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Preface

Central Potato Research Institute is credited with converting potato from a temperate to a sub-tropical crop. The potato varieties and other related technologies developed by the Institute have fuelled unprecedented growth with very high trajectory. As a result, India now is the second largest producer of potatoes in the world, preceded only by China. The Technology Portfolio of the Institute is getting bigger and bigger that caters to all segments of the society including potato growers and the industry alike. It is a matter of joy for all of us but we should not become complacent as the challenges ahead are equally tough. The annual growth rate is to be maintained above three percent if we have to achieve the projected potato production of 125 million tons by 2050. This is not an easy proposition by any means looking at the overall agricultural scenario in the country. For this, we have to take quantum jump by vertical and horizontal expansions.

Vertical expansion would require development of agile potato that can be grown in 70 days window without disturbing or encroaching on the existing dominant crop rotations. To achieve the targeted production horizontal expansion on the other hand would require tropicalization of potato crop by way of developing heat tolerant varieties. These efforts will bring in more acreage under potato which is critical to achieving the projected potato production in this country. However, this alone may not be enough. We need to enhance our productivity from over 21 t/ha to 35 t/ha. It will involve analysis of productivity gaps that exists in different agro-ecological regions, including identification of constraints and development of strategies to address them. Besides, science driven productivity enhancement will also be required by exploiting the existing gene pool using modern approaches including transgenics.

If you wade through the scientific content of this document you will find that all the above issues have been addressed. However, it will take some time to convert these science discoveries/results into products to show the impact at the ground level. Nevertheless, research being pursued at the institute augurs well for the bright future of potato crop in the country.

I would like to congratulate the entire team of scientists and other staff for carrying out all the research and development activities as per plan and bringing out the results in a comprehensive manner as reflected in this report. I also thank members of editorial committee for making this report crisp and comprehensive. Finally, I express my gratitude to DG, ICAR, DDG (Horticultural Science) and Chairman as well as members of Research Advisory Committee for providing valuable guidance, direction and suggestions in development and implementation of various research programmes during entire period of report.

(Bir Pal Singh)
Director

Content

Preface iii

Introduction 1

Research Highlights

Executive Summary

Research Programmes

Division of Crop Improvement

Management and Enhancement of Potato Germplasm

Development of Improved Varieties

Biotechnology in Potato Improvement

Division of Crop Production

Resource Management and Information Technology in Potato Based Cropping Systems

Nutrients and water Management in Potato

Nutrient Dynamics Studies on Long term Manurial/fertilizer Application and Organic Farming in Potato Production

Climate Change Impact and Adaptation Strategies for Potato Crop

Farm Machines for Potato Cultivation

Division of Plant Protection

Management of Late Blight

Molecular Characterization, Detection and Management of Potato Pathogens

Characterization, Detection and Management of Major Soil and Tuber Borne Pathogens of Potato Population Dynamics and Management of Potato Pests

Management of Potato Nematodes

Division of Crop Physiology, Biochemistry & Post-harvest Technology

Nutritional Value of Potato and Potato Products

Potato Storage : Efficient and Eco-friendly Methods of Improved Quality

Physiological and Genetic Approaches in Managing Heat and Water Stress under Sub-tropical Environment in Potato

Division of Seed Technology

Production of Breeder Seed of Potato through Conventional and Hi-tech System

Division of Social Sciences

Impact of Potato Production Technologies Developed by Institute

Transfer of Technology

Library and Documentation Services

Institute Research Council Meeting

Publications

Institute Activities

Foreign Visit of CPRI Scientists

Education, Training, Awards & Honours

Classified Abstract of Expenditure for the Year 2014-15

Promotions/Retirements/Transfers/Deaths

Station- wise Staff Sanctioned

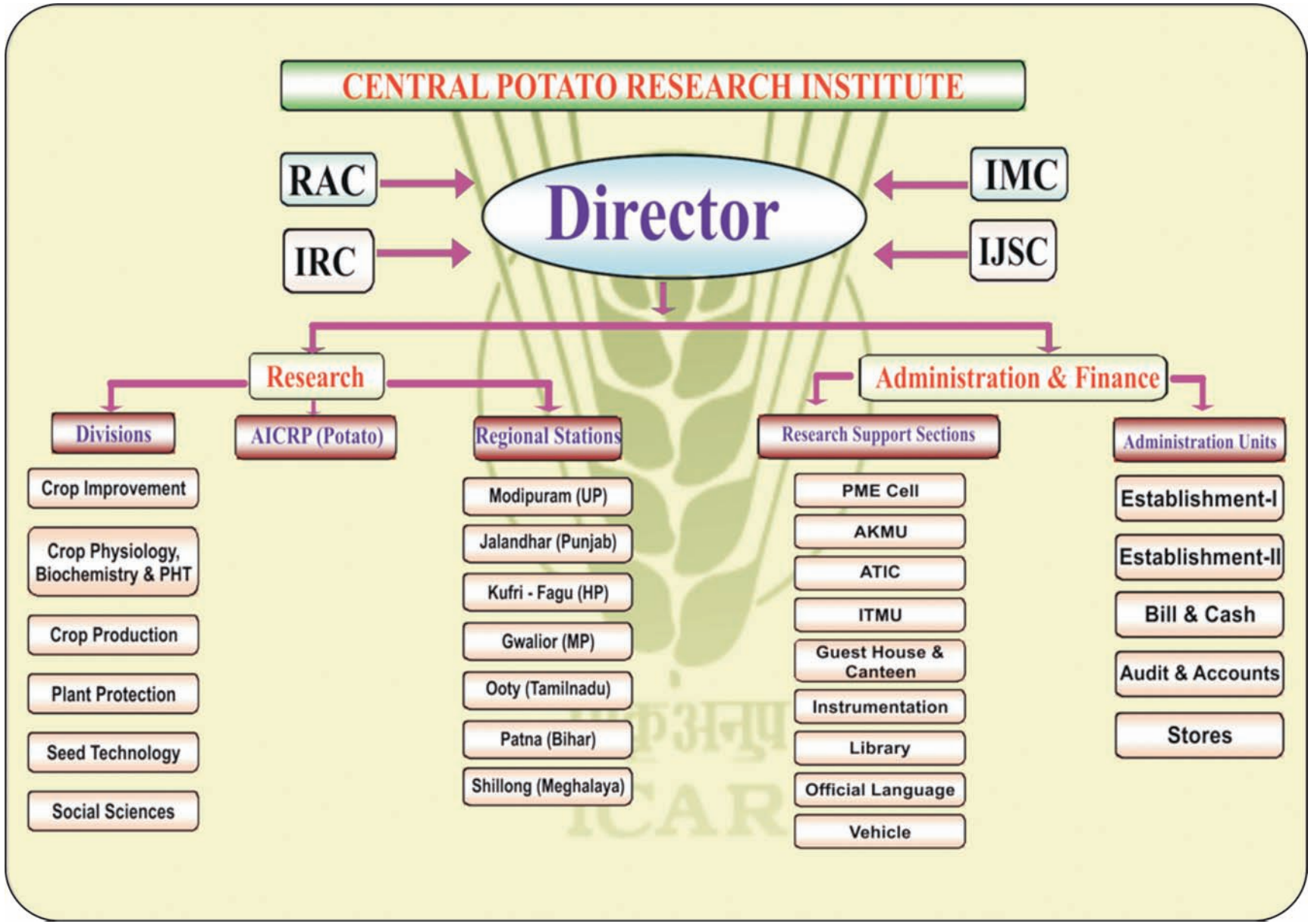
Results-Framework Document

ICAR-CPRI: An Introduction

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

The Research and Development Activities of the institute is carried out under the six divisions namely, Division of Crop Improvement, Crop Production, Plant protection, Seed technology, Crop Physiology, Biochemistry and Post-harvest Technology and Social Sciences. The institute headquarter is located in the heart of Shimla city, 4 kilometer from Shimla bus stand near Bemloe. It is located at an altitude of 2000 metres above mean sea level and has a wet temperate climate. It has one campus at Modipuram (UP) and six regional stations located across the country *viz*. Kufri-Fagu (HP), Jalandhar (Punjab), Gwalior (MP), Patna (Bihar), Shillong (Meghalaya) and Ooty (Tamil Nadu) to cater the need for location specific research and extension activities.

The institute created the state-of-the-art laboratories for conducting basic and strategic research in different areas of potato. The all India co-ordinated research project on potato (AICRP-Potato) is also located in the institute and has been functioning since 1971. It has 25 regional centers located in nearly all agro climatic zones of the country to test the performance of new potato varieties and technologies in different locations. An Agricultural Technology Information Centre (ATIC) is also functioning in the institute which looks after the transfer of technology activities of the institute. The institute not only develops new


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

varieties and technologies for potato growers of the country but also takes care of dissemination of these technologies to the ultimate consumers through various trainings, demonstrations, farmers fair, exhibitions etc. Currently the institute has a dedicated team of 73 scientists, 155 technical staffs and 87 administrative staffs working on potato crop.

The Mission

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

Mandate

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

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

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

Staff & Finance

The institute has 594 sanctioned staff strength comprising of 107 scientific, 178 technical,102 administrative and 207 supporting staff excluding RMP. The staff position as on 31.03.2015 was 430 including 73 scientific, 155 technical, 87 administrative and 115 supporting staff. The expenditure of the institute for the year (Plan & Non Plan) was Rs 55.31crores and receipts Rs. 5.69 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 286.38 lakhs this year and the scheme has been very successful and widely acclaimed. During the year, three scientists were retired and three were transferred from the institute. In technical category, 33 technical staff were promoted, 10 retired and 2 were transferred. In

administrative category, 14 persons were promoted, 11 retired and one transferred. In skilled supporting staff, three were promoted under 33.33% departmental promotion quota from SSS to technical posts and four 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. A BPD Unit has been established at CPRS, Jalandhar for commercialization of potato technologies developed by the institute. The institute 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 well equipped to organize training programmes with the facilities like audio-visual aids, projector, Guest house, farmers' hostels etc.

Research Highlights

Crop Improvement

- Sixty-nine (69) accessions were added to cultivated germplasm collection from 8 different countries, besides TPS of fourteen accessions of 8 different wild species were procured from IPK Gene bank, Germany.
- During the year the potato germplasm was evaluated for various traits *viz*., foliage late blight resistance under field (155 accessions), foliage and tuber late blight resistance under lab conditions (117 accessions), vitamin C (75 accessions), Water use efficiency (29 accessions), PCN (60 accessions), viruses (61 accessions), adaptability in plains (139 accessions) and keeping quality & processing traits (76 accessions).
- In the varietal development programme, Kufri Lalit, a red coloured variety suitable for eastern plains region covering Bihar, West Bengal, Assam, Orissa, Jharkhand etc. was identified for commercial release by Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticulture Crops.
- Based on consistence performance during last three years, six advanced stage hybrids namely J/7-5, J/7-15, J/7-37 (Jalandhar), MS/9-2196 (Modipuram), PS/8-8 and PS/8-31 (Patna) were identified for introduction in AICRP (P) for multi-location trials. Besides, 116 advanced stage hybrids were evaluated in 13 yield trials at 60/75/90 DAP at Jalandhar, Modipuram & Patna and 44 promising hybrids were selected.
- Nine advanced stage hybrids namely J/6-182 (Jalandhar), MS/8-1148, MS/8-1565, MS/9-723, MP/09-901, MP/06-39 (Modipuram), SM/00-42, SM/00-120 and VMT 5-1 (Shimla) were recommended by Institute Research Council, 2014 for introduction in AICRP (P) for multi-location testing.
- Identified ten late blight resistance related genes and 5 pathogen virulence genes in the background of Kufri Girdhari and Kufri Bahar, respectively through microarray analysis. Out of 10 identified genes, four gene constructs were developed for enhancing late blight resistance.
- Bioassay of the selected transgenic, Kufri Khyati and Kufri Pukhraj encoding Avr3a (siRNA and amiRNA) genes from *P. infestans* revealed that 4 out of 18 siRNA lines and 4 out of 15 amiRNA lines had 60-75% late blight resistance.
- Differentially expressed genes were identified through microarray analysis of two potato cultivars, Kufri Surya and Kufri Chandramukhi with contrasting tuberization behaviour at elevated night temperature (24°C). Based on differential expression analysis, 5 heat tolerance genes involved in tuberisation at 24°C in Kufri Surya were identified. These genes will be exploited for developing cultivars suitable for non-traditional areas of the country.
- Inheritance and stability of the inserted RB gene was done in SP 951 event and KJ–RB hybrid lines. The RB gene copy number was the same in the parental transgenic Katahdin SP 951 and its crossing progenies.
- Complete profiling of the fungal diversity in the rhizosphere soils from potato fields at Shimla was done using metagenomics approach. The results revealed that the fungal community in the soil samples is distributed across four phyla, i.e., ascomycota, basidiomycota, zygomycota and chytridiomycota.
- Molecular characterization of somatic hybrids between *Solanum tuberosum* (+) *S. cardiophyllum* was done using 35 RAPD, 24 ISSR and 39 SSR markers and somatic hybrids

were confirmed for possessing diagnostic bands from both the parents.

- Gene expression pattern was investigated in the tuber-bearing potato somatic hybrid (E1-3) and control non-tuberous wild species *S. etuberosum* by microarray and identified a total of 468 genes providing an insight into the genes in potato tuberization.

Crop Production

- WOFOST crop growth model was used to assess the impact of climate change on potato productivity in Bihar. The model has projected a decline in productivity of Kufri Badshah, Kufri Jyoti & Kufri Pukhraj to the tune of 5.9, 5.8 & 6.5%, respectively in 2020 and 10.0, 11.1 &13.1%, respectively in 2055.
- JHULSACAST model has predicted a 3 to 15 days delay in late blight appearance in West Bengal in 2020 over 2000, the total late blight favourable period is likely to be reduced by 3 to 15 days and the mean number of sprays required to control late blight is likely to reduce from 5.5 to 4.2 during this period.
- In the long term manurial/ fertilizers trial at Modipuram, Maize-Potato-Onion (51.4 t/ha) sequence recorded highest mean system productivity followed by Rice-Potato-Wheat and Groundnut- Potato- Moong bean system.
- At Shimla, when urea or CAN were used as N source, 2nd and 3rd additional application of 25 kg N/ha was needed at 90 and 95% RCI, respectively over Neem cake coated urea. 20% recommended N applied at 90% of the reference SPAD value at Patna and 95% of the reference SPAD value at Gwalior gave similar yield as compared to the recommended N level.
- Out of 100 genotypes/hybrids evaluated during 5 consecutive years, the six promising genotypes/hybrids *viz*. J 93-58, J 92-164, 83-P-142, JN-2207, MS/82-279, J 92-167 gave higher/equal potato yield in comparison to popular cv. Kufri Bahar and Kufri Pukhraj at all soil moisture levels. During 2014-15, the genotypes *viz*. JN-2207, J.92-167 & 83-P-142 produced maximum yield at higher moisture regime, but, at low soil moisture conditions the genotypes i.e. JN-2207, J.92-167 & J.93-58 gave higher yield against Kufri Pukhraj.
- A 2-row tractor operated trailed type potato combine harvester (Prototype-II) with provision for inspection and simultaneous collection of tubers in bags/ crates was developed and fabricated.
- Design and development work of the small grader (Rubber rollers type) with four different sizes is worked out along with their fabrications at Jalandhar.
- A Portable aeroponics system was tested on long term basis (for 110 days) using Kufri Jyoti.
- A new system for planting of in vitro plants was designed and fabricated for taking two crops in aeroponics system in plains using high density planting for six-seven months (Oct to April) in Jalandhar conditions.

Plant Protection

- Microarray analysis of potato-*Phytophthora infestans* interactions in resistant and susceptible cultivars revealed that *P. infestans* effector genes expressed in susceptible cultivar (Kufri Bahar), while genes belonging to signal transduction, biotic stress and cell rescue pathways were up regulated in resistant cultivar (Kufri Girdhari).
- Beta amino butyric acid and phosphorous acid involved in systemic acquired resistance reduced late blight severity significantly and induced expression of defence genes in Kufri Chandramukhi.
- Out of 61 germplasm accessions tested for combined resistance to two viruses, PVY and PVX and late blight, sixteen CP numbers were found to have combined resistance, while 29 and 11 other CP numbers were resistant to PVY and PVX, respectively.

- Two potato transgenic lines resistant to ToLCNDV developed by CPRI previously, *viz.*, GTLC2-127 and KPLC2-53 were confirmed to possess the transgenes through event PCR analysis.
- Standardized multiple displacement amplification-PCR technique that can now detect *R. solanacearum* up to 10^{-5} dilutions, and 1000 times more sensitive than PCR.
- Mapping of the aphid populations in potato growing regions of India indicated occurrence of thirteen aphid species, and *Aulacorthum solani, Aphis spiraecola* and *Macrosiphum euphorbiae* were predominant in Jalandhar and Gwalior.
- Uniplex and duplex RT-PCR detection protocols were standardized to detect PVY and PLRV from viruliferous aphids.
- Two advance generation hybrids of potato, *viz.*, OS/94-I-126 and OS/01 161, were found promising in terms of combined resistance to both species of potato cyst nematodes and to late blight.

Division of Crop Physiology, Biochemistry and Post-harvest Technology

- A study on flavouring compounds suggested that the potato products prepared solely from potato contained higher levels of *umami* 5' nucleotides compared to products prepared by mixing potato with other cereals and vegetables.
- An indirect method of estimation of Glycaemic index was standardised through α-glucosidase and α-amylase inhibitors estimation.
- Microwave processing at 600 W for 2.5-3 min. can produce potato chips with acceptable sensory scores (≥ 7.6 on 9.0 point on Hedonic scale vs 8.0 of control preparation) and low fat content (~3.57% vs 35.5% in commercial preparation).
- A cost effective methodology was standardized for rapid estimation of fat in potato chips using solvent extraction principle.
- Time saving and cost effective methodology for estimation of total phenolics and % DPPH inhibition through ELISA plate reader was standardized and validated.
- Treatment of potatoes with organic sprout suppressant resulted in complete sprout suppression at 200 ppm up to 180 days.
- Amongst naturally occurring compounds, vapour treatment with menthone (derived from *Mentha arvensis*) at 250 µl/l concentration, induced complete sprout inhibition with nil rotting in potatoes up to 100 days.
- Paclobutrazol (5 ppm spray 35 days after planting) improved tuber yield under heat stress conditions.
- Two hybrids WS/2005-146 (for drought tolerance) and HT/2007-1105 (for high temperature tolerance) were introduced into AICRP (Potato) for multi-location trials.

