPRIC, Modipuram to CPRS Gwalior, on 1.6.2012
3. Shri Sita Ram Sahu, T-3, transferred from CPRS, Kufri to CPRS, Jalandhar. He joined at Jalandhar on 1.9.2012
4. Shri Udaivir Singh, T-4 (FFT), transferred from CPRS, Jalandhar to CPRIC, Modipuram. He joined at Modipuram on 1.12.2012.
5. Shri Anil Kumar Chandel, T-2 (Electrical Operator), transferred from CPRS, Patna to CPRS, Jalandhar. He joined at Jalandhar on 3.12.2012

Transfer outside the Institute

1. Shri Rajneesh Rajput, T-6 (Technical Officer), AKMU, CPRI, Shimla, relieved from CPRI, Shimla, in the afternoon of April 09, 2012, to report for duty in the Horticulture Division, KAB-II, Pusa, New Delhi.

Probation Clearance

1. Probation of Shri Sunil Kumar, T-1 (FFT) cleared w.e.f. 13.4.2012, vide office order dated 12.12.2012.

Administrative Category

Promotion:-

1. Sh. Baldev Raj, Assistant, CPRI, Shimla promoted as AAO at CPRIC, Modipuram w.e.f. 12.04.2012 in the Pay Band of Rs. 9300-34800+Grade Pay of Rs. 4600/-.

Appointments

1. Miss Prawartika Das joined at CPRI, Shimla on 16.7.2012 as Assistant (DR).
2. Miss Simranjeet Kaur Lall joined at CPRI, Shimla on 16.8.2012 as Assistant (DR).
3. Sh.Narender joined at CPRI, Shimla on 17.9.2012 at CPRI, Shimla as Assistant (DR).
4. Sh.Sandeep joined at CPRI, Shimla on 22.10.2012 at CPRI, Shimla as Assistant (DR).

Transfer:-

1. Sh. KK Sood, Admn.Officer transferred from Directorate of Mushroom Research, Solan and joined at CPRI, Shimla on 1.3.2013.
2. Sh.Girish Thakur, Steno. Gr.III, CPRS, Gwalior to CPRI, Shimla(Temporary transfer) upto 4th June,2013.
3. Sh.Sandeep, Asstt. CPRI, Shimla to CPRS Patna on 8.3.2013.
4. Sh. Pradhuman Kumar Sarswat, LDC, transferred from CPRIC, Modipuram and joined at CPRS, Gwalior on 7.5.2012.

Retirements

1. Smt.Nirmal Rani, UDC,CPRS, Jalandhar on 31.10.2012
2. Sh.Lekh Ram Thakur, PA, CPRI, Shimla w.e.f. 31.1.2013.
3. Sh.Arjun Singh, Asstt., CPRS, Patna w.e.f. 28.2.2013.

Probation & Confirmation

Sl.No.	Name & Designation	Date from which probation cleared	Date of confirmation
1.	Sh.Chander Prakash, Asstt. Fin.& Accounts Officer, CPRI, Shimla	23.5.2012	24.5.2012
2.	Sh.Ashish Dhangar, Asstt. Fin.& Accounts Officer, CPRI, Shimla	27.5.2012	28.5.2012
3.	Sh.Girish Thakur, Steno.Gr.III, CPRI, Shimla.	25.06.2012	26.06.2012

Probation

Sl.No.	Name & Designation	Date from which probation cleared
1.	Sh. DD Kashyap, Asstt. (Store), CPRI,Shimla	24.11.2012
2.	Sh. Devendra Kumar, Asstt., CPRS, Kufri.	25.11.2012
3.	Smt. Teirina Nongkhlaw, Asstt., CPRS, Shillong	24.11.2012

Granted financial up gradation under MACP Scheme.

Sl. No.	Name & Designation of the Officials	Granted financial up gradation under MACP Scheme
1.	Smt. Bindra Gupta, Asstt., CPRI, Shimla	Granted 3rd MACP w.e.f. 13.8.2012 in the PB Rs. 9300-34800+4600GP
2.	Sh. Dharam Das Kashyap, CPRI, Shimla.	Granted 3rd MACP w.e.f. 7.9.2012 in the PB Rs. 9300-34800+4600GP
3.	Smt. Urmila Verma, UDC,CPRI, Shimla	Granted 2nd MACP w.e.f. 20.7.2012 in the PB Rs.5200-20200+2800GP
4.	Smt. Sunita Thakur, UDC, CPRI, Shimla	Granted 2nd MACP w.e.f. 30.4.2012 in the PB Rs. 5200-20200+2800GP
5.	Sh. Om Parkash, UDC, CPRI, Shimla.	Granted 2nd MACP w.e.f. 16.6.2012 Rs.5200-20200+2800GP
6.	Sh. Lekh Ram, PA, CPRI, Shimla	Pay fixed on 17.4.2010 in the Pay band of 9300-314800+4800GP
7.	Sh. Roshan Lal Verma, Private Secretary, CPRI, Shimla	Granted 3rd MACP w.e.f. 03.06.2011 in the PB Rs. 9300-34800+4800GP
8.	Sh. HK Sen, Private Secretary, CPRS, Patna	Granted 3rd MACP w.e.f. 13.04.2011 in the PB Rs. 9300-34800+4800GP
9.	Smt. M.Rani, UDC, CPRS, Muthorai	Granted 2nd MACP w.e.f. 23.1.2011in the PB Rs.5200-20200+2800GP