Division of Seed Technology

- During 2013-14, total production of 2705.82 tons nucleus and breeder seed was achieved in both conventional and hi-tech seed production system from an area of 128.47 hectares in plains.
- Total 1960.14 tons breeder seed was supplied to various government and private agencies out of which 1915.42 tons from plains which includes both pre- (1753.02 tons) and post-cold storage (162.406 tons) and 44.718 tons breeder seed has been supplied from hills.
- A total number of 525485 mini-tubers were produced from 77466 microplants, 3298 microtubers and 1, 76, 998 aeroponic mini-tubers.

- 102 individual tubers (virus-free, true to type, uniform size and genetically pure) of 17 varieties were selected as basic material and 43 virus-free in vitro nodal cuttings were carried out for mother culture.
- A total no. of 2541 culture tubes of 15 varieties were supplied to different seed production stations/centers and 105 virus-free *in vitro* culture tubes of basic seed material of 13 different varieties were supplied to 12 different private seed producing organi-zations in India.
- Bacterial endophytes from potato were selected and found antagonistic to several potato pathogens like *Fusarium* spp., *Phytophthora infestans, Rhizoctonia solani* and *Ralstonia solanacearum*.
- *Methylobacteria* spp a potential potato endophyte was found effective for potato propagation of *in vitro* microplants.
- Various types of priming material and its integration can be successfully done on aeroponic mini-tubers without any adverse effect on growth and germination.
- Bower system in aeroponics is most suitable for hills due to very high yield and vigour while minimum driage and rottage.
- Kufri Chipsona-IV is the most suitable variety followed by Kufri Surya for February planting.

Social Sciences

- Survey in Assam and Meghalaya revealed that Kufri Jyoti was the predominant potato variety occupying 61 per cent area in Assam and 65 per cent in Meghalaya. Kufri Pukhraj with 33% area was second most popular variety in Assam while local variety LS Smith was popular in Meghalaya with 26% area after Kufri Jyoti.
- It was also found that for Kufri Jyoti, seed potato purchased from traders was the most commonly used source of seed (54.76%) in Assam while in Meghalaya, own farm production retained as seed potato (72.9%) was the most commonly used seed source.
- The cost of potato cultivation was estimated to be Rs. 114625 in Assam and Rs. 95872 in Meghalaya. Further it was observed that seed constituted 57.7 and 44.6% of this cost in Assam and Meghalaya, respectively.
- Expensive seed potato was found to be the severest problem for potato farmers in the Assam followed by bad quality of seed potato, expensive fertilizers and chemical and unavailability of healthy seed from local government farms. In Meghalaya, unavailability of healthy seed potato from local government farms was the major problem.
- In Agra (UP), Kufri Bahar was the most popular variety while in Kannauj district, Kufri Pukhraj was most popular with one third area under cultivation.
- NPK dose in both the districts Agra (210:207:109 Kg/ha) and Kannauj (251:253:99 Kg/ha) were found to be higher than recommended dose especially for phosphate use.
- The average yield of potato in Agra was found to be 27 t/ha while it was slightly less at 25 t/ha in Kannauj district.
- Altogether 40 varietal demonstrations of Kufri Himalini were laid out in Shimla, Kinnaur and Lahaul-Spiti districts of HP. Observations from these demonstration revealed that Kufri Himalini was having higher yield advantage over local variety Kufri Jyoti in all locations.
- The impact of 21-day Summer School revealed that average increase in knowledge of trainees before and after training was estimated at 21.42%. A majority of the trainees (68.4%) graded the training as Very Good while 26.3% graded it as Excellent.

Executive Summary

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, 69 accessions were added to cultivated germplasm collection from Peru (33), USA (12), New Zealand (8), Netherlands (6), Australia (5), Canada (2), France (2) and UK (1), besides TPS of fourteen accessions of 8 different wild species were procured from IPK Gene bank, Germany. An exploration was conducted in Meghalaya and a total of 33 samples were collected with varied tuber colour, shape, eye depth and flesh colour. The present germplasm collection at CPRI consists of more than 4,150 accessions of cultivated, semi-cultivated and wild species from 30 countries. A large number of accessions were evaluated for various biotic and abiotic stresses, adaptability and physcio-biochemical qualities and promising accessions were identified. Information generated has 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 consistence performance during last three years, six advanced stage hybrids namely, J/7-5, J/7-15, J/7-37, MS/9-2196, PS/8-8 and PS/8-31 has been identified for introduction in AICRP (P) for multi-location trials. Based on superior performance nine advanced hybrids *viz.* J/06-182, MS/08/1148, MS/08-1565, MS/09-723, MP/9-901, MP/6-39, SM/00-42, SM/00-120 and VMT 5-1 were introduced in AICRP (P).

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, complete profiling of the fungal diversity in the rhizosphere soils from potato fields at Shimla was done using metagenomics approach. The results revealed that the fungal community in the soil samples is majorly distributed across four phyla, (ascomycota, basidiomycota, zygomycota and chytridiomycota) with highest abundance of Ascomycota (60%). Towards understanding the molecular mechanisms by which temperature affects tuberization, differentially expressed genes in Kufri Surya and Kufri Chandramukhi having contrasting tuberization behaviour at elevated night temperature (24°C) were successfully analysed using microarray technique. Inheritance and stability of the inserted RB gene was done in SP 951 event and KJ RB hybrid lines. The RB gene copy number was the same in the parental transgenic Katahdin SP 951 and its crossing progenies. Inheritance and stability of the inserted RB gene in the progenies developed by crossing Kufri Jyoti and transgenic Katahdin SP 951 were confirmed implying that the RB gene was stably inherited in to the hybrid progenies with similar pattern of co-integration. Molecular characterization of somatic hybrids between *Solanum tuberosum* (+) *S. cardiophyllum* was done using 35 RAPD, 24 ISSR and 39 SSR markers and somatic hybrids were confirmed for possessing diagnostic bands from both the parents. Gene expression pattern was investigated in the tuber-bearing potato somatic hybrid (E1-3) and control non-tuberous wild species *S. etuberosum* by

microarray and identified a total of 468 genes providing an insight into the genes in potato tuberization.

Crop Production

After Punjab and Uttar Pradesh, the WOFOST crop growth model was used to assess the impact of climate change on potato productivity in Bihar. The productivity of Kufri Badshah, Kufri Jyoti and Kufri Pukhraj ranged from 26.6 to 45.8, 23.9 to 45.3 & 24.2 to 49 t/ha respectively under baseline scenario. The productivity of Kufri Badshah, Kufri Jyoti & Kufri Pukhraj is expected to decline by 5.9, 5.8 & 6.5% in 2020 and 10.0, 11.1 &13.1% in 2055.

In a study on impact of climate change on late blight in West Bengal using JHULSACAST model, it has predicted earliest late blight appearance during 4th to 11th December in baseline scenario (2000) which is expected to be delayed by 3 to 15 days in 2020 under favourable relative humidity. The study further shows that the mean number of sprays required to control late blight is likely to reduce from 5.5 in 2000 to 4.2 in 2020. Study on the effect of higher temperature on epidemiological components of *P. infestans* showed that incubation period and latent period were more at 30 °C than the 28 °C, however lesion area was less developed at 30 °C than 28 °C in detached leaf test.

At Shimla, *Ralstonia solanacearum* strains RS-2 (phylotype II bv 2) survived for one month at 40 °C, two months at 37 °C, four months at 32 °C and six months at 20 - 28 °C in sterilized soil and un-sterilized soil for one month at 37 °C and 4 months at 20-28 °C, while no growth of was observed at 40 °C after one month and at 32 °C and above after two months. At Gwalior, the highest thrips population (40.8/ 5 plants) was recorded in the month of November, resulting in high incidence of stem necrosis disease (40.75%) in 15th September planted crop under unprotected condition but low incidence of thrips (24.6/5 plants) and stem necrosis disease (21.48%) was recorded in protected condition.

In the long term manurial and fertilizer trials at Modipuram, the highest mean system productivity was achieved in Maize-Potato-Onion (51.4 t/ha) sequence followed by Rice-Potato-Wheat (47.5 t/ha) and Groundnut- Potato- Moong bean system (40.8 t/ha). Maize-Potato-Onion recorded 7.6 and 20.6% higher productivity over Rice-Potato-Wheat and Groundnut-Potato-Moong bean system, respectively. Inorganic macro, secondary and micro-nutrients recorded highest system productivity in Maize-Potato-Onion (66.2 t/ha) and Groundnut-Potato-Moong bean (53.2 t/ha) system over all other treatments. Rice-Potato-Wheat system also recorded highest mean system productivity (60.3 t/ha) with this treatment over other combinations except for inorganic+ crop residue (58.5 t/ha) treatment. The varieties Kufri Anand and Kufri Chipsona-1 recorded comparable productivity with 50% inorganic+50% vermi-compost and 100% inorganic fertilizers. Complete replacement of inorganic nutrition with vermi-compost showed deficit in tuber productivity (28.7-30%). Yields were not affected distinctly upto 50% replacement of inorganic nutrients with vermi-compost. Potato- Wheat- Rice and Potato- Onion-Maize showed higher Carbon stocks in soil than Potato- Moong bean- Groundnut sequence. Alkaline phosphatase activity increased significantly with 100% inorganic NPK or 50% inorganic NPK+ 50% organic NPK in Potato-Wheat- Rice and Potato- Moong bean- Groundnut crop sequence. While in Potato- Onion- Maize system, alkaline phosphatase activity was greater in 100% organic NPK and 100% organic NPK+ crop residue treatments. Integrated application of organic amendments (vermi-compost, crop residue) along with chemical fertilizer could be the best management practices for enhancing Carbon sequestration in soil and sustainable crop productivity. In all three systems, incidence of apical leaf curl (16.2, 7.4 & 11.6%) and hopper burn (8.7, 5.8 & 1.8%) were significantly lower with

100% organic nutrition as compared to 100% inorganic nutrition for apical leaf curl (18.0, 8.6 &14.2%) and hopper burn (10.5, 7.8 & 3.2%), respectively. Thrips and leaf folder population was less in 100% organic treatment as compared to 100% inorganic while high incidence of stem borer was recorded in maize in 100% inorganic nutrition (2.84%) as compared to control (1.67%) or 100% organic nutrition (0.72%).

At shimla, to schedule the nitrogen application in potato on the basis of RCI (Relative Chlorophyll index), it was noticed that when urea or CAN was used as N source, 2nd and 3rd additional application of 25 kg N/ha was needed at 90 and 95% RCI, respectively but with NCCU (neem cake coated urea) as a source of N, only one application of 25 kg N/ha was required after earthing up. Thus, the use of NCCU resulted in a saving of 25 to 50 kg N/ha over urea or CAN. At Patna three varieties *viz*., Kufri Khyati, Kufri Jyoti and Kufri Pukhraj were evaluated for fine tuning of N top dressing with the help of chlorophyll contents index using SPAD reading and the results showed that 20% recommended N applied at 90% of the reference SPAD value at Patna and 95% of the reference SPAD value at Gwalior gave similar yield as compared to the recommended N level. Under omission plot technique, maximum yield reduction was in N omission plots (14.37 t/ha) as compared to over fertilized reference (OFR) plots. The K omission plots was second to N omission plots with yield reduction of 3.55 t/ha followed by Zn (3.22 t/ha), and S (2.96 t/ha). The difference of yield indicated that the N was the most limiting nutrient element in potato productivity in the region, whereas, P and Mg were the least one. At Gwalior, highest total tuber yield was recorded with 2% NCCU (75% NPK) which was followed by 2% 2mm sieved FYM coated (100% RDF). Out of 100 genotypes/hybrids evaluated during 5 consecutive years from 2009-10 to 2013-14 the six promising genotypes/hybrids *viz*. J 93-58, J 92-164, 83-P-142, JN-2207, MS/82-279, J 92-167 gave higher/equal potato yield in comparison to popular cvs Kufri Bahar and Kufri Pukhraj at all soil moisture levels. During 2014-15, the genotypes *viz*. JN-2207, J.92-167 & 83-P-142 produced maximum yield at higher moisture regime, but, at low soil moisture regime the genotypes i.e. JN-2207, J.92-167 & J.93-58 gave higher yield against Kufri Pukhraj.These six hybrids/genotypes were also found promising for higher water use efficiency (WUE) at all soil moisture regimes. At Shillong, Kufri Jyoti was found to be the most nitrogen efficient among tested potato cultivars under acidic soil conditions.

At Modipuram, Bentazone 48% (1.5 l/ha) was effective in controlling dicot weeds and decreased total weed dry weight by 89.5 % . Performance of Bentazone was consistent at Gwalior and herbicide (1 l/ha) reduced total weed dry weight by 87.0%.

Under micro-irrigation study at Modipuram, the application of ¼ NPK as basal + ¾ through drip-fertigation in eight equal splits through liquid fertilizers (LF) gave maximum tuber yield (47.1 t/ha) followed by 1/3 NPK as basal + 2/3 through drip-fertigation in six equal splits through water soluble fertilizers (WSF), which produced 38.3 tons tubers/ha against soil application of ½ N with full P & K as basal at the time of planting + ½ N at earthing-up (35.6 t/ha). In case of mulching experiment, the potato yields were significantly higher under paddy straw mulch followed by black polythene mulch (25µ size) as compared to without mulch under drip irrigation. Maximum soil temperature was higher (0.6 -2.4 °C) under un-mulched control and all polyethylene mulches than air temperature (25.4 °C) while Minimum soil temperature was elevated (by 1.5 -3.4 °C) from air temperature (14.8 °C) in all the mulched plots. Black polyethylene mulch conserved 6.2% more moisture as compared to the un-mulched control followed by transparent polyethylene mulch (5.8%), silver polyethylene mulch (5.7%), FYM mulch (4.4%) and hay mulch (3.1%).

A small, compact and low cost potato combine harvester, to eliminate manual picking/ collection, to save upon labour and time, thereby reduce the cost of operation and human drudgery involved in tuber collection was designed and fabricated. Two different prototypes of tractor operated potato combine harvester were developed one to dig and collect tubers in a trolley (Prototype-I) and other to dig and collect tubers in bags/crates (Prototype-II).

A 2-row tractor operated trailed type potato combine harvester (Prototype-II) with provision for inspection and simultaneous collection of tubers in bags/crates was re-fabricated. Development of a power operated potato grader for grading potatoes into four size grades with three number of grading sieves was carried out. Further refinement of aeroponic technology for producing potato minitubers with three grow boxes and four cultivars was under taken. Two approaches were tried for designing of systems for plant holding and drudgery free picking of potato minitubers. Six prototypes of plant holding cages were fabricated in first approach while in other approach netting was provided on units of three plant trays consisting of total 96 plants. Steel frames were fabricated for supporting these nettings which ultimately hold plants straight and don't allow them to lodge. In this system three trays were lifted together for picking of tubers which enabled fast picking without damaging plant shoots and root system that needs further refinement. A new system for planting of *in vitro* plants was designed and fabricated for taking two crops in aeroponics system in plains using high Density planting for six-seven months (Oct to April) in Jalandhar conditions.

With HD planting in second crop (Kufri Khyati) produced 32.1 mini-tubers/plant of average weight of 2.16 g which was 25% higher in number and 12.5% in weight per mini-tuber as compared to traditional method followed in aeroponics.

Use of sensing and dosing system was developed wherein with only one system up to four chambers can be monitored to maintain pH of the medium.

For grading of aeroponically produced minitubers (1-6 gm wt.) two grading sieves were designed made of PVC of 3 mm thickness with overall dimensions of 50x40x10 cm (LxWxH) and are drilled with 11 mm and 16 mm hole size.

Eleven cropping sequences were evaluated at CPRS, Shillong and the results showed that the potato yield was similar (22.4 to 24.3 t/ha) in all the sequences during summer while turnip (23.5 t/ha) and knol-khol (23.0 t/ha) were recorded significantly high productivity followed by onion (11.3 t/ha) over other crops in the subsequent autumn. At Patna, eight potatoes based cropping systems were evaluated and their results showed that the average yield of early planted potato crop was lower than the main season crop. Potato-Bottle gourd-Rice was most productive system in terms of Rice equivalent yield (REY) followed by Potato-Onion-Rice, Early potato - oat - cowpea - maize and Early potato -Wheat-Green gram-Maize.

Plant protection

Late blight incidence in the sub-tropical plains was insignificant this year. No change in race spectrum, mating types, metalaxyl tolerance and mitochondrial haplotyping was observed in *Phytophthora infestans*. Five SSR markers which showed polymorphism in Indian population of *P. infestans* were selected for genotyping. Cell wall based protein from *P. infestans* was customised to develop ELISA kit and the kit could efficiently differentiate between negative and positive samples. Complete mitochondrial genome of *P. infestans* A2 mating type has sequenced, which is slightly higher than all A1 types. Microarray analysis of potato-*Phytophthora infestans* interaction studies in resistant and susceptible cultivars revealed that in susceptible cultivar only

P. infestans effector genes were expressed whereas in resistant cultivar genes belonging to signal transduction, biotic stress, cell rescue and metabolism pathways were up regulated. JHULSACAST model successfully forecasted late blight appearance in western Uttar Pradesh whereas Indo-Blightcast forecasted late blight appearance accurately in hills, tarai region and Indo-Gangetic plains. When Rhamnolipid based formulation (0.25%) with botanical (4%) was effective against late blight under field conditions. Cymoxanil and dimethomorph based fungicides provided good protection from late blight. Systemic acquired resistance chemicals (BABA and phosphorous acid) reduced late blight severity significantly and induced expression of defence genes.

Early generation (F_1C_1-F_1C_5) hybrids (1003) were evaluated and 296 hybrids resistant to late blight were retained for further evaluation. In advanced generation, of the 25 hybrids evaluated,15 were retained for further evaluation. Three hybrids (SM/00-42, SM/00-120 and VMT/5-1) were introduced into AICRP (Potato) for multilocation trials.

Pure cultures of major potato viruses were multiplied in standard hosts. Out of 61 germplasm accessions tested for PVY and PVX resistance through mechanical inoculation, 16 CP nos. were found having combined resistance to PVX and PVY, 29 CP Nos. to PVY and 11 CP Nos to PVX, respectively. Seven hundred and eighteen leaf samples were tested for the presence of PVX, PVS, PVY, PVA, PVM, and PLRV by DAS- ELISA and ToLCNDV-potato by PCR under Accredited Test Laboratory (NCS-TCP) and 515 samples were tested for viruses under non-ATL. Twenty one samples were tested for the presence of PVT, PYDV, AVB, APMoV, APLV, TRV, TRSV, PSTVd and Clavibacter under post-entry quarantine testing. Three hundred and eighty three samples of different potato varieties were tested for ToLCNDV-potato through PCR at CPRIC, Modipuram. Eighty five field samples and one hundred and twenty microplants were tested for ToLCNDV-potato, PVX, PVY, PLRV, PVA, PVS and PVM. A total of 2164 tubers of eight varieties were indexed for ToLCNDV-potato through PCR at CPRIC, Modipuram. Surveys were carried out in Western U.P., Ooty, Karnataka, Faizabad and Kanpur in U.P. and virus infected samples were collected, tested through EM, ELISA, & PCR and used for virus characterization. Immunogold electron microscopic technique was used to detect PVM. Uniplex RT-PCR assay for GBNV and multiplex RT-PCR technique was developed to detect different strains of PVY. SYBR green based duplex qRT-PCR assay coupled with melt curve analysis was developed for the detection of ToLCNDV-potato and PVX. Integration of transgene in two transgenic lines GTLC2-127 and KPLC2-53 resistant to ToLCNDV-potato were confirmed through event PCR analysis. CP gene of PVS isolates from different parts of the country was sequenced and found 0-2% variation in CP gene sequence. Through multiplex RT-PCR assay, the occurrence of different strains of PVY *viz.*, PVYO, PVYC, PVYN, PVYNTN were identified. Partial dimers of DNA A & B components of two ToLCNDV-potato isolates were cloned in transformation vector and immobilized to *Agrobacterium* for further studies. Gene expression analysis was carried out in ToLCNDV-potato resistant and susceptible cultivars through micro array and the differentially expressed genes were identified.

Thirty isolates of *R. solanacearum* (15 from East Khasi Hills, 5 from Raipur, Chhatisgarh and 10 from Hoogly, West Bengal) and eight isolates of *Streptomyces* species were collected and purified. The phylotype and biovar analysis of 30 *R. solanacearum* strains revealed that out of 15 isolates from East Khasi hills of Meghalaya, 11 (73.3%) belonged to phylotype II bv 2 and 4 (26.7%) to phylotype IV biovar 2T of the pathogen, whereas all the 10 isolates from West Bengal and 5 from Chhattisgarh belonged to phylotype II bv 2 of the

pathogen. The phylogenetic analysis of 16S rRNA gene sequences of 43 Streptomyces strains revealed that among 36 pathogenic strains, 8 strains clustered with reference strain ATCC 49173 (*S. scabies*), 4 with reference strain ATCC 33282 (*S. bottropensis*), 1 with reference strain NBRC 13350 (*S. griseus*), 7 strains closely clustered with reference strain TX07-01D (*Streptomyces* spp., American pathogenic strain) and 10 strains were closely clustered with reference strain Y00411 (*S. coelicolor*). The rest 6 pathogenic strains did not cluster with any of reference strain. Among the 7 non-pathogenic strains, 2 clustered with reference strain TX07-01D (*Streptomyces* spp, American pathogenic strain), 1 with reference strain Y00411 (*S. coelicolor*), 1 with reference strain NBRC 13350 (*S. griseus*) while remaining 4 non-pathogenic strains did not cluster with any reference strains. Multiple displacement amplification-PCR could detect *R. solanacearum* up to 10^{-5} dilutions and was 1000 times more sensitive than PCR as PCR could detect *R. solanacearum* up to 10^{-2} dilutions only. Among the five tomato accession screened in glass house, Hawaii 7998 and Arka Alok were found apparently resistant to *R. solanacearum* (r3bv2). Neem cake powder application to soil (@8.0 q ha^{-1}) in two split doses (half at the time of planting and half at earthing up) was effective in reducing the black scurf incidence and severity. Real time PCR analysis showed 2.5 fold higher expression of PAP transcript in tissues infected with *R. solanacearum* compared to non-infected tissues. This confirmed that expression of PAP might contribute to disease susceptibility by inhibiting the accumulation of reactive oxygen molecules.

Monitoring aphid and whitefly populations during the year under report revealed that the aphids crossed critical level during fourth week of December while latter was very high on early planted crop up to second week of November. Mapping of the aphid population from various potato growing regions of India shows occurrence of thirteen aphid species on potato. Recently, *Aulacorthum solani, Aphis spiraecola*, *Macrosiphum euphorbiae* have been frequently appearing on potato in Jalandhar and Gwalior besides *M. persicae* and *A. gossypii*. Uniplex and duplex RT-PCR detection protocols were standardized to detect PVY and PLRV from aphids. Non edible oils, neem and karanj oils were found to be effective in reducing the whitefly population on potato. Mustard as a border/barrier crop was found to be very effective in trapping aphid population at Modipuram.

Crop Physiology, Biochemsitry and Post-harvest Technology

Flavouring compounds particularly umami 5' nucleotides (AMP+GMP) were estimated from local potato products available in the market and processed potato products being sold by the retailers. Umami 5' nucleotides were found to be high in aloo bhujia, dehydrated aloo lachcha and dehydrated potato chips. The study suggested that the potato products prepared solely from potato contained higher levels of umami 5' nucleotides compared to other products prepared by mixing potato with other cereals and vegetables. On cooking, there was about 14% increase due to microwave cooking and 31% increase due to pressure cooking in flavouring compounds. An indirect method of estimation of Glycaemic index was standardised through α-glucosidase and α-amylase inhibitors estimation. The natural forms of α-glucosidase and α-amylase inhibitors that we ingest through our daily diet have potential to prevent hyperglycemia helping manage the incidence of type II diabetes. The *in vitro* α-glucosidase inhibitory activity ranged from 0% to 52.8% in Indian potato cultivars. Similarly, the Glycaemic index is inversely related to resistant starch (RS) content, hence the RS content was also analysed. RS content in cooked tubers of Indian potato cultivars ranged from 1.22 to 1.93 mg/100mg DW. For making potato chips with low oil content, microwave processing was followed and potato chips with acceptable

sensory scores (≥7.6 on 9.0 point Hedonic scale vs 8.0 of control preparation) and low fat content (~3.57% vs 35.5% in commercial preparation) were obtained. A cost effective methodology was standardized for rapid estimation of fat in potato chips using solvent extraction principle keeping its high surface area to weight ratio in view. Using this methodology, the estimated fat content of commercially available chips and control samples were found to be 35.76% and 36.37%, respectively. The fortification of potato chips with calcium and zinc minerals using calcium lactate and zinc sulphate as fortificants was attempted keeping their high bioavailability in view. Calcium and zinc fortification were done by vacuum impregnation method.

Time saving and cost effective methodology for estimation of total phenolics and % DPPH inhibition through ELISA plate reader was standardized and validated. Phenolic contents ranging between 25.4 to 39.5 mg/100g FW in freshly harvested tubers of thirty two Indian potato cultivars increased during storage up to 180 days with a higher increase recorded at 12°C compared to 4°C. Processing cultivars recorded least and table purpose cultivars recorded highest phenolic contents. In studies on the effect of storage temperature on anti-oxidant system of potato tuber, dehydroascorbate contents decreased during storage and were higher in processing cultivars (Kufri Chipsona-1 and Kufri Chipsona-3) in comparison to table purpose variety Kufri Pukhraj. Glutathione reductase (GR) activity which was more pronounced at low temperature (4°C) than at elevated temperature (12°C), also remained consistently higher in processing cultivars. Sprout suppression effect of two organic sprout suppressants *viz*. R-23 and R-24 were evaluated in different doses (25-200 ppm) on potato tubers during storage at 12°C for six months. Treatment with 200 ppm recorded best results with complete sprout inhibition up to 180 days. In the confirmatory experiment with 200 ppm dose of R-23 and R-24, only 20-30% sprouting was recorded after six months of storage with significant reduction in sprout growth. The treatment did not record any adverse effect on the processing quality of potatoes. In experiments with four naturally occurring compounds for sprout suppression at 24.2°C, vapour treatment with menthone (derived from *Mentha arvensis*) at 250 µl/l concentration, induced complete sprout inhibition with nil rotting in potatoes up to 100 days in comparison to CIPC treated and control (untreated) potatoes which recorded 23.8 and 100% sprouting, respectively.

Out of 101 successful crosses made at Kufri and Modipuram,183846 TPS were extracted. 269 selections were made from the 6120 seedlings raised from these seeds in the field and 152 selections were made from 500 seedlings in the glass house at Shimla. In the field selection at Modipuram, 110 clones were selected from F_1C_1-F_1C_3 stage for further evaluation. A screening method based on tuberization in leaf bud cuttings under controlled conditions was evaluated. Slow release formulations PS10 and PP10 of growth retardant Paclobutrazol at 5 ppm spray 35 days after planting improved tuber yield under heat stress conditions. At Jalandhar, Kufri Khyati was found unsuitable for planting during early September. For drought tolerance 2 hybrids were selected from 2007- 2008 series, 4 from 2009, 6 from 2010, 23 from 2011 series and 96 from 2012 series were selected. Two hybrids WS/2005-146 and HT/2007-1105 were introduced into AICRP (Potato) for multi-location trials.

Seed Technology

During 2013-14, total production of 2705.82 tons nucleus and breeder seed was achieved in both conventional and hi-tech seed production system from an area of 128.47 hectares in plains. This includes 2019.02 tons breeder seed produced from 93.12 ha area. Total 1960.14 tons breeder seed was supplied to various government and private

agencies out of which 1915.42 tons from plains which includes both pre- (1753.02 tons) and post-cold storage (162.406 tons) and 44.718 tons breeder seed has been supplied from hills. A total number of 525485 (6.28 tons) minitubers were produced, 329855 (5.57 tons) minitubers from microplants, 18632 (0.18 tons) from microtubers and 1, 76, 998 (0.53 tons) of aeroponic minitubers. During 2014, total no. of 1248 tubers of different commercial potato varieties were indexed at Kufri /Fagu and total no. of 1500 indexed tubers comprising 680 tubers of Kufri Jyoti, 260 tubers of Kufri Himalini, 280 tubers of Kufri Kanchan and 280 tubers of Kufri Girdhari were supplied in clonal form for further multiplication in subsequent cycles to augment seed potato production at Manipur and supply chain in NE regions. During current year, total production of 70.696 tons nucleus and breeder seed was produced from 5.0 hectare area including 43.235 tons of breeder seed from 3.35 ha area with average productivity of 12.905 t/ha at Kufri. Total 48.20 tons breeder seed was supplied to different government and private agencies. 102 individual tubers (virus-free, true to type, uniform size and genetically pure) of 17 varieties were selected and aseptically maintained at 4ºC as basic material. Total no. of 43 nodal cuttings of 18 virus free varieties (basic material) was taken for micropropagation. A total no. of 2541 culture tubes (6352 microplants) of 15 varieties were supplied to different seed production stations/ centers *viz.*, Modipuram, Jalandhar, Gwalior, Patna, Kufri, Shillong and Ooty and 105 virus-free *in vitro* culture tubes of basic seed material of 13 different varieties were supplied to 12 different private seed producing organizations in India. Quality seed production of 121.53 tons was achieved in 9.84 ha area at Ooty and 25.99 tones was achieved in 3.92 ha area in Generation-3 at Shillong. A total amount of Rs. 8,44,83,250 generated during 2014-15 by the sale of breeder seed under Revolving Fund Scheme (RFS) in which Rs. 45004040, 17024600, 11563582, 3339435, 1221380 and 6330213 from Modipuram, Jalandhar, Gwalior, Patna, Kufri and Shimla respectively. This includes money received from the sale of post cold stored breeder seed of cropping year 2013-14 and current crop of 2014-15 as well as microplants.

Isolation from Kufri Bahar round (peel and core part) and elongated (rose-end, distal and core part) tubers from seed farm of Modipuram revealed stolen end of elongated tubers 88.89% Fusarium while 47.37% in elongated rose-end which may be responsible for elongation of tubers. A total of 55 endophytic bacterial isolates were categorized on five grades of rating scale for their percent zone of inhibition test and among these several isolates were rated as very good (++++) antagonists on and may be playing very important role for inherent suppression of potato pathogens like *Fusarium* spp., *Rhizoctonia solani, Ralastonia solanacearum, Phytophthora infestans*. The above potential bacterial endophytes may also be exploited as potential biocontol agents. All the growth parameters of microplants such as height, number of roots, number of nodes, fresh weight and dry weight were enhanced in Kufri Chandramukhi under association of *Methylobacteria*. The growth parameters like height, number of leaves as well as nodes shown positive effect in Kufri Khyati. The culture media pigmented with yellow colored endophytic bacteria also showed the positive effect on different morphological growth parameters except no. of leaves and no. of nodes in Kufri Lauvkar after 42 days. Priming with *T. viride* & pencycuron and storage in cloth bags was resulted comparatively stout, green, vigorous and healthy aeroponic minitubers. Most of the priming treatments increased the sprout length over control. Maximum sprout vigour in *T. viride*, pencycuron, *P. fluorescence* and integration of *T viride* + *P. fluorescence* + Tricel clearly indicates the growth promoting activities as well as successful integration. Among both the priming methods, wet priming was comparatively better in stout,

multiple and vigorous sprouting of aeroponic minitubers. It was concluded from three experimental dates and various varieties, that only Kufri Chipsona-4 is most suitable variety for planting in summer season under long day condition for satisfactory yield followed by Kufri Surya. Delay planting in March had adverse effect on Kufri Chipsona-4. Bower system of planting & training significantly increased several fold yield by number as well as weight, vegetative growth, biomass of plant and reduced the post harvest loss as driage/rottage of minitubers in both mid August and 1st September planting. The post harvest loss percentage was less in Bower system as compared to Non-Bower in all the varieties. Planting at 15 cm intra row spacing produced higher proportion of seed size tubers. Haulm cutting at 80 days after planting helped in increasing proportion of seed size tubers at Gwalior. Under sprayed conditions, the aphid count remained below the critical levels throughout the crop season i.e. up to mid August, whereas under unsprayed conditions, aphid count crossed the critical limit from mid July onwards at Fagu hills.

Social Sciences

During this year, a survey was conducted in Assam and Meghalaya to find out real problems and seed potato utilization pattern of the potato growers. Variety wise potato area was assessed and it was found that in both the states Kufri Jyoti was the predominant potato variety occupying 61% area in Assam and 65% area in Meghalaya. Kufri Pukhraj and LS Smith were the other popular varieties of these states. It was also found that seed potato purchased from traders was the most commonly used source of seed in Assam while in Meghalaya own farm production retained as seed potato was the most commonly used seed source. Overall, it was found that 50% respondents with higher seed potato expenditure invariably had higher potato yield, cost of cultivation, net income and benefit-cost ratio compared to the 50% respondents with lower expenditure on seed potato in both the states. Expensive seed potato was found to be the severest problem for potato farmers in the state of Assam. In Meghalaya, unavailability of healthy seed potato from local government farms was the number one constraint.

Another survey of 90 potato growers was carried out in Agra and Kannauj districts of Uttar Pradesh. The varietal adoption pattern was observed in these two district and It was observed that in case of Agra, Kufri Bahar has the monopoly with 90% of total potato area under cultivation. In Kannauj district, several varieties of potato were grown, of which Kufri Pukhraj was the most popular variety covering nearly one third of the total area under potato followed by Kufri Bahar (22.2% area). The seed rate of potato in Agra and Kannauj were 38.5 q/ha and 37 q/ha. Thus farmers from both the districts were using higher seed rate. Similarly, NPK doses in both the districts Agra (210:207:109 Kg/ha) and Kannauj (251:253:99 Kg/ha) were found to be higher than recommended dose especially for phosphate use. Late blight was the major disease in both districts followed by black scurf and common scab. A majority of farmers were aware about controlling late blight but no farmers were practicing boric acid treatment for black scurf and common scab. The average yield of potato in Agra was found to be 27t/ha while it was slightly less at 25 t/ha in Kannauj district. Moreover, 40 demonstrations were laid out in different locations of HP namely Shimla, Kinnaur and Lahaul spiti to assess the performance of potato variety Kufri Himalini at farmers' field. Analysis of data revealed that Kufri Himalini out yielded local variety Kufri Jyoti at all three locations.

During this period, Social Sciences Division conducted an ICAR sponsored 21-days Summer School on "Current trends in quality potato production, processing and marketing". A total

of 19 scientists/researchers from 8 statesattended this training. The impact of this training course revealed that average increase in knowledge of trainees before and after training was estimated at 21.4% which shows that training was successful in significantly increasing the knowledge of the respondents. Majority of the trainees were very well satisfied with the training contents and training delivery mechanism. More than 70% of trainees felt that training programme environment and behaviour and style of teacher was excellent during training. A majority of the trainees (68.4%) graded the training as Very Good while 26.3% graded it as Excellent.

In addition, 10 more trainings were conducted at CPRI, Shimla and several 1 to 5 days trainings at its regional stations to train farmers in improved methods of potato cultivation. Eastern Zone Regional Agriculture Fair was also organized at CPRS, Patna during 19-21 Feb., 2015. The experts from institute also took part in 14 live phone in programmes/agricultural talk on AIR and Shimla Doordarshan.