Skilled Support Staff Category

Promotion

Sr. No.	Name, place of posting and date of promotion
1.	Sh. Bijender Singh, SSS, CPRS, Gwalior promoted to under 33.33% to T-1 with effect from 06.08.2012 in the pay scale of Rs. 5200-20200 +2000 GP
2.	Sh. Pawan Kumar, SSS, CPRS, Jalandhar promoted to under 33.33% to T-1 with effect from 06.08.2012 in the pay scale of Rs. 5200-20200 +2000 GP
3.	Sh. Tara Chand, SSS, CPRS, Gwalior promoted to under 33.33% to T-1 with effect from 06.08.2012 in the pay scale of Rs. 5200-20200 +2000 GP
4.	Sh. Sita Ram, SSS, CPRI, Shimla promoted to under 33.33% to T-1 with effect from 06.08.2012 in the pay scale of Rs. 5200-20200 +2000 GP
5.	Sh. Satpal Singh, SSS, CPRIC, Modipuram promoted to under 33.33% to T-1 with effect from 06.08.2012 in the pay scale of Rs. 5200-20200 +2000 GP
6.	Sh. Parvesh Kumar, SSS, CPRS, Patna promoted to under 33.33% to T-1 with effect from 06.08.2012 in the pay scale of Rs. 5200-20200 +2000 GP
7.	Sh. Laiq Ram, SSS, CPRI, Shimla promoted to under 33.33% to T-1 with effect from 07.08.2012 in the pay scale of Rs. 5200-20200 +2000 GP
8.	Sh. Surinder Pal, CPRI, Shimla promoted to under 33.33% to T-1, with effect from 16.11.2012 in the pay scale of Rs. 5200-20200 +2000 GP

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Sl. No.	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
1.	Sh. Anant Ram, Tea/Coffee Maker CPRI, Shimla	Rs. 5200-20200+1900	2nd MACPS w.e.f. 05.05.2010	Rs. 5200-20200+Rs. 2000
2.	Sh. Nand Lal, Wash Boy, CPRI Shimla	Rs. 5200-20200+1900	2nd MACPS w.e.c. 01.09.2008	Rs. 5200-20200+Rs. 2000

Financial upgradaton granted under MACP scheme:

Sl. No.	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
1.	Sh. Shatrughan Prasad, LDC, CPRS, Patna	Rs.5200-20200+1900	2nd & 3rd MACPS w.e.f. 01.09.2008	Rs.5200-20200+ Rs.2000+2400
2.	Sh. Sonu Devi, SSS, CPRS, Kufri	Rs.5200-20200+1900	2nd MACPS w.e.f. 07.11.2011	Rs.5200-20200+Rs.2000
3.	Sh. Kulwant Singh,SSS, CPRI, Shimla	Rs.5200-20200+1900	2nd MACPS w.e.f. 14.02.2012	Rs.5200-20200+Rs.2000
4.	Ms. Niranjan Kaur,SSS, CPRS, Jalandhar	Rs.5200-20200+1900	2nd MACPS Rs.2000 w.e.f. 03.06.2012	Rs.5200-20200+Rs.2000
5.	Smt. Kamla Devi,SSS, CPRI, Shimla	Rs.5200-20200+1800	1st & 2nd MACPS w.e.f. 25.10.2009	Rs.5200-20200+ Rs.1900+2000
6.	Sh. Ram Sarup, SSS, CPRS, Jalandhar	Rs.5200-20200+1800	1st MACPS w.e.f.15.01.2012	Rs.5200-20200+Rs.1900
7.	Sh. Joginder Pal, SSS, CPRS, Jalandhar	Rs. 5200-20200+1900	1st MACPS w.e.f. 11.01.2012	Rs.5200-20200+Rs.1900

Retirements

1. Sh. Dhani Singh, SSS, CPRS, Kufri on 31.12.2012.
2. Mrs M Murugeshwari, SSS, CPRS, Muthorai on 28.02.2013.
3. Sh. Dakur Sah, SSS, CPRS, Patna on 31.03.2013.
4. Sh. Parmanand, SSS, CPRS, Kufri on 31.03.2013.