Research Programmes

Research programmes, programme leaders and associates for the year 2014-15

Sl. No.	Research Programmes & Institute Code No.	Programme Leader and Associates
1.	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, Sanjeev Sharma, A Jeevalatha, Kamlesh Malik, MS Gurjar, R Uma Maheshwari, Ashiv Mehta, Name Singh, Bandna, SP Trehan, MJ Sadawarti, Shambhu Kumar, R Baswaraj, R Sudha, Aarthi Bairwa, KR Naik (Dharwad), Kiran Kumar (Hassan), Anil Gupta (Hissar), Kameshwar Sen and Shruti Gupta.
2.	Breeding for improved varieties. P1-2010/2-IPR-F30/0210	Dr. SK Luthra. **Associates:** Drs. Raj Kumar, Shambhu Kumar, VK Gupta, RatnaPreeti Kaur, Sanjay Rawal, SP Trehan, SK Singh, MehiLal, RK Arora, Rahul R Bakade, Ashiv Mehta, Vinay Bhardwaj, Bandna, AK Srivastava, Jagesh Kumar Tiwari, VK Yadav, Harvir Singh, Ravinder Sharma, Ramesh Chand and Vineet Sharma.
3.	Biotechnology in potato improvement. P1-2010/3-IPR-F30/0210	Dr. Jagesh Kumar Tiwari. **Associates:** Drs. VU Patil, Shashi Rawat, Baswaraj Raigond, Vinay Bhardwaj, Sanjeev Sharma, Brajesh Singh, Raj Kumar, SK Luthra, S Sundaresha and Dalamu
4.	Resource management strategies and information technology tools for potato based cropping systems. P1-2010/4-IPR-F27/0210	Dr. PM Govindakrishnan. **Associates:** Drs. VK Dua, Shashi Rawat, SP Singh, Sanjay Rawal, RK Arora, SK Singh, MA Khan, SK Yadav, RK Rana, R Uma Maheshwari, Name Singh, EP Venkatasalam, R Sudha, Aarthi Bairwa, Islam Ahmed, Ashwani Kumar Sushil Kumar and Yogesh. (Dr SS Lal, as PI upto 31st July, 2014)

5.	Nutrients and water management. P1-2010/5-IPR-F25/0210	Dr. Manoj Kumar. **Associates:** Drs. MC Sood, VK Dua, Manoj Kumar, Name Singh, MK Jatav, MA Khan, Raj Kumar, SK Yadav, AK Sharma, Prince Kumar, Sushil Kumar and Yogesh.
6.	Nutrient dynamics studies on long term manurial/fertilizer application and organic farming in potato production. P1-2010/6-IPR-F25/0210	Dr. Sanjay Rawal. **Associates:** Drs. MC Sood, MA Khan Anuj Bhatnagar, Mahesh Kumar and Avinash Chaudhary.
7.	Farm machines for potato cultivation. P1-2010/7-IPR-N20/0210	Er. Manjit Singh. **Associates:** Ers. Sunil Gulati, Sukhwinder Singh, Dr. RK Rana, Tarlochan Singh, Jagdish Chander and Gurdev Singh.
8.	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 Srivastave, Shashi Rawat, Ravinder Kumar, S Sundaresha, R Umamaheshwari, MS Gurjar, R Sudha, Islam Ahmed, Subhash Chand and SBS Parihar.
9.	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, RP Pant, Sridhar Jandrajupalli, Vallepu Venkataswarlu and Tarvinder Kochar.
10.	Characterization, detection and management of major soil and tuber borne pathogens of potato. P1-2010/10-IPR-H20/0210	Dr. Vinay Sagar. **Associates:** Drs. Sanjeev Sharma, KK Pandey, A Jeevalatha, Malkhan Singh Gurjar and Rahul R Bakade. (Dr RK Arora, as PI upto 30th May, 2014)
11.	Integrated pest management in potato. P1-2010/11-IPR-H20/0210	Dr. (Mrs.) Kamlesh Malik. **Associates:** Drs. M Nagesh, Anuj Bhatnagar, Vallepu Venkateswarlu and Sridhar
12.	Management of potato nematodes. P1-2010/12-IPR-H10/0210	Dr. Aarti Bairwa. **Associates:** Drs. Vinod Kumar, EP Venkatasalam, R Sudha and B Chandran.

13.	Physiological and genetic approaches in managing heat & water stress under sub-tropical environment in potato P1-20EP 10/13-IPR-F60/02107	Dr. JS Minhas. **Associates:** Drs. Devendra Kumar, VK Gupta, Sanjay Rawal, Kamlesh Malik, Brajesh Singh, Shashi Rawat, Name Singh, Shelly Chopra and Om Pal Singh.
14.	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.
15.	Nutritional value of potato and potato products. P1-2010/15-IPR-Q10/0210	Dr. Brajesh Singh. **Associates:** Drs. Ashiv Mehta, Pinky Raigond, Bandana, Vineet Sharma and Yogesh Gupta.
16.	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, SP Singh, MJ Sadawarti, Manoj Kumar, SK Singh, Rahul R Bakade, Sukhwinder Singh, R Muthuraj, Ratna Preeti Kaur, RK Singh, TK Bag, Prince Kumar, Parvesh 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 Samadhiya, Sanjay Sharma, Harveer Singh and V Rajinderan.
17.	Impact of potato technologies developed by the Institute. P1-2010/17-IPR-C00/0210	Dr. NK Pandey. **Associates:** Drs. Rajesh Kumar Rana, Dhiraj Kumar Singh, SK Yadav, Ravinder Kumar, TK Sinha and Ashok Kumar Chauhan.
18.	Climate change impact and adaptation strategies for potato crop. P1-2010/18-IPR-F27/0210	Dr. VK Dua. **Associates:** Drs. BP Singh, Jagdev Sharma, Shashi Rawat, Sanjay Rawal, SK Singh, SP Singh, Mehi Lal, Sanjeev Sharma, Vinay Sagar, Kamlesh Malik, Anuj Bhatnagar, Prince Kumar, Islam Ahmed and Sushil Kumar.

Division of Crop Improvement

Management and Enhancement of Potato Germplasm

Efforts were continued to augment the potato germplasm collection at CPRI, which is the designated National Repository for Potato germplasm. During the year under report, 33 accessions were imported from CIP, Peru, 12 from USA, 8 from New Zealand, 6 from The Netherlands, 5 from Australia, 2 from Canada, 2 from France and 1 from UK. In total, 69 accessions were imported from 8 countries and 25 accessions were added to cultivated germplasm collection after quarantine clearance. Besides, the TPS of 14 accessions belonging to 8 different wild species were imported from IPK Gene bank, Germany. An exploration was conducted in Meghalaya to enrich indigenous variability in the potato gene bank (Fig. 1A). A total of 33 samples were collected with varied tuber colour, shape, eye depth and flesh colour (Fig. 1B). The present germplasm collection at CPRI consists of more than 4,150 accessions of cultivated and wild species from 30 countries.

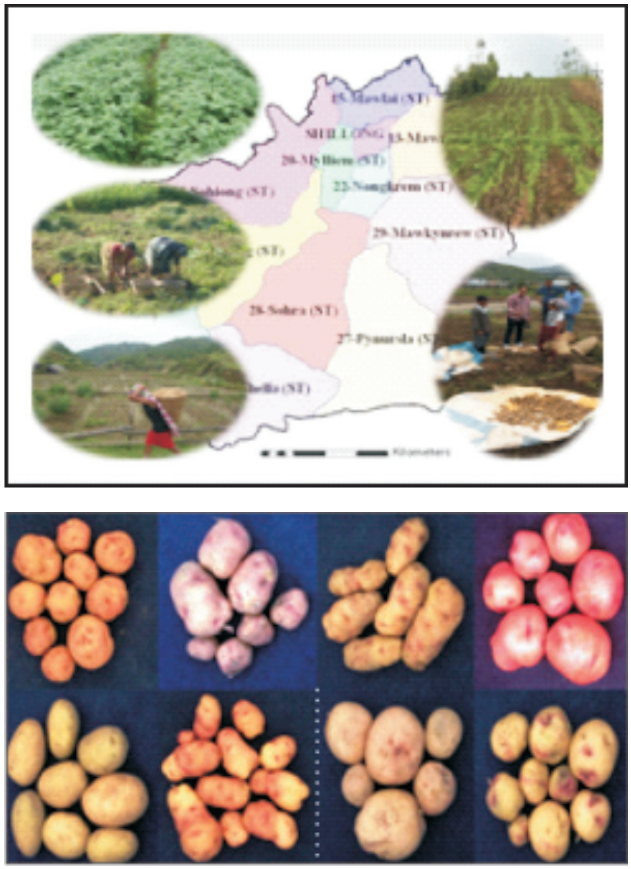


Fig. 1: Exploration in Meghalaya (A) and indigenous variability in tuber traits (B)

Conservation

One thousand four hundred and seventy two Tuberosum accessions, 768 Andigena accessions and 69 indigenous samples were maintained in fields at Jalandhar. Nearly 1,375 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 wild species, 600 accessions (both in tuber and TPS form) of 134 species are conserved at CPRI, Shimla.

Nearly 2,000 Tuberosum accessions were maintained in the *in vitro* form. Minitubers of 86 accessions from *in vitro* repository were produced and added to the germplasm collection, maintained under field conditions at Jalandhar & Kufri. Forty-nine mericlones of 10 varieties were tested for their freedom from all viruses and the results of 7 varieties namely Kufri Jyoti, Kufri Surya, Kufri Bahar, Kufri Lauvkar, Kufri Chipsona-3, Kufri Chipsona-4 and Kufri Girdhari were found free from all viruses.

Evaluation

As in previous years, a large number of accessions were evaluated for various biotic and abiotic stresses and also for adaptability and physio-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	18	CP nos. 3999, 3916. 4123, 4126,
	Replicated Row Trial	160	4228
	Jalandhar Spring	100	CP No: 3863 and Kufri Jyoti
	Modipuram Autumn (early)	69	CP nos. 3853. 3854, 3881, 3892, Kufri Garima and Kufri Surya
	Autumn (Main)	75	CP nos. 3786, 3815, 3849, 3858, 3869, 3892, 3898, 4047, Kufri Khyati, Kufri Sadabahar, Kufri Pushkar and Kufri Garima.
Late blight Foliage	Kufri (field)	178	16-HR; 16-R; 43-MR (Promising CP Nos: 3841, 3842, 3885, 4051, 4070, 4138, 4174, 4179, 4229, 4238
	Shillong (field)	77	4-R (CP 2132, 2279, 3841, 3605); 13-MR
	Ooty (field)	75	1-R (CP 2278); 7-MR
	Shimla (Lab)	95	10-HR (4221, 4222, 4223, 4229, 4237, 4238, 4239, 4240, 4241)
Tuber Viruses	Shimla (Lab)	72	2-MR (CP Nos: 3367 & 3586)
PVX & PVY	Shimla	61	16- R (PVX and PVY); 45-R (PVY); 27-R (PVX) Accessions *viz.*, CP Nos. 1425,
	Shimla		1737, 1790, 3168, 3291, 3421, 3473, 3576, 3581, 3588, 3605, 3650, 3802, 3841, 3917 and 4126 were resistant to both PVX and PVY
Leaf hopper and Mites	Modipuram	69	No conclusive results
Cyst nematodes	Ooty	60	6 accessions *viz.*, CP Nos: 1316, 3395, 3486, 3992, 4004 and 4081 were resistant to both the species of PCN.

Character	Location	No. of accessions evaluated	Promising accessions*
Keeping quality	Jalandhar	85	18- Best keepers; 44-good keepers. (CP nos. 1515, 3590, 3702, 3883, JEX/A-865 and JEX/A-413) having long dormancy and total weight loss less than the best control.
Chipping	Jalandhar	77	Eleven accessions *viz*. CPNos. 2033, 2182, 2294, 3179, 3258, 3452, 3456, 3495, 3647, 3649 and 3702 were found to be suitable for chipping.
Vitamin C	Jalandhar	74	CP Nos. 1589, 1590, 1614, 1622, 1623, 1659, 1665, 1668, 1679 and 1697 were promising.
Water use efficiency	Modipuram	29	4 accessions *viz*., CP Nos. 2148, 2163, 2164 and 2217 were promising.
Foliage maturity	Patna	235	23 accessions were found early maturing. Few promising CP Nos: 1800, 1802, 1809, 1813, 1815, 1817, 1822, 1836, 1846 and 1854

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

Analysis of genetic stability of *in vitro* propagated potato microtubers using DNA markers Five *in-vitro* propagated potato genotypes/cultivars (IC, Kufri Sindhuri, IWA-I, KCM and IWA-III) were used to assess genetic stability by RAPD, ISSR, SSR and AFLP markers. Plantlets were multiplied using leafy nodes in the propagation medium (MS medium + 30 gl^{-1} sucrose + 7 gl^{-1} agar) at 20°C under environment controlled chamber. Twenty-days old *in vitro* plants were induced for microtubers on the tuber inducing medium (MS medium + 80 gl^{-1} sucrose + 10 ml l^{-1} BAP) without agar. Microtubers (1-2 nos.) were conserved at 6°C on the conservation media [T1: MS medium + 80 gl^{-1} sucrose + 10 ml l^{-1} BAP + 7 gl^{-1} agar; T2: MS medium + 40 gl^{-1} sorbitol + 7 gl^{-1} agar; and T3: MS medium + 20 gl^{-1} sucrose + 40 gl^{-1} sorbitol + 7 gl^{-1} agar]. After one year of *in vitro* conservation, plants raised through micropropagation from original, T1, T2 and T3 microtubers and used for genetic stability analysis. During the study, a total of 38 (10 RAPD, 11 ISSR, 12 SSR and 5 AFLP) primers produced a total of 407 (58 RAPD, 56 ISSR, 96 SSR and 197 AFLP) clear, distinct and reproducible amplicons. Cluster analysis revealed 100% genetic similarity among the mother plant and its derivatives within the clusters by SSR, ISSR and RAPD analysis, whereas AFLP analysis revealed 85 to 100% genetic similarity (Fig. 2). This study concludes that AFLP is the best method followed by SSR, ISSR and RAPD to detect genetic stability of in vitro conserved potato mirotubers. The *in vitro* conservation medium (T2) is a safe method for conservation of potato microtubers to produce true-to-type plants.

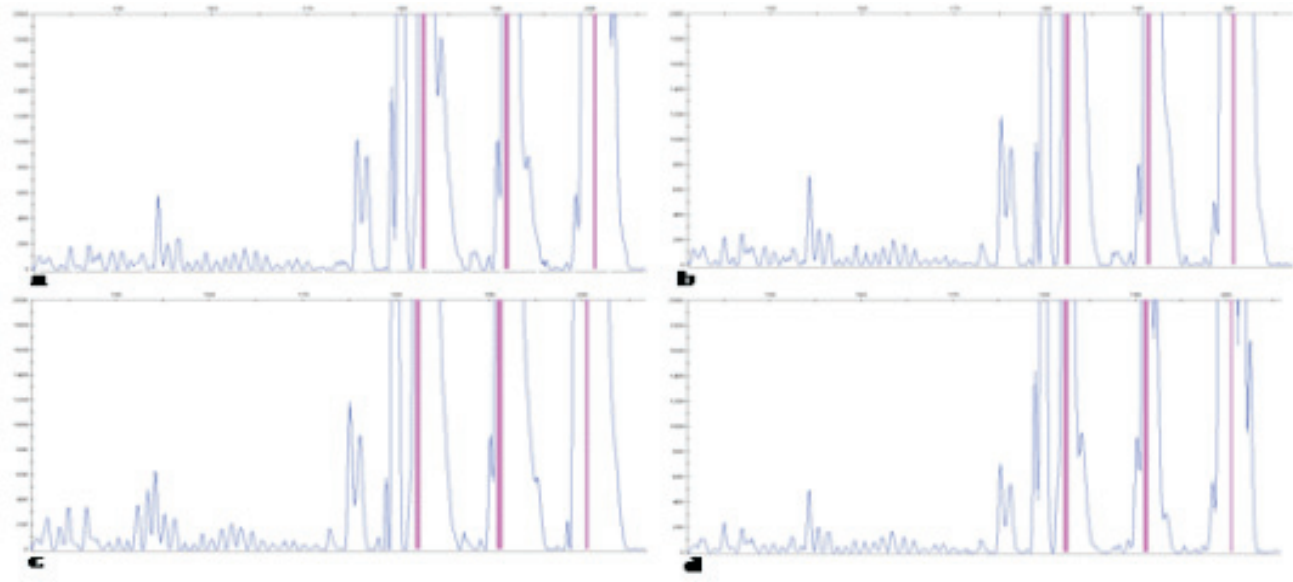


Fig. 2: SSR profiles generated by marker STU6 of potato genotypes a) KS *in vitro*, b) KS T1, c) KS T2, and c) KS T3

Genetic enhancement of Tuberosum

At Jalandhar, 979 F_1 selections from previous year were planted in first clonal generation. Out of these, based on tuber character, 271 clones were selected for further evaluation. In F_1C_2 generation, 505 clones were planted and 135 were selected. These clones will be evaluated for late blight resistance and foliage maturity with the objective to select early maturing late blight resistant clones. Further, 10 F_1C_3 clones were evaluated for foliage maturity at Patna and late blight at Kufri and 2 clones were found promising for both the traits.

Evaluation of wild species

Screening for Late blight resistance under lab condition

To broaden the resistance source against late blight one hundred forty one clones of forty one accessions of nineteen different wild species were screened for foliar late blight resistance by detached leaf method using complex races of *Phytophthora infestans*.

Two clones *viz*., SS nos 2615-08, 2615-13 (*S. pinnatisectum*) were highly resistant (lesion area up to 1.0 cm^2), twenty-three clones *viz*., SS nos 2206-0, 2206-01 (*S. albicans*), 1825-09 (*S. cardiophyllum*), 2635-09, 2727-0 (*S. demissum*), 2609-02, 2609-04, 2610-05, 2610-10, 2612-03, 2612-05, 2612-12 (*S. microdontum*), 2614-01, 2614-02 (*S. pampasense*), 2616-0, 2658-07 (*S. pinnatisectum*), 1724-14 (*S. sparsipilum*), 2619-01, 2619-03 (*S. spegazinii*), 2706-12 (*S. stenophyllidium*), 2710-15 (*S. stoloniferum*), 2371-01 (*S. tarijense*) and 2746-0 (*S. tuberosum ssp. andigena*) were resistant (lesion area 1.1 to 2.5 cm^2) and fifty seven moderately resistant (lesion area 2.51 to 6.0 cm^2). The resistant sources will be further confirmed for their resistance in the next crop season in the open field conditions. These resistance sources can be used for diversifying the source of resistance against late blight in cultivated potatoes.

Documentation

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

Development of Improved Varieties

Breeding improved varieties for plains

One hundred and sixteen advanced stage hybrids were evaluated in 13 yield trials at 60/75/90DAP at Jalandhar, Modipuram and Patna and 44 promising hybrids were selected. In preliminary yield trials, 23 promising hybrids namely J/9-111, J/9-117, J/9-175, J/9-129, J/9-141 and J/9-149 (Jalandhar), MS/11-451, MS/11-664, MS/11-673, MS/11-679, MS/11-938, MS/11-947, MS/11-1123, MS/11-1161, MP/10-595, MCIP/09-12, MCIP11-163 (Modipuram), PS/10-1, PS/10-2, PS/10-5, PS/10-10, PS/10-11, PS/10-22 (Patna) were selected from 80 hybrids evaluated. In confirmatory yield trials, 13 promising hybrids namely J/8-85, J/8-91, J/8-116, J/8-119 (Jalandhar), MS/10-885, MS/10-927 and MS/10-1529 (Modipuram), PS/9-9, PS/9-16, PS/9-18, PS/9-23, PS/9-28 and PS/9-38 (Patna) were selected from 23 hybrids evaluated. In final yield trial, eight advanced hybrids namely J/7-5, J/7-15 and J/7-37 (Jalandhar) MS/9-2196 and MP/09-39 (Modipuram) and PS/7-7, PS/8-8 & PS/8-31 (Patna) were selected from 12 hybrids evaluated.

Proposal for introduction of advanced stage hybrids in AICRP

Based on consistence performance during last three years, six advanced stage hybrids namelyJ/7-5, J/7-15, J/7-37 (Jalandhar), MS/9-2196 (Modipuram), PS/8-8 and PS/8-31 (Patna) has been identified for introduction in AICRP for multi-location trials.

J/7-5: The hybrid produced higher tuber yield at 60 DAP (8%) and 75 DAP (11%) than best control K. Khyati. It possessed 15 % dry matter at 75 DAP. The hybrid produces yellow, ovoid tubers with shallow eyes with pale yellow flesh colour (Fig. 3A).

J/7-15: The hybrid produced higher tuber yield at 60 DAP (19%) and 75 days (9%) than best control K. Khyati. It possessed 16% dry matter at 75 DAP. The hybrid produces white, ovoid tubers with shallow eyes and cream flesh colour (Fig. 3B).

J/7-37: The hybrid produced higher tuber yield at 60 days (23%) and 75 DAP (16%) than best control Kufri Khyati. It possessed 15% dry matter at 75 DAP. The hybrid produces white, round-ovoid tubers with shallow-medium deep eyes and white-cream flesh colour (Fig. 3C).

MS/9-2196 (J/93-77 x J9/97-243):The hybrid produced 39%, 24%, 13% and 22% higher tuber yield than K. Bahar, K Garima, K. Pukhraj and K Sadabahar, respectively at 90 DAP. The hybrid produces attractive yellow, ovoid tubers with shallow eyes and yellow flesh colour (Fig. 3D). The hybrid possesses 15% dry matter and good keeping quality. MS/9-2196 showed resistance (AUDPC 276) to late blight than K. Bahar (AUDPC 705) at Modipuram.

PS/8-8 (YY 6 x CP 2407): The hybrid produced 8% and 7% higher tuber yield than K. Khyati at 75 and 90 DAP respectively. The hybrid produces white, ovoid tubers with medium deep eyes and yellow flesh (Fig. 3E). The hybrid possesses 19% dry matter, medium dormancy with good keeping quality and moderate resistance to late blight under Patna conditions.

PS/8-31 (K. Arun x PRT-19): The hybrid produced 6% and 12% higher tuber yield than K. Lalit at 75 and 90 DAP respectively. The hybrid produces red round tuber with medium deep eyes and yellow flesh. It possesses 19% dry matter, medium dormancy with good keeping quality and moderate resistance to late blight under Patna conditions.

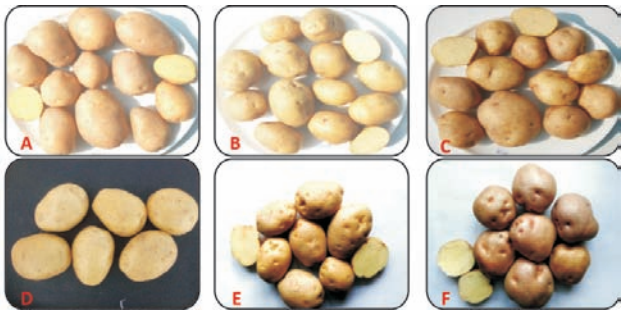


Fig. 3. Tubers of J/7-5 (A), J/7-15 (B), J/7-37 (C), MS/9-2196 (D), PS/8-8 (E) and PS/8-31 (F)

Advanced hybrid introduced in AICRP

Four advanced stage hybrids namelyJ/6-182 (Jalandhar), MS/8-1148, MS/8-1565, MS/9-723 (Modipuram) recommended by Institute Research Council 2014 were introduced in AICRP for multi-location testing.

J/6-182 (CP3125 x MS/82-797): The hybrid produced 3.5% and 8.5% higher total yield than K. Khyati at 60 and 75 DAP, respectively. It produces white ovoid tubers with shallow eyes and cream flesh colour. It possesses 17% dry matter than K. Khyati (15%).

MS/8-1148 (K. Surya x CP3125): The hybrid produced 31%, 4% and 7% higher total tuber yield than K. Bahar, K. Pukhraj and K Sadabahar, respectively at 90 DAP. It produces attractive light yellow ovoid tubers with shallow eyes and yellow flesh colour (Fig. 4). The hybrid possesses 17% dry matter, good keeping quality and moderate resistance (AUDPC 445) to late blight than K. Bahar (AUDPC 794) under Modipuram conditions.

Fig. 4: Leaf, flower, tuber and sprout of MS/8-1148

MS/8-1565 (MS/89-1095 x CP3290): The hybrid is suitable for specialty sector and produced 17%, 20%, 41% and 16% higher total tuber yield than K Arun, K Lalima, K Sindhuri and K. Bahar, respectively at 75 DAP. The hybrid showed advantage of 7%, 18% and 12% higher total tuber yield than K Lalima, K Sindhuri and K. Bahar, respectively at 90 DAP. It produces attractive purple, ovoid tubers with shallow eyes and yellow flesh colour (Fig. 5). MS/8-1565 possesses moderate 18% dry matter, good keeping quality and moderate resistance (AUDPC 445) to late blight than K. Bahar (AUDPC 794) under Modipuram conditions.

Fig. 5. Leaf, flower, tuber and sprout of MS/8-1565

MS/9-723 (CP3780x MS/90-512): The hybrid showed advantage of 30%, 5%, 4% and 13% than K. Bahar, K Garima, K. Pukhraj and K Sadabahar, respectively at 90 DAP. It produces light yellow ovoid tubers with shallow eyes and light yellow flesh colour (Fig. 6). It possesses high resistance to late blight than K. Bahar under Modipuram and Kufri conditions. It possesses 16% dry matter, good keeping quality. It has mealy texture, good flavour & good taste and free from discolouration after cooking.

Fig. 6. Leaf, flower, tuber and sprout of MS/9-723

Optimization of NPK requirement of MS/05-1543

The hybrid with N level of 120 kg/ha had significantly better marketable (47.6 t/ha) and total tuber yield (48.2 t/ha) over control (32.4 & 32.8 t/ha, respectively). MS/05-1543 exhibited

no response towards P_2O_5 application in term of tuber productivity due to medium and higher availability of phosphorous in soil. Moderate potassium application @ 50 kg/ha) was better for improving tuber productivity in MS/05-1543 as this level attained maximum and significantly better marketable (48.7 t/ha) and total tuber yield (50.4 t/ha) over the control (45.5 & 46.5 t/ha, respectively).

Fertilizer requirement of advanced hybrid 2002-P-14 at Patna

The total yield (28.57 t/ha) obtained with the application of $N_{180}P_{60}K_{100}$ was significantly higher than the control $N_0P_0K_0$.

Evaluation of advanced stage hybrids for late blight resistance at Modipuram

Among 27genotypes minimum AUDPC was recorded in six advanced hybrids *viz* MP/07-214 (13), MS/09-723 (30), MS/10-885 (71), MS/10-966 (88), MS/08-88 (93) and MS/11-664 (136) as compared to control. K. Bahar (795) and their rAUDPC were also less. By detach leaf method two hybrids *viz*, MCIP/09-12 and MS/10-940 were found resistant and 15 were found moderately resistant (HT/10-2505, MCIP/09-1, MCIP/09-11, MCIP/10-32, MP/06-39, MP/07-214, MS/08-1148, MS/08-88, MS/09-1083, MS/09-723, MS/10-927, MS/11-664, MS/11-673 MS/11-759, MS/11-947) and remaining 10 were susceptible.

Breeding for processing & export quality

Initial clonal stages

In initial clonal stages (F_1C_1, F_1C_2, F_1C_3), 274 promising clones were selected from the 1424 clones evaluated at 90DAP based on tuber characters and processing attributes.

Preliminary yield trial

Seventeen advanced hybrids were evaluated at 75 and 90 DAP and five promising advanced hybrids namely MP/10-24, MP/10-82, MP/10-123, MP/10-168 and MP/10-172 were selected based on tuber yield, tuber characters and processing attributes.

Confirmatory yield trial

Nine advanced hybrids were evaluated at 75 and 90 DAP and seven promising advanced hybrids namely MP/9-21, MP/9-22, MP/9-28, MP/9-36, MP/9-45, MP/9-73 and MP/9-86 were selected based on tuber yield, tuber characters and processing attributes.

Final yield trial

Seven advanced hybrids were evaluated at 75 and 90 DAP and four promising advanced hybrids namely MP/06-39, MP/07-214, MP/8-57 and MP/8-1900 were selected based on tuber yield, tuber characters and processing attributes.

Advanced hybrid trial at Jalandhar

Among the twelve hybrids evaluated at 90 DAP, maximum total tuber yield was recorded in MP/07-214 followed by MP/06-39. Processing grade tuber yield was maximum in MP/06-39 followed by MP/07-214. All hybrids recorded higher dry matter (>20%) except MP/06-39 and MP/07-214. All hybrids recorded lower reducing sugar contents and acceptable colour chips and French fries were made at harvest. MP/06-39 recorded the maximum vitamin C contents (13.77 mg/100g fresh weight).

Performance of advanced processing hybrids at Shimla

Twenty processing hybrids were evaluated for yield and late blight resistance at 120 DAP. Among 11 genotypes at Kufri, MP/08-328 yielded about 8% higher than best control Kufri Chipsona-1 and its late blight resistance was also better than K. Himsona. Among nine genotypes at Shimla, K. Frysona produced highest total tuber yield, while for late blight resistance MP/8-172 possessed lowest AUDPC (13).

Regional evaluation trials

Advanced hybrids MP/8-1900 and MP/7-214 at Burdwan (West Bengal) and MP/6-39 at Amirgarh (Gujarat) and Indore (Madhya Pradesh) were found promising for processing grade, total tuber yield and processing attributes.

Proposal for entry into AICRP

MP/8-1900 (for chipping) has been identified based on results at Modipuram and Burdwan (WB) for introduction into AICRP for multi-location trials. It produced higher mean processing (32 t/ha) and total (39 t/ha) tuber yields than best control K. Chipsona-3 (29 and 36 t/ha). It produces attractive white-cream, ovoid tubers with shallow eyes and cream flesh. The hybrids possess 22% dry matter and acceptable chip colour/fry score (2.8).

Advanced hybrid introduced in AICRP

Based on superior performance two processing advanced hybrids MP/9-901 and MP/6-39 were introduced in AICRP.

MP/9-901 (CP1717 x MP/99-406): It is an early maturing hybrid produced 21 and 23 t/ha processing and total tuber yields respectively than the best control Atlantic (17 and 19 t/ha) at 75 DAP. The yield advantage of 19% was over Atlantic at 90 DAP. MP/9-901 produced 27 t/ha and 30 t/ha processing and total tuber yields respectively than best control K. Chipsona-4 (26 and 28 t/ha) with yield advantage of 5% and 9 % respectively. It produces attractive white, round tubers with medium deep eyes and white flesh (Fig.7). MP/9-901 possesses medium dormancy period, excellent keeping quality, 23-24% dry matter and acceptable chip colour score (1.2 to 2.2).

Fig. 7: Leaf, flower, tuber and sprout of MP/9-901

MP/6-39 (K Himsona x K Pukhraj): It produced higher processing grade (37 t/ha; 28%) and total tuber yield (43 t/ha; 22%) than the best control K. Chipsona-3 (29 and 35 t/ha) at 90 DAP. The hybrid produced higher processing grade (37 t/ha; 38%) and total tuber yield (43 t/ha; 33%) than the French fry control K. Frysona (27 and 32 t/ha) at 90 DAP (Mean yield at UP, Punjab, Gujarat, West Bengal and Madhya Pradesh). MP/6-39 possessed 19% tuber dry matter content and the fry colour was in acceptable range (2.8) as compared to K. Chipsona-3 (2.7) and K. Frysona (2.5). The hybrid produces attractive white cream, ovoid tubers with shallow eyes and cream flesh (Fig. 8). The hybrid possesses moderate resistance to late blight, long dormancy period and excellent keeping quality.

Fig. 8: Leaf, flower, tuber and sprout of MP/6-39

Processing quality of genotypes during storage at 10-12°C with CIPC

Mean dry matter (%) remained higher than 20% during storage up to 180 days and ranged between 21.23 (MP/7-214) to 23.32% (Atlantic and K. Chipsona-1). Initial (0 day) reducing sugar (RS) contents were acceptable (<150 mg/100 g fr wt) for chips in all genotypes except in MP/4-578, MP/4-816, MP/6-86 and MP/6-39 which were however acceptable for making French fries. RS contents increased during storage with mean minimum contents recorded in hybrids MP/6-595 and MP/7-214 (17-179 mg/100 g fr wt). Sucrose contents also increased during storage with mean

minimum contents recorded in MP/6-816 (346.4 mg/100g fr wt), followed closely by MP/6-39, MP/7-214 and MP/4-578. Chip colour at 0 day was unacceptable in some hybrids, which was related well to the higher RS contents. Chip colour in general deteriorated at 60 days of storage due to higher RS contents at harvest. Fry colour however, remained acceptable throughout storage up to 180 days in all cultivars/hybrids.

NPK requirement of French fry advanced hybrid MP/04-578

Nitrogen (270 kg/ha) recorded French fry grade (27.1 t/ha) and total tuber yield (39.5 t/ha), which were significantly better over lower doses and comparable to highest N level. Specific gravity (1.079) and French fry colour score (4.26) were comparable at this dose in comparison to lower N levels. Phosphorous (40 kg/ha) had French fry grade (25.9 t/ha) and total tuber yield (36.8 t/ha), which were comparable to all P_2O_5 levels. Specific gravity (1.076) and French fry colour score (4.26) were also comparable to lower or higher P_2O_5 doses. Potassium (75 kg/ha) attained statistically comparable French fry grade (25.9 t/ha) and total tuber yield (37.7 t/ha) as compared to higher K_2O levels. Specific gravity (1.077) was not influenced with K_2O levels, but French fry colour score (3.86) was superior over control or higher K_2O doses.

Development of TPS population

Production of TPS

Produced 100 gm TPS of 10 crosses from 10 females and 2 male lines for parental line development.

Evaluation of TPS populations as seedling transplanted crop

Patna: Among the 10 populations evaluated at 90DAP, population PT/14-2, PT/14-5, PT/14-8, PT/14-13 PT/14-16 gave significantly higher total tuber yield than the control 92PT-27.

Shillong: Among the 12 TPS populations evaluated, PS 6/37-1 x D-150 (12.37 t/ha) gave significantly higher tuber yield than the control 92PT-27 (5.93 t/ha) as transplanted crop under rainfed conditions.

Evaluation of seedling tubers

Patna: Among the 9 populations evaluated, populations PT/08-109 and PT/13-8 yielded significantly higher tuber than the control 92PT-27 at 90 DAP.

Shillong: Among the 28 TPS populations evaluated, PRT-13A2 X PS8/97-1 (13.38 t/ha), PS 6/76-6 X D-150 (13.25 t/ha), MST-7 X D-150 (13.12 t/ha) and PS6/78-4 X PRR 908C1 (12.63 t/ha) gave significantly higher tuber than check 92PT-27 (11.95 t/ha) under rainfed conditions.

Table 2: Performance of processing hybrid MS/8-1900 proposed for introduction in AICRP (Mean of 2012-13 to 2014-15)

Genotype	Processing grade yield t/ha			Total tuber yield /ha			Dry matter (%)			Chip colour/French fries colour		
	MDP	WB	Mean	MDP	WB	Mean	MDP	WB	Mean	MDP	WB	Mean
MP/8-1900	27.88	36.85	32.37	33.45	44.65	39.05	22.51	22.02	22.27	3.07	2.50	2.78
K. Chipsona-1	24.16	35.04	29.60	31.11	38.51	34.81	20.38	21.36	20.87	3.50	2.70	3.10
K. Chipsona-3	25.08	33.14	29.11	31.39	39.71	35.55	21.57	21.02	21.29	3.83	3.33	3.58
K. Chipsona-4	26.53	31.19	28.86	30.95	34.58	32.77	22.10	20.67	21.39	4.97	3.33	4.15
K. Frysona	23.72	31.18	27.45	29.25	37.14	33.19	21.16	21.96	21.56	3.17	3.00	3.08
Atlantic	26.19	33.46	29.83	29.67	36.51	33.09	20.30	21.14	20.72	3.37	2.77	3.07

MDP- Modipuram (2012-13 to 2014-15), WB-Burdwan West Bengal (2014-15)

Analyzing the fungal diversity from potato rhizosphere soils through metagenomics

Complete profiling of the fungal diversity in the rhizosphere soils from potato fields at shimla was done using metagenomics approach. The variable regions, V4 and V5 of conserved 18S gene was targeted and analyzed. The preliminary cloning and sequencing results revealed that the fungal community in the soil samples is distributed across four phyla, i.e., ascomycota, basidiomycota, zygomycota and chytridiomycota. Ascomycota (with 60% abundance) is the largest phylum of fungi associated with potato rhizospere followed by basidiomycota (10%) and zygomycota (10%) and the least found is chytridiomycota (8%) (Fig. 9).