Scientific Personnel CPRI, Shimla

1. Dr. BP Singh, Director, CPRI, Shimla
2. Dr. PM Govindakrishnan, PS & PC, CPRI, Shimla. (Agronomy)
3. Dr. R. Ezekiel, PS & Head , Division of CPB & PHT (Food Technology)
4. Dr. KK Pandey, PS & Head, Division of Seed Technology(Seed Technology)
5. Dr. S.S. Lal, PS & Head , Division of Crop Production (Agronomy)
6. Dr. NK Pandey, PS & Head, Division of Social Sciences (Agril. Economics)
7. Dr. M.C. Sood, PS (Soil Physics & Water Conservation)
8. Dr. VK Dua, Principal Scientist (Agronomy)
9. Dr. Brajesh Singh, Principal Scientist (Plant Physiology)
10. Dr. Rajesh Kumar Rana, Pri. Scientist (Agril. Economocs)
11. Dr. Vinay Bhardwaj, Sr. Scientist (Genetics & Plant Breeding)
12. Dr. Shashi Rawat, Sr. Scientist (Computer Application)
13. Dr. Sanjeev Sharma, Sr. Scientist(Plant Pathology)
14. Dr. Vinay Sagar, Sr. Scientist (Plant Pathology)
15. Dr. R. Muthu Raj, Sr. Scientist (Seed Technology)
16. Dr. MK Jatav, Scientist (SS)(Soil Sci.)
17. Dr. Jagesh Kumar, Scientist (Hort.)
18. Sh. Virupakshagouda U Patil, Scientist (Biotechnology)
19. Dr. (Ms.) Jeevalatha A, Scientist(Plant Pathology)
20. Dr. Baswaraj R, Scientist (Plant Pathology)
21. Dr.(Mrs.) Pinky, Scientist (Plant Physiology)
22. Dr. Dhiraj Kumar Singh, Scientist (Agril. Extn.)
23. Dr. S Sunderasha, Scientist (Plant Pathology)
24. Dr.(Ms) Dalamu, Scientist (Horticulture)

25. Dr. Ravinder Kumar, Scientist (Plant Pathology)
26. Dr. Vallepu Venkateswarlu, Scientist (Entomology)
27. Sh. Sridhar Jandrajupalli, Scientist (Entomologist)
28. Dr.(Mrs.) TC Kumari Saugitha, Scientist (Microbiology)

CPRIC, Modipuram

29. Dr. SK Kaushik, Joint Director, CPRIC, Modipuram (Plant Breeding)
30. Dr. NC Upadhayay, PS (Soil Sci.)
31. Dr. Devendra Kumar, PS (Plant Physiology)
32. Dr. (Mrs.) Kamlesh Malik, Pri. Scientist (Entomology)
33. Dr. Sanjay Rawal, Principal.Scientist , (Agronomy)
34. Dr. Anuj Bhatnagar, Principal Scientist (Agril. Entomology)
35. Dr. SK Luthra, Principal. Scientist (Gen. & Cyto. Gen.)
36. Dr. Name Singh, Sr. Scientist (Agronomy)
37. Dr. Vinay Singh, Pr. Scientist (Seed Technology)
38. Er. Sukhwinder Singh, Scientist (SG) (Ag. Engg. FM &P)
39. Dr. Dhruv Kumar, Principal Scientist (Agronomy)
40. Dr. MA Khan, Sr. Scientist (Agril. Chemistry).
41. Dr. Vijay Kishore Gupta, Sr. Scientist (Hort-VS)
42. Dr. Mehi Lal, Scientist (Plant Pathology)
43. Dr.(Ms.) Bandana, Scientist (Bio-chemistry)
44. Dr. RK Verma, Sr. Scientist (Presently working with CITH, RS, Mukteshwar)

CPRS, Jalandhar

45. Dr. JS Minhas, Head, CPRS, Jalandhar (Plant Physiology)
46. Dr. RK Arora, PS (Plant Pathology)
47. Dr. (Mrs.) Ashiv Mehta, PS (Plant Physiology)
48. Er. Manjit Singh, PS (Ag. Engg. FM &P)
49. Dr. SP Trehan, PS (Soil Science)
50. Dr. Raj Kumar, PS Scientist (Gen. & Cyto. Gen.)
51. Er. Sunil Gulati, Scientist (SG) (Ag. Engg. FM & P).
52. Dr.(Mrs.) Ratna Preeti Kaur, Scientist (Genetics)