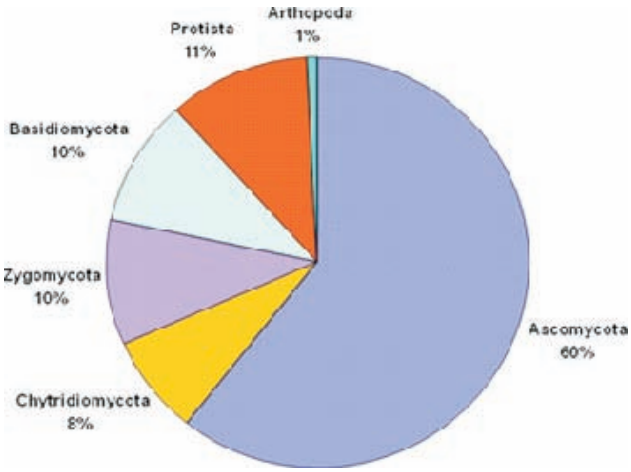


Fig. 9: The distribution of fungal population according to their relative abundance in the rhizosphere of potato plant

Development of gene construct for enhancing late blight resistance in potato

During Kufri Girdhari-*Phytophthora infestans* infection process, 532 genes showed 100 fold expression and out of 532 genes 10 genes were validated for their expression through Real time PCR and showed similar level of expression. Out of 10 genes, five genes were selected for development of gene construct for enhancing late blight resistance. Of those, 303 bp steroid binding protein, 402 bp proline rich protein and two hypothetical genes of 174 bp and 564 bp respectively have been amplified and cloned. Further the full length genes were sub cloned into pRI101 under the control of CaMV35S and translation enhancer element and these four construct will be used for genetic transformation of popular potato cultivar for enhancing late blight resistance (Fig. 10).

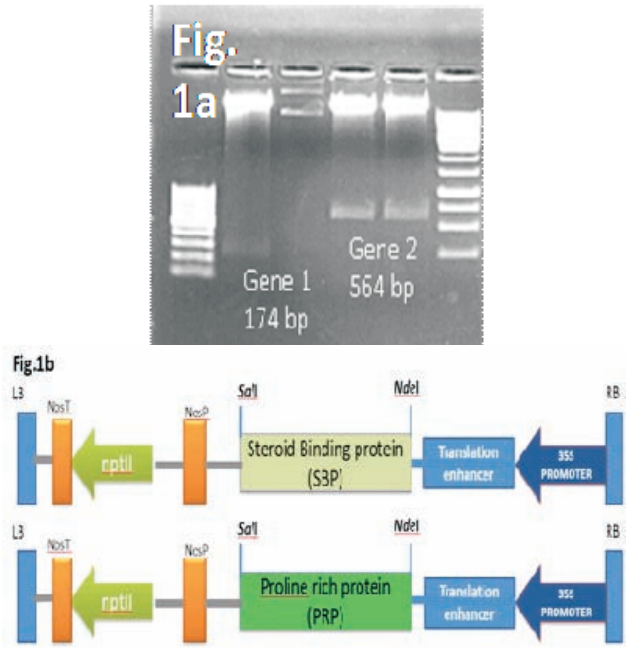


Fig. 10: Restriction digestion of pRI101::gene1 and gene2 binary vector with NdeI and SalI enzymes (2a) and T-DNA map of binary vector pRI101 (2b)

Inheritance and stability analysis of the inserted RB gene in SP 951 event and KJ RB hybrid lines

Copy number of *RB* gene was analyzed in transgenic Katahdin SP 951 (parent) and its

crossing progenies of Kufri Jyoti (non-hybrid parent). The copy number of RB gene in the Katahdin SP 951 event is single copy as detected by hybridization of *npt* II gene specific probe with the *Hin*d III digested genomic DNA of transgenic plant. The same results were obtained in the progenies (KJ-16, KJ-21, KJ-65, KJ-66 and KJ-77) developed by crossing Kufri Jyoti and transgenic Katahdin SP 951. Therefore it implies that the RB gene was stably inherited in to the hybrid progenies of Kufri Jyoti and transgenic Katahdin SP 951 with similar pattern of co-integration (Fig. 11).

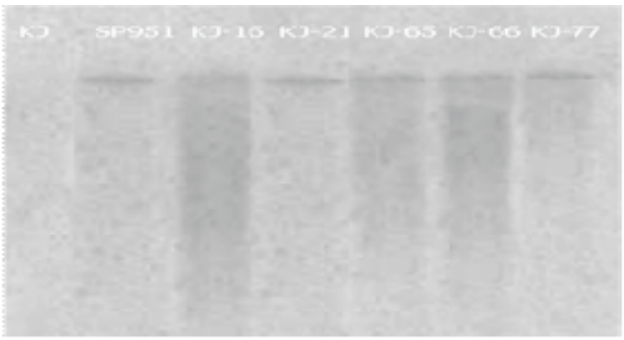


Fig.11: Copy number analysis of the *RB* gene in transgenic SP 951 and its hybrid progenies

Studies on molecular responses of potato to high temperature stress

Understanding the molecular mechanisms by which temperature affects tuberization in potato is crucial for development of thermo-tolerant potato cultivars. We analyzed the differentially expressed genes through microarray analysis of two potato cultivars, Kufri Surya and Kufri Chandramukhi having contrasting tuberization behaviour under elevated night temperature (24^{0}C). According to the Gene Ontology (GO) and pathway analysis of up-regulated genes in tolerant cultivar, Kufri Surya at 21 days, it was discovered that the genes related to defense (8.27%), stress (7.9%) and response to stimulus (7.54%) were significantly up-regulated. Moreover these included the genes for circadian rythmicity, signal transduction and development (Fig. 12).

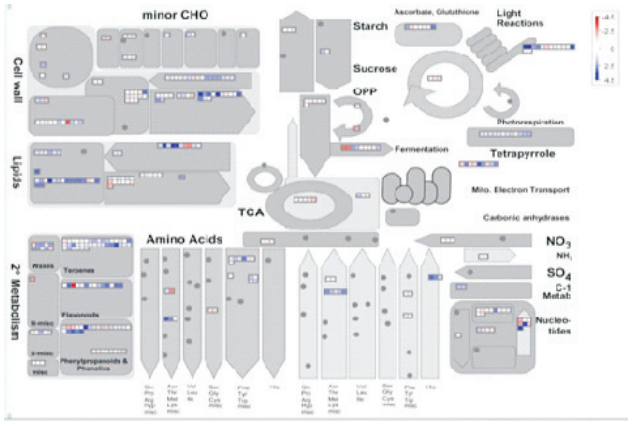


Fig. 12: Metabolic pathways of differentially expressed genes in Kufri Surya exposed at 24 ^{0}C. Blue colour indicates up-regulated genes and red colour indicates down-regulated genes

Molecular characterization of somatic hybrids *Solanum tuberosum* (+)*S. cardiophyllum*

Four somatic hybrids namely Crd-6, Crd-10, Crd-16 and Crd-23 developed via protoplast fusion between *Solanum tuberosum* dihaploid C-13 and *S. cardiophyllum* (PI341233) were confirmed by possessing diagnostic bands from both the parents using 35 RAPD, 24 ISSR and 39 SSR markers. Markers confirmed the hybridity of somatic hybrids namely clones nos. 1 to 4. For example, somatic hybrids possessing bands of both the parents are shown, as revealed by RAPD primer OPAC06, ISSR primer ISSR10 (Fig. 13), SSR marker (STM1104) (Fig. 14) and AFLP primer pair combination (*Eco*RI ACA + *Mse*I CTG) (Fig. 15).

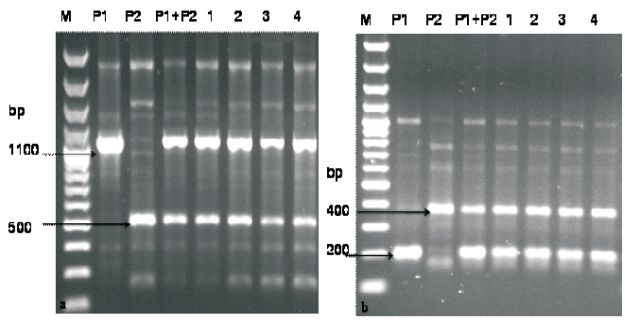


Fig. 13: Potato somatic hybrids C-13 (+) *S. cardiophyllum* confirmed by a) RAPD marker OPAC06, and b) ISSR marker ISSR10 possessing both parental bands. P_1= C-13, P_2 = *S. cardiophyllum*, P_1+P_2 = pooled parental DNA

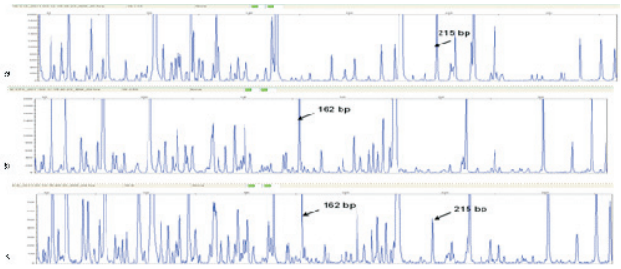


Fig. 15: AFLP marker (EcoRI ACA + MseI CTG) profiling of the potato somatic hybrids of C-13 (+) S. cardiophyllum confirmed hybridity possessing species-specific parental bands. (a) C-13, (b) S. cardiophyllum and (c) somatic hybrid.

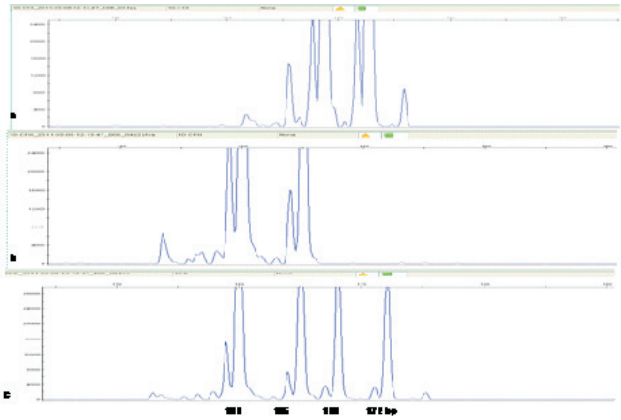


Fig. 14: Potato somatic hybrids C-13 (+) S. cardiophyllum confirmed by SSR marker (STM1104). a) C-13, b) S. cardiophyllum, and c) somatic hybrid

Somatic fusion and regeneration

Interspecific symmetric somatic hybridization was carried out between the androgenic dihaploid C-13 and wild *Solanum* species. In total, 830 somatic fusions were attempted for C-13 (+) *S. cardiophyllum*, C-13 (+) *S. microdontum*, C-13 (+) *S. iopetalum*, C-13 (+) *S. verrucosum*, C-13 (+) *S. lesteri*, C-13 (+) *S. berthaultii*, C-13 (+) *S. polytrichon*, C-13 (+) *S. hougsii*, C-13 (+) *S. polyadenium*, C-13 (+) *S. jamesii*, C-13 (+) *S. huacambense* and C-13 (+) *S. stoloniferum*. Post-fusion products were cultured in VKM liquid medium supplemented with glucose at 20°C in the dark. Following the cell wall development, regenerating cells were cultured on $MS_{13}K$ solid medium at 20°C under a 16-h photoperiod for the calli development.

Cloning of late blight resistance genes from wild potato species

Allelic variants of the late blight resistance gene *Rpi-pta1* (2.5 kb) was isolated from the late blight resistant wild potato species *S. cardiophyllum*. This novel gene was cloned in a binary vector pRI101AN at the restriction sites of *Kpn* I-*Eco*RI. Further, the gene insert was confirmed by colony PCR and restriction digestion and sequenced for analysis of allelic variants (Fig. 16).

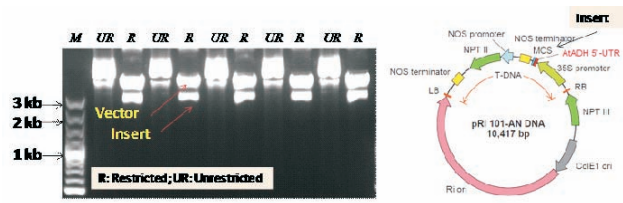


Fig. 16: Confirmation of the gene insert by restriction digestion with enzymes KpnI-EcoRI into the binary vector pRI101-AN.

Monitoring gene expression patterns in somatic hybrids *S. tuberosum* (+) *S. etuberosum* for tuberization by microarray

Gene expression pattern was investigated in the tuber-bearing potato somatic hybrid (E1-3) vs. control non-tuberous wild species *S. etuberosum* (Etb) by microarray. Leaf tissue of E1-3 and Etb grown under controlled environmental conditions were collected at eight tuber developmental stages. A t-test analysis identified a total of 468 genes statistically significant and differentially expressed for E1-3/Etb gene ratio. The GO characterization categorized them in GO-annotated 147 genes of three major functional Sets (# 1-3) and remaining 321 genes (68%) of either unknown function types and/or GO-unannotated. The GO-annotated 147 genes (32%) represented: Set 1)cell structure, transport, carbohydrte and other metabolic process (11% genes); Set 2) photosynthesis, phytohormones and oxidation-reduction process (6% genes); and Set 3) transcription, ion binding and protein-

related process (15% genes). This finding provides an insight into the genes induced in leaf tissues and involved in potato tuberization in somatic hybrid E1-3 (Fig. 17).

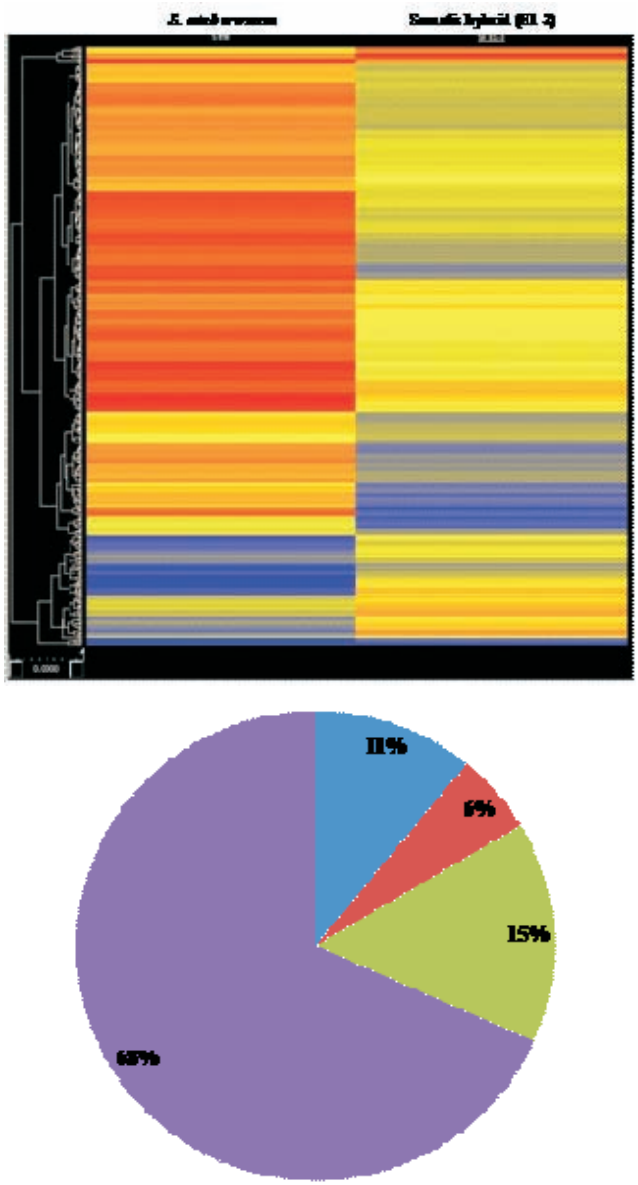


Fig. 17: Heat map (left side) profiles of 468 genes in somatic hybrid vs. *S. etuberosum* and the Pie chart (right side) shows functional categories of genes based on GO annotations.

MicroRNAs (miRNAs) are a class of small regulatory RNAs which play crucial role to modulate gene expression at the post-transcriptional level. Using computational approach of the online tool psRNA Target, eight miRNAs (stu-miR1030, stu-miR1510, stu-miR5213, stu-miR5021, stu-miR3979-5p, stu-miR2673, stu-miR821b and stu-miR395x) belonging to different miRNA families were identified to nine transcripts (pgsc0003 dmt 4000 86622, pgsc0003dmt400088371, pgsc0003dmt400095641, pgsc0003dmt400090864, pgsc0003dmt400067981, pgsc0003dmt400089304, pgsc0003dmt400051014, pgsc0003dmt400066288 and pgsc 0003 dmt 4000 56326) from 150 putative known genes in the interspecific potato somatic hybrid (P-7). These 150 up-regulated genes in P-7 were identified in another microarray experiment for late blight resistance after challenge inoculation with *Phytophthora infestans*. Majority of the target mRNAs are involved in different biological functions, including development and morphology, transcription factors, plant regulators, binding proteins and disease resistance proteins. This study offers a comprehensive analysis of miRNA and their targets in potato somatic hybrid of *Solanum tuberosum* (+) *S. pinnatisectum*.

In-silico analysis of structural properties of PR1 proteinin somatic hybrid

The three-dimensional structure of pathogen related protein from somatic hybrid of *Solanum tuberosum* (+) *S. pinnatisectum* was constructed by using the crystal structure of P14A from *Solanum lycopersicum* (PDB ID: 1CFE) as template using Modeller 9.11. The best model was further assessed by PROCHECK, ProSA, and ERRAT plot in order to analyze the quality and reliability of generated model. The overall quality of computed model from Ramachandran plot revealed that 99.1% amino acid sequence in favoured and allowed regions. The StPR1 forms α-α-α sandwich fold with four α helices (α1-α4) and four stranded α sheets (α1-α4) which forms a tight topology stabilized by hydrogen bonding. The three-dimensional structure of PR from the somatic hybrid has a conserved cleft with two histidine

and two glutamate residues which forms a putative active site in the model protein. This model might be helpful in developing new strategies to develop transgenic plants with increased fungal resistance in the field in response to disease and stress (Fig. 18).

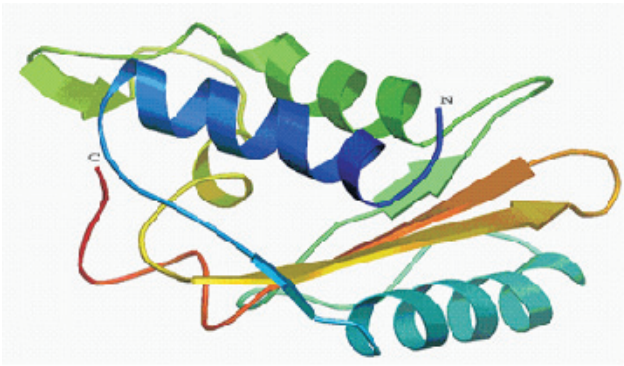


Fig. 18: Overall topology of the theoretical structure of StPR1 showing four a-helices and a-strands along with the N-terminal and C-terminal of the protein

Improvement of somatic hybrids: Somatic hybrids were crossed with potato varieties and resulted progenies were evaluated. Interestingly, high number of seed of BC_1 progenies was recovered when somatic hybrids were used as a male parent than female, and more viable seeds were formed by random mixed pollens from many somatic hybrids compared to individual plant. The BC_1 hybrid clones were selected for the crosses such as K. Garima × mixed pollen (37), K. Sadabahar × mixed pollen (36), K. Jyoti × mixed pollen (35), K. Gaurav × P2 (26), K. Gaurav × P3 (19) and K. Gaurav × P3 (3). In contrary, when somatic hybrids were used as a female parent, despite of good berry formation there was no seed set, except P8 × K. Jyoti, in which 14 clones (BC_1) were selected. The selected clones were retained for further agronomic evaluation in advance stages.

Division of Crop Production

Resource Management Strategies and Information Technology Tools for Potato Based Cropping System

Evaluation of potato based cropping systems

Meghalaya experiences heavy rainfall which varies from 800-5000 mm, a major part (70-90%) of which is received during pre monsoon and monsoon period (April-October). Besides the plenty of rainfall, prevailing other climatic conditions especially temperature of the region is favorable for cultivation of high value crops. However, the average cropping intensity in this landlocked region is stagnated at 125%, still below all India average (138%). To meet the basic food needs of the expanding human population, a productive sustainable agricultural system become, a major priority. The conventional potato based cropping system *viz.*, potato–french bean/cabbage/cauliflower/carrot/radish/maize has been developed for this region but system has several disadvantage e.g. chances of subsequent crop failure is more common either due to frost or terminal drought at the time of maturity due to early cessation of rain. Although radish is a short duration crop but both potato and radish are exhaustive crops having shallow root system and hence are not advisable to be grown in rotation. Field preparation in the month of July after harvesting of potato is very difficult due to heavy rainfall hence the planting of subsequent crops is often delayed. In such situations, the short or medium duration crops are to be selected for successful cultivation in this region. Many subtropical vegetables can be fitted in sequence as subsequent crops and needs to be evaluated for higher profitability as well as productivity of soil by suppressing the weed growth.

Eleven cropping sequences (Potato-Capsicum/soybean/broccoli/lettuce/chilli/turnip/knolkhol/coriandar/cucumber/beet/onion) were evaluated during summer and autumn season of 2014 at CPRS, Shillong. The results showed that the potato yield was similar (22.4 to 24.3 t/ha) in all the sequences during summer season while turnip (23.5 t/ha) and knol-khol (23.0 t/ha) were recorded significantly high productivity followed by onion (11.3 t/ha) over other crops in the subsequent autumn season.

At Patna, eight potatoes based cropping systems were evaluated for their productivity, resource use efficiency and profitability. The second year results showed that the average yield of early planted potato crop was lower than the main season crop. In the early planted crop, Kufri Ashok outyielded Kufri Surya by 17.5 per cent. The higher yield in variety Kufri Ashok was associated with better and early emergence even under early planting condition, more number of stems/m^2 and more number of tubers per unit area.

In the main season potato crop, the average yield of Kufri Khyati and Kufri Pukhraj were at par and in the range of 236-240 q/ha.

Potato-Bottle gourd–Rice was most productive system in terms of Rice equivalent yield (REY) followed by Potato-Onion-Rice, early potato – oat - cowpea – maize and Early potato –Wheat-Green gram-Maize. Though Potato (Kufri Pukhraj)-onion- Rice (SRI) and Potato (Kufri Pukhraj)-cowpea- Rice (basmati puddled) are three crops sequences, even then they out yielded the four crops sequences Early potato (Kufri Ashok)- late sown wheat-green gram-maize (cob) and Early potato (Kufri Surya)- late potato (Kufri Khyati)-maize (grain)-green manuring (Sesbania).

Early Potato- late sown gram-Maize- Cowpea cropping system used the land for longer duration

and had land use efficiency (LUE) of 96.4% and was followed by early potato- late sown wheat-green gram-maize and early potato - oat- cowpea-maize cropping system. The variation in land use efficiency was due to the variation in duration of crops in the cropping system. Potato-onion-rice cropping systems registered the highest production efficiency (PE) of 98.55 Kg REY/ha/day. This system was closely followed by Potato-Bottle gourd -Rice sequence and Potato-Green gram-Rice-system with corresponding values of 90.56 and 83.08 kg REY/ha/day. In monetary terms (ME), Potato-Bottle gourd- Rice cropping system registered highest production efficiency (Rs. 548.73/ha/day) This system was closely followed by Potato-onion-Rice and early potato - oat- cowpea- maize system with corresponding values of Rs.527.8 /ha /day and Rs. 466.58 /ha/day respectively.

The yield of potato crop during third year was significantly influenced by cropping system and preceding crop. The tuber yield of potato was significantly higher in the system where leguminous crop was taken and in the main season potato yield was higher where rice was transplanted using SRI method (Fig. 1) which may be due to the increase in the bulk density of the plots where puddling was done (Fig. 2) and in these plots the smaller grade tubers accounted for more than 45% of the total tuber population thus resulting in lower yield.

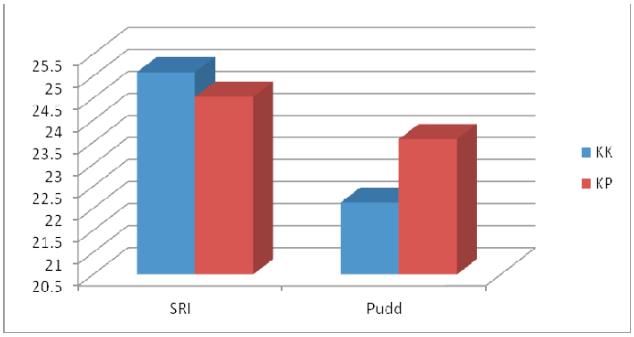


Fig. 1: Tuber yield as influenced by rice establishment technique

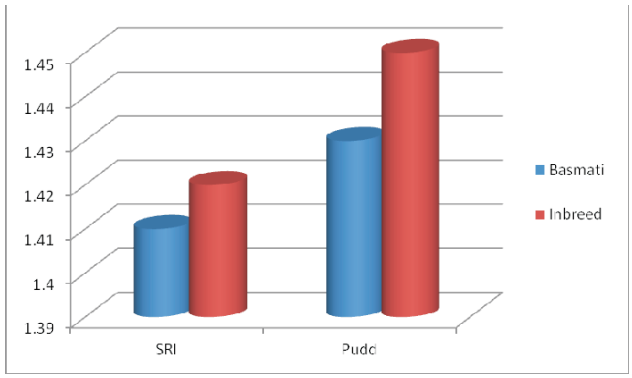


Fig. 2: Bulk Density (g/cc) of soil preceding potato planting

Effect of mulching on plant growth, hydro-thermal regime and the yield of potato

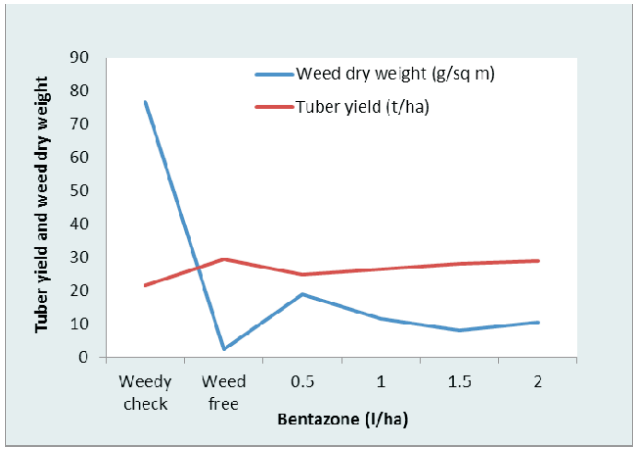
The effect of various mulch materials (silver polyethylene mulch, black polyethylene mulch, hay mulch, transparent polyethylene mulch and FYM as mulch) on plant growth, hydro-thermal regime and the yield of potato was evaluated at Shimla. Maximum soil temperature was 0.6 -2.4 °C higher than air temperature under un-mulched control and all polyethylene mulches. However, under hay and FYM mulch, it was lower (2.6-3.0 °C) than the air temperature. Among the mulch treatments maximum temperature was higher by 1.0- 1.8 °C under all polyethylene mulches and lower under hay and FYM mulch (3.2 & 3.6 °C, respectively), than the un-mulched control. Maximum increase in temperature was registered under black polyethylene mulch. Minimum soil temperature was higher by 1.5 -3.4 °C over air temperature (14.8 °C) in all the mulched plots.

Black polyethylene mulch conserved 6.2% more moisture as compared to the un-mulched control. It was followed by transparent polyethylene mulch (5.8%), silver polyethylene mulch (5.7%), FYM mulch (4.4%) and hay mulch (3.1%). Significantly higher yield as compared to un-mulched treatment was recorded under all the mulch treatments. All the mulch treatments were at par in potato yield. Among the mulch

treatments, maximum yield was recorded under FYM mulch (18.5 t/ha) followed by black polyethylene mulch (18 t/ha) and the least yield was observed under un-mulched control (13.7 t/ha).

Development of weed management strategies for potato crop

Weed occurrence in potato crop can cause yield losses up to 80% as they compete for common resources like moisture, nutrients, space and light. These plants also act as alternate host to several pests and diseases. Therefore, weed management below critical limits is very important part of potato crop management for getting higher productivity. Chemical weed control is one of the most important components of integrated weed management, where several herbicides are available in pre-plant incorporation and pre-emergence categories. These are very effective in killing weeds during their initial germination phase. However many a times, farmers are unable to foresee the potential yield losses due to weeds and when these unwanted plants come up early, they need post emergence herbicides for their control. There is very limited option of chemicals like paraquat and propanil for post-emergence application. That is why review for new potential molecules was done and field evaluation of Propaquizafop, Bentazone and Sulfosulfuron was carried out since. Propaquizafop was not found effective in controlling monocot and dicot weeds in potato crop. However, at Modipuram, Bentazone 48% (1.5 l/ha) was very effective in controlling dicot weeds and decreased total weed dry weight by 89.5% over weedy check remaining comparable to weed free conditions (Fig. 3). Total tuber yield (28.0 t/ha) was at par with weed free treatment (29.6 t/ha). Performance of Bentazone was also consistent at Gwalior (Fig. 3) and herbicide (1 l/ha) reduced total weed dry weight by 87.0% over weedy check which was



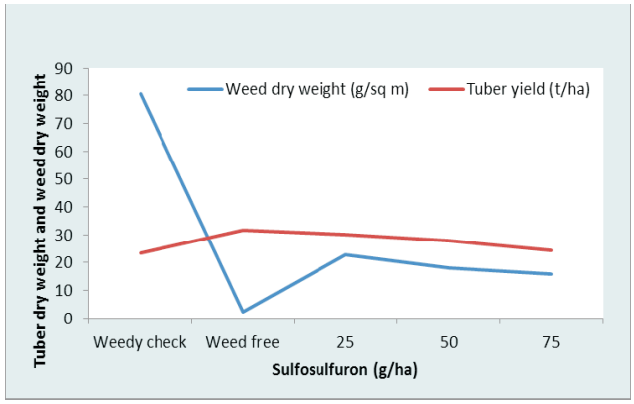


Fig. 3: Influence of Bentazone and Sulfosulfuron on mean tuber yield and weed dry weight at Modipuram

statistically at par with weed free plots and was reflected in total tuber number and yield. Sulfosulfuron 75% WG was also effective in controlling weeds particularly monocots at Modipuram and not much phyto-toxicity was observed in cv. Kufri Garima. Sulfosulfuron (25 g/ha) reduced total weed dry weight by 71.7%. Total tuber productivity (30 t/ha) was also similar to weed free treatment (31.8 t/ha). The herbicide effectively controlled weeds at Gwalior, but varieties like Kufri Khyati, Kufri Jyoti, Kufri Surya and Kufri Chandramukhi exhibited phytotoxic symptoms (Fig. 4), which had adverse effect on potato growth ultimately leading to significant tuber yield reduction. Thus Bentazone 48% (1.0-1.5 l/ha) is promising post-emergence herbicide and needs to be further evaluated in different potato growing regions.

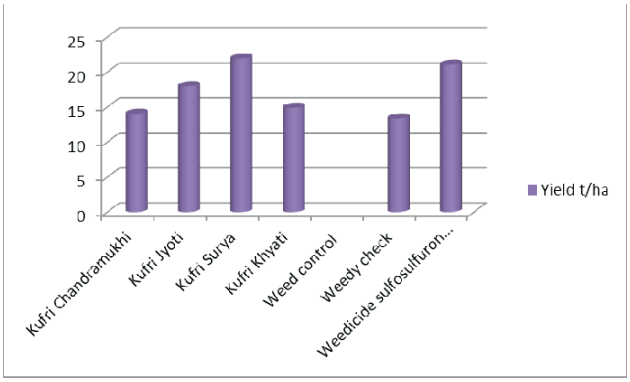


Fig. 4: Influence of Sulfosulfuron on mean tuber yield in different potato varieties at Gwalior

Efficient use of Metribuzin herbicide in rainfed potato

Due to heavy rainfall, weed poses a serious problem for cultivation of potato in Meghalaya hills. The planting time of potato starts from second fort night of February and continues up to mid March and at that time the field is almost dry and crop emergence depends on the rains. Hence, the pre–emergence weed control is not appropriate under dry weather conditions. Further, delayed planting of potato after the onset of rains is good for pre–emergence application of metribuzin but the crop succumbs to late blight which is a very dreaded disease in the region. Weed emergence is directly related to the intensity of rainfall. Different flushes of weeds come out at different times depending upon the rains. Therefore, post–emergence directed (because of wide spacing between two row) spray of metribuzin may be a possibility to control the weeds after emergence of the crop in the timely planted potato crop in rainfed hilly region of Meghalaya. Hence, the different doses of Metribuzin and different datesof application was studied for finding appropriate timing of metribuzin application in potato under rainfed condition of Meghalaya hills.

The results showed that the potato yield did not differ significantly due to different doses of Metribuzin (0.5-1.0 kg/ha) while the highest increase in yield in potato productivity was obtained with application of Metribuzin after 14 days of crop emergence.

Nutrient and Water Management in Potato

Nutrients and water are two crop production inputs which are becoming scarce and precious day-by-day. Besides, serious environmental concerns have made it essential to manage these two key inputs most efficiently. To mitigate the declining factor productivity besides maintaining the land and environmental quality, both these resources need their judicious use. Utilization of varietal and genetic variability with respect to their efficiency to nutrients and water use along with development of strong management strategies for specific location and pocket are the main aims of this programme. Important objectives of this programme include exploitation of genetic variability of germplasm for better efficiency of resources, developing nutrient and water management strategy for major potato growing pockets based on site specific nutrient management and geo-reference mapping of resources and use of micro-irrigation techniques through drip and fertigation for improving efficiency.

Optimizing N requirement using chlorophyll content index

Time and quantity of N fertilizer to be top dressed is the most important issue in nutrient management of potato crop. Owing to its bearing not only on productivity, efficiency and cost of cultivation but also due to large scale environmental concerns, efforts are being made worldwide to fine tune the timing and quantity of N fertilizer application so that there is minimum loss to the environment without compromising on productivity level. In this line, attempts were made to manage nitrogen on real time basis based on chlorophyll content of potato crop leaves. The experiments were conducted at Shimla, Patna and Gwalior.

At Shimla, an experiment was initiated to schedule the nitrogen application in potato on the basis of RCI (Relative Chlorophyll index= CCI in a plot/CCI in control X 100), as affected by the nitrogen source. The RCI was worked out at every 2-3 days interval by comparing CCI (Chlorophyll content index) value of treatment plot with control plot (150 kg N/ha basal and 100 kg N/ha at earthing up) using hand held chlorophyll meter. The basal dose of 100 kg N/ha and 20 kg N/ha at earthing up was applied to all plots uniformly, irrespective of N source treatment, as CAN. The additional dose of 25 kg N/ha was applied either at 90 or 95% RCI value from different sources (CAN, Urea and Neem cake coated urea (NCCU)). All the treatments produced statistically similar tuber yields (14.6-15.6 t/ha). Results indicated that when urea or CAN were used as N source, 2nd and 3rd additional application of 25 kg N/ha was needed at 90 and 95% RCI, respectively. However, with NCCU as a source of N, only one application of 25 kg N/ha was required after earthing up. Thus, the use of NCCU resulted in a saving of 25 to 50 kg N/ha over urea or CAN.

At Patna three varieties namely, Kufri Khyati, Kufri Jyoti and Kufri Pukhraj were evaluated for fine tuning of N top dressing with the help of chlorophyll contents index using SPAD reading. Treatments included one over-fertilized reference

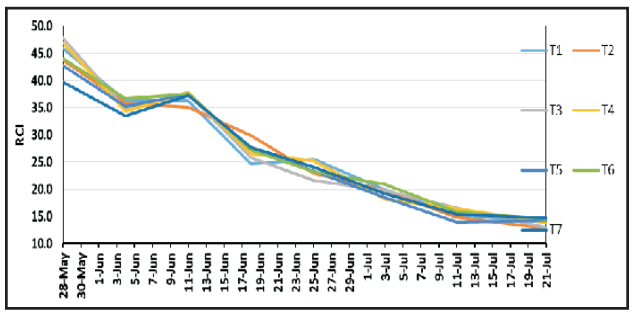


Fig. 1: Change in CCI values with time under different treatements

T1- 25 kg N at 90% RCI as CAN, T2- 25 kg N at 95% RCI as CAN, T3 - 25 kg N at 90% RCI as Urea, T4- 25 kg N at 95% RCI as Urea, T5 - 25 kg N at 90% RCI as NCCU, T6- 25 kg N at 95% RCI as NCCU, T7- control (150 kg N at planting and 100 kg at earthing up)

plot (150% of recommended N), one recommended fertilized plot and others plots having top dressing at variable rate based on SPAD reading in comparison to over-fertilized reference plot. In treatment plots after basal application of 50% of recommended N and 20% N application at earthing up, 10 or 20% of recommended N was top dressed at 80 or 90% of SPAD value as compared to over fertilized plot. SPAD values were recorded every 3-5 days interval and the value of treatments plots were compared with that of over fertilized reference plot.