CPRS, Patna

53. Dr. Manoj Kumar, PS & Head, CPRS, Patna (Soil Science)
54. Dr. SK Singh, Pri. Scientist (Agronomy).
55. Dr. Shambhu Kumar, Sr. Scientist (Plant Breeding)
56. Dr. Raj Kumar, Scientist(SS), (Seed Technology)
57. Sh. Rahul R Bakade, Scientist (Plant Pathology)

CPRS, Shillong

58. Dr. TK Bag, PS & Head (Plant Pathology)
59. Dr. AK Srivastava, Scientist (Plant Breeding)
60. Dr. Sanjay Kumar Yadav, Scientist (Agronomy)
61. Dr. Malkhan Singh Gurjar, Scientist (Plant Pathology)

CPRS, Gwalior

62. Dr. Shiv Pratap Singh, Sr. Scientist (Agronomy)
63. Dr. Murlidhar J. Sadawarti, Scientist (Seed Technology)

CPRS, Ooty

64. Dr. (Mrs.) K. Manorama, Sr. Scientist (Agronomy)
65. Dr. G. Ravichandran, Sr. Scientist (Seed Tech.)
66. Dr. (Mrs.) Uma Maheshwari, Scientist (Nematology)

CPRS, Kufri

67. Dr. Vinod Kumar, Sr. Scientist (Plant Breeding)
68. Dr. Ashwani Kumar Sharma, Sr. Scientist, (Horticulture)

Station- wise staff sanctioned of all categories as on 31.3.2013

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	13	3	21	16	5
5.	Gwalior	1	-	1	1	-	1	3	2	1	5	2	3
6.	Patna	1	1	-	1	1	-	9	3	6	11	5	6
7.	Ooty	1	-	1	-	-	-	3	3	.	4	3	1
8.	Shillong	1	1	-	-	-	-	5	3	2	6	4	2
	Total	**11**	**9**	**2**	**19**	**6**	**13**	**77**	**52**	**25**	**107***	**67***	**40**

Administrative Category

Name of Post	Shimla	Modipuram	Jalandhar	Patna	Shillong	Gwalior	Ooty	Kufri	Total
Chief Admn. Officer	1	-	-	-	-	-	-	-	1
Sr. Fin. & A/Cs Officer	-	-	-	-	-	-	-	-	-
Admn. Officer	2	-	-	-	-	-	-	-	2
Asstt. Admn. Officer	5	1	2	1	-	-	-	-	9
Asstt. Fin. & A/Cs Officer	2	-	-	-	-	-	-	-	2
Asstt. Director(OL)	1	-	-	-	-	-	-	-	1
Private Secretary	3	-	-	-	-	-	1	-	4
Personal Assistant	5	-	1	-	-	-	-	1	7
Stenographer Grade-III	-	1	-	1	-	-	-	-	2
Assistant	19	1	2	-	3	1	1	1	28
UDC	11	3	3	-	-	1	-	1	19
LDC	16	4	4	4	-	-	3	-	31
Total	**65**	**10**	**12**	**6**	**3**	**2**	**5**	**3**	**106**

Technical Category

Grade	Shimla	Modipuram	Jalandhar	Patna	Gwalior	Shillong	Ooty	Kufri	Total
(T.O.) T-9	1	1	-	-	-	-	-	-	2
(T.O.) T-7-8	2	4	1	1	-	-	-	-	8
(T.O.) T-6	7	10	3	1	1	-	-	-	22
(T.O.) T-5	10	15	3	3	5	1	2	2	41
Tech. T-4	7	2	4	2	2	2	-	-	19
Tech. T-3 / T-I-3	14	5	4	3	1	3	-	1	31
Tech. T-2	13	-	4	3	3	1	1	2	27
Tech. T-1	5	5	1	2	4	1	-	-	18
Total	**59**	**42**	**20**	**15**	**16**	**8**	**3**	**5**	**168**

Skilled Supporting Staff Category

Station	Sanctioned Strength	Grade-IV	Grade-III	Grade-II	Grade-I	Total
Shimla	75	01	11	06	08	26+3* canteen staff
Kufri	12	--	02	02	05	09
Patna	20	01	01	07	01	10
Jalandhar	26	--	01	14	08	23
Modipuram	42	--	02	04	09	15
Shillong	12	02	06	-	-	08
Muthorai	08	-	-	-	05	05
Gwalior	12	-	-	18	11	29
Total	**207**	**04**	**24**	**50**	**47**	**125+3=128**

Staff in position showing number of SCs, STs, OBCs & Women

Category	Sanctioned	Filled	SC	ST	OBC	Women
Scientific	108	68	08	03	05	09
Technical	178	168	35	7	8	11
Administrative	102	106	27	07	07	29
Skilled Support Staff	207	128	38	07	10	17

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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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