Among three cultivars the SPAD value of Kufri Pukhraj was always the highest followed by Kufri Khyati and Kufri Jyoti (Fig. 2). However, in potato tuber yield of Kufri Khyati and Kufri Pukhraj gave

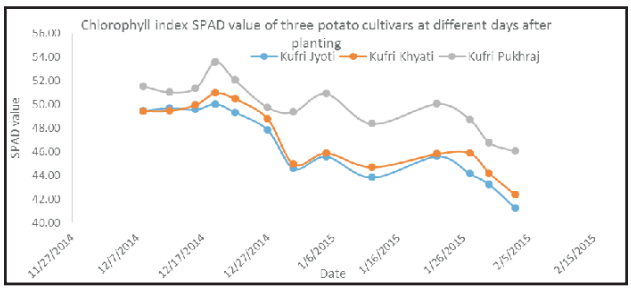


Fig. 2: Chlorophyll index (SPAD value) of three cultivars

better response and yielded significantly better than Kufri Jyoti. The SPAD value of over fertilized plots in all the three varieties remain the highest almost throughout the season. However, there were fluctuations of the value as and when either N was top dressed or irrigation was given. In general, it tends to decrease with advancing of the season. In general, where N was top dressed at 90% of the reference SPAD value showed higher chlorophyll index as compared to the plot which were fertilized at 80% of the reference SPAD value. The treatment where 20% recommended N was applied at 90% of the reference SPAD value (T_6) gave similar yield as compared to the recommended N level and was significantly better than the treatments where N was top dressed at 80% of the reference SPAD value (Fig. 3) The former's yield level was also at par with over fertilized plots. Among varieties, result indicated that there is possibility to decrease the amount of N to be top dressed by increasing the number of splits and applying N based on SPAD value in comparison to over fertilized reference plot without compromising on yield.

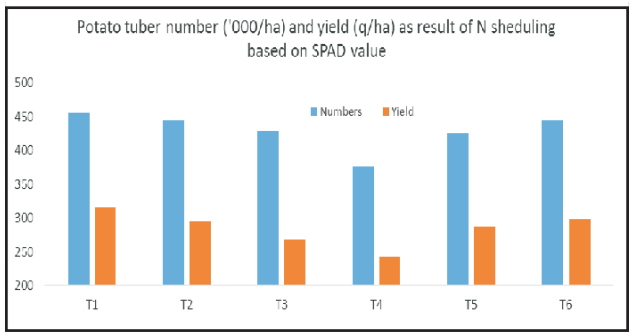


Fig. 3: Potato tuber numbers and yield as result of N scheduling

T_1 : 150% of recommended N half at planting and rest at earthing up; T_2 : Recommended N half at planting and rest at earthing up; T_3: 50% of recommended N at planting, 20% N at earthing up and 10% N at 80% SPAD value of T1; T_4 : 50% of recommended N at planting, 20% N at earthing up and 20% N at 80% SPAD value of T1; T_5 : 50% of recommended N at planting, 20% N at earthing up and 10% N at 90% SPAD value of T1 & T_6 : 50% of recommended N at planting, 20% N at earthing up and 20% N at 90% SPAD value of T1.

Similar experiment was also conducted at Gwalior with two cultivars Kufri Jyoti and Kufri Chandramukhi. 20% of recommended N applied at 95% of the reference SPAD value proved to be the best treatment where the yield level was similar with that of the recommended N, which was also similar with the treatment, where 10% of recommended N was applied at 95% of the reference SPAD value. The treatments where N was top dressed at 90% of the reference SPAD value yielded most poorly.

At Gwalior, highest tuber yield of both the cultivars Kufri Jyoti and Kufri Chandramukhi was recorded with 100% RDF (N) over other treatments including 150% N. Splitting of N could not gave any significant effect on tuber yield which might be due to high initial fertility of soil. (Fig. 4).

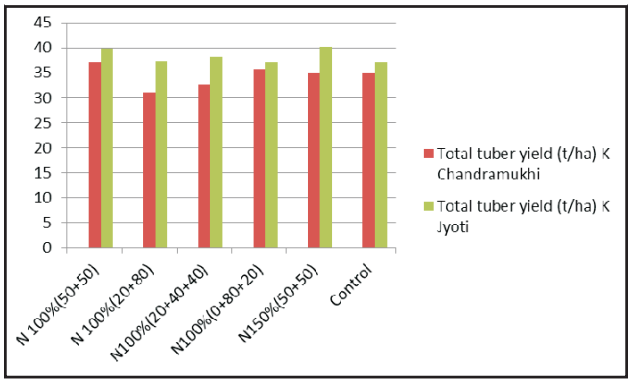


Fig. 4. Tuber yield as result of N scheduling at Gwalior

Scheduling of nitrogen fertilization through foliar spray of urea in potato

A field experiment was conducted at Shillong, for scheduling of nitrogen fertilization through foliar spray of urea in potato crop. Application of 60 kg N/ha as basal followed by four foliar spray recorded similar productivity to the application of the highest dose of nitrogen i.e. 150 kg N/ha (50 % as basal + 50% as earthing up).

Development of site specific nutrient management

With an objective to developed nutrient management strategy very specific to a particular site taking account of both, the intricate soil system and agro climatic condition a "site specific nutrient management" experiment with over fertilized reference (OFR) and omission plots using variety Kufri Khyati was conducted at Modipuram, Meerut. The maximum yield reduction was in N omission plots (14.37 t/ha) as compared to OFR plots. The K omission plots was second to N omission plots with yield reduction of 3.55 t/ha, which was followed by Zn (3.22 t/ha), and S (2.96 t/ha). The difference of yield in N omission plots and control plot was only 5.11 t/ha which indicated that the N was the most limiting nutrient element in potato productivity in the region, whereas, P and Mg appeared to be least limiting as the yield difference in these two element omitted plots showed least yield reduction as compared to OFR.

An experiment on site specific nutrient management was also conducted at Gwalior to assess NPK requirement of potato in that region (Fig. 5).

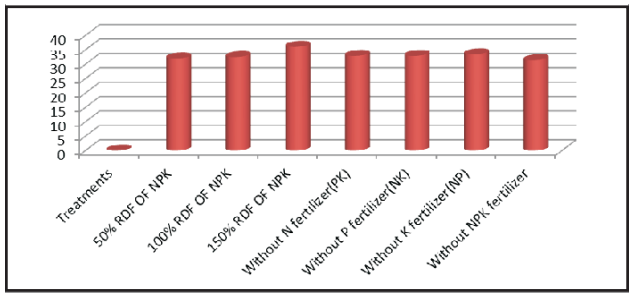


Fig. 5. Potato tuber yield (t/ha) in omission plot experiments at Gwalior

Coating of urea to increase nitrogen use efficiency

Nitrogenous fertilizer happens to be one of the most costly nutrient input and at the same time most mobile nutrient element in soil leading to its loss from the root zone in very short period. There have been many attempts to increase the efficiency of N fertilizer by increasing its longevity in soil with help of some amendments. With these objectives experiments were planned at Gwalior and Patna. At Gwalior, highest total tuber yield was recorded with 2% Neem cake coated urea (75% NPK) which was followed by 2% 2mm sieved FYM coated (100% RDF). Hence to increase efficiency of applied N and save N (25%), locally coating of urea with neem cake powder might be one of the options. Coating with 2 mm sieved FYM (100% RDF) also increased tuber yield (Fig. 6).

At Patna, potato tuber yields, neither at recommended N level nor at 75% of recommended N level could be improved significantly by different amendments (Fig. 7). However, the yield level at recommended N was higher as compared to that 75% of recommended N with all amendments and on contrary, agronomic efficiency was in general higher at 75% of recommended N with different coating materials.

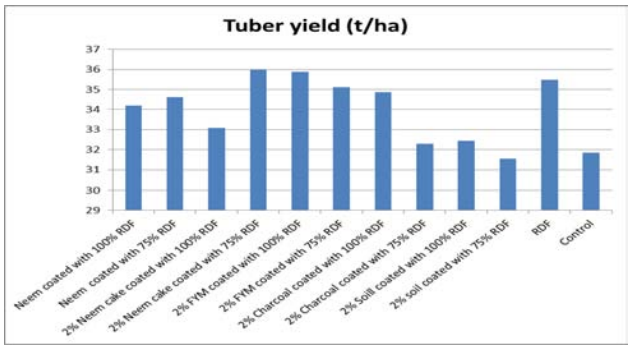


Fig. 6: Potato tuber yield as influenced by coating of urea

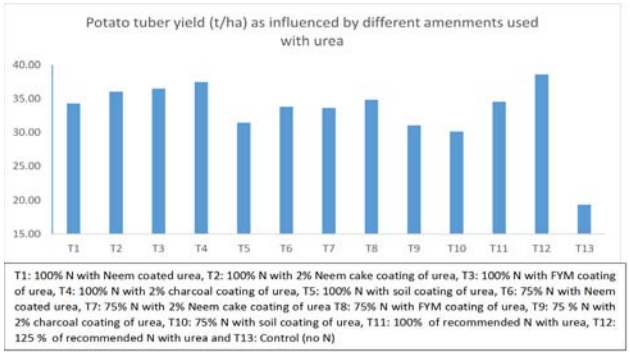


Fig. 7: Potato tuber yield as influenced by coating of urea

Develop/identify nutrients and water use efficient potato cultivars/hybrids.

Develop nutrients and water efficient cultivars for northern plains.

Out of 100 genotypes/hybrids evaluated during 5 consecutive years *i.e.* 2009-10, 2010-11, 2011-12, 2012-13 & 2013-14 the six promising genotypes/hybrids *viz.* J 93-58, J 92-164, 83-P-142, JN-2207, MS/82-279, J 92-167 gave higher/equal potato yield in comparison to popular *var.* Kufri Bahar and Kufri Pukhraj at all soil moisture levels. During 2014-15, the genotypes *viz.* JN-2207, J.92-167 & 83-P-142 produced maximum yield at higher moisture regime, but, at low soil moisture regime the genotypes *i.e.* JN-2207, J.92-167 & J.93-58 gave higher yield against Kufri Pukhraj. These six hybrids/genotypes were also found promising for higher water use efficiency (WUE) at all soil moisture regimes.

Screening for N use efficiency: A field trial was conducted at Shillong for identification of nitrogen efficient potato cultivars. Kufri Jyoti was found the most nitrogen efficient among tested potato cultivars followed by Kufri Girdhari, Kufri Giriraj, Kufri Megha and Kufri Himalini in the acidic soils of NEH region.

Root parameters of different Potato cultivars at varying NO_3^- level in solution culture and in sand culture

In a hydroponics (solution culture) studies at Patna three cultivars namely Kufri Jyoti, Kufri Gaurav and Kufri Pukhraj responded differently to decreasing NO_3^-. Root parameter such as fresh root weight and root volume in general decreased with decreasing NO_3^- level. The cultivar Kufri Gaurav had highest value followed by Kufri Pukhraj and Kufri Jyoti. When root fresh weight tend to decrease linearly with decreasing NO_3^- concentration efficient varieties tried to maintain their surface area by decreasing diameter and increasing root length (Fig. 8 & 9). In sand culture efficient cultivars like Kufri Gaurav, Kufri Pukhraj

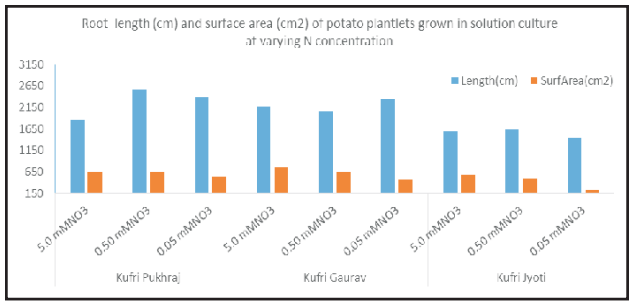


Fig. 8: Root length and surface area in solution culture

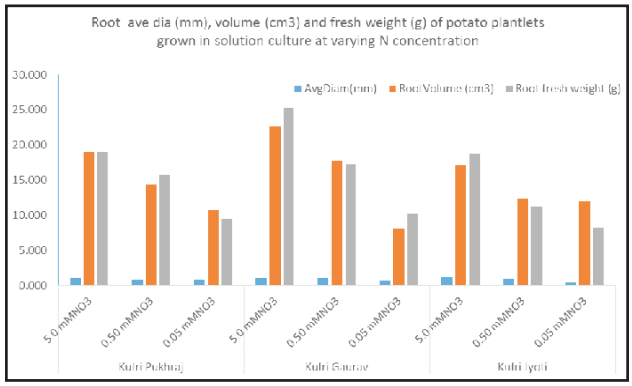


Fig. 9: Root average dia, volume and fresh weight in solution culture

and Kufri Lalima had higher root volume, root length and surface area as compared to cultivars like Kufri Kanchan and Kufri Jyoti.

Improving water and nutrient use efficiency through micro-irrigation

Effect of fertigation sources and poly-mulch on potato under drip irrigation

Use of micro-irrigation in high input crop potato is inevitable not only for improving water use efficiency but also for improving nutrient efficiency through fertigation. Micro irrigation and mulch based water management experiments were conducted at Shimla and Modipuram with objectives to conserve soil moisture and improve nutrient and water use efficiency. Field experiment at Modipuram under drip irrigation comprised of three fertigation sources (*viz*. ¼ NPK applied as basal at planting & ¾ NPK as drip-fertigation through liquid fertilizers, F_1; 1/3 NPK applied as basal at planting & 2/3 NPK as drip-fertigation through water soluble fertilizers, F_2 and ½ N along with full P & K applied as basal at planting and ½ N as top dressing, F_3) as main plots, and the four mulch (*i.e.* No mulch, M_0; paddy straw mulch, M_1; black polythene mulch, M_2 & silver polythene mulch, M_3) as sub plots treatments. Fertigation sources and mulching treatments significantly affected the total yield and tuber numbers as well as graded tuber yields. The application of ¼ NPK as basal + ¾ through drip-fertigation in eight equal splits (started from crop emergence to 45 days after planting) through liquid fertilizers (LF) gave maximum tuber yield (47.1 t/ha) followed by 1/3 NPK as basal + 2/3 through drip-fertigation in six equal splits through water soluble fertilizers (WSF), which produced 38.3 t tubers/ha) against soil application of ½ N with full P & K as basal at the time of planting + ½ N at earthing-up (35.6 t/ha). In case of mulching, the potato yields were significantly higher under paddy straw mulch followed by black polythene mulch (25µ size) as compared to without mulch under drip irrigation, The soil moisture content was 10-12% higher in the paddy straw mulch and polythene mulch treatments during entire crop growth period as compared to no mulch treatment. The nutrients use efficiency (NUE) was also slightly higher under the crop raised with liquid fertilizers followed by water soluble fertilizers applied through drip fertigation.

Role of different mulching material and surface conditions on soil moisture conserving, moderating soil temperature and enhancing potato yield

In order to conserve soil moisture and moderate soil thermal regime in potato crop grown under rainfed hill condition experiment with various mulch materials (silver polyethylene mulch, black polyethylene mulch, hay mulch, transparent polyethylene mulch and FYM as mulch) were conducted using cultivar Kufri Jyoti. Maximum soil temperature was higher (0.6 -2.4 °C) under un-mulched control and all polyethylene mulches than air temperature (25.4 °C). However, under hay and FYM mulch it was lower (2.6-3.0 °C) than the air temperature. Minimum soil temperature was elevated (by 1.5 -3.4 °C) from air temperature (14.8 °C) in all the mulched plots. Black polyethylene mulch conserved 6.2% more moisture as compared to the un-mulched control. It was followed by transparent polyethylene mulch (5.8%), silver polyethylene mulch (5.7%), FYM mulch (4.4%) and hay mulch (3.1%). Potato yield was greatly influenced by the application of various mulch treatments. All mulch treatment except transparent polyethylene significantly increased the yield as compared to un-mulched treatment and maximum yield was recorded under FYM mulch (18.5 t/ha) followed by black polyethylene mulch (18 t/ha) and the least yield was observed under un-mulched control (13.7 t/ha).

Nutrient Dynamics Studies on Long Term Manurial/Fertilizer Application and Organic Farming in Potato Production

Continuous cropping on a piece of land, year after year, without much change in cropping system and management practices has its own ramification on soil health and environmental quality. Soil fertility and soil quality are of utmost importance for the continuous supply of healthy food. Thus long-term research is important to provide ecological insights and is crucial for the improved management of resources. Keeping these in view, a long term manurial and fertilizer experiment was started at the CPRI Campus, Modipuram during 2005-06 to formulate nutrition strategy for potato based cropping systems and to study the effect of long term application of organic manure and inorganic fertilizers on crop productivity, soil fertility, physico- chemical properties of soil, soil micro fauna, and pest and disease dynamics for sustaining system productivity. Work is going on three potato based cropping systems, Potato- Wheat- Paddy, Potato-Onion- Maize and Potato- *Moong* bean-Groundnut with seven source of nutrients i.e. absolute control, 100% NPK (inorganic), 100% NPK (organic), 50% NPK (inorganic)+ 50% NPK (organic), 100% NPK (inorganic)+ secondary & micro nutrients, 100% NPK (inorganic)+ crop residue and 100% NPK (organic)+ crop residue.

Long term manurial and fertilizer experiment on potato based cropping systems

Effect of organic manure, crop residue and inorganic fertilizer application on sustainable crop production was studied in three potato based cropping systems. Highest mean system productivity was achieved in Maize-Potato-Onion (51.4 t/ha) sequence followed by Rice-Potato-Wheat (47.5 t/ha) and Groundnut- Potato-*Moong* bean system (40.8 t/ha). Maize-Potato-Onion had 7.6 and 20.6% higher system productivity over Rice-Potato-Wheat and Groundnut- Potato-*Moong* bean system, respectively (Fig. 1). Inorganic macro, secondary and micro-nutrients recorded highest system productivity in Maize-Potato-Onion (66.2 t/ha) and Groundnut- Potato-*Moong* bean (53.2 t/ha) system over all other treatments. Rice-Potato-Wheat system also observed distinctly highest mean system productivity (60.3 t/ha) with this treatment over other combinations except for inorganic + crop residue (58.5 t/ha) treatment. Organic nutrition recorded significantly lower system productivity in all three crop sequences. Yield decline of 20.7, 20.6 and 17.3% was observed in Rice-Potato-Wheat, Maize-Potato-Onion and Groundnut- Potato-*Moong* bean cropping system, respectively. Productivity of Onion and Maize was at par in both organic and inorganic treatments. Rice (14.9%) and Wheat (46.1%) had drastic reduction in their respective economic yield. *Moong* bean (33.3%) and Groundnut (153.1%) exhibited improvement in their yields under organic nutrient management in this year.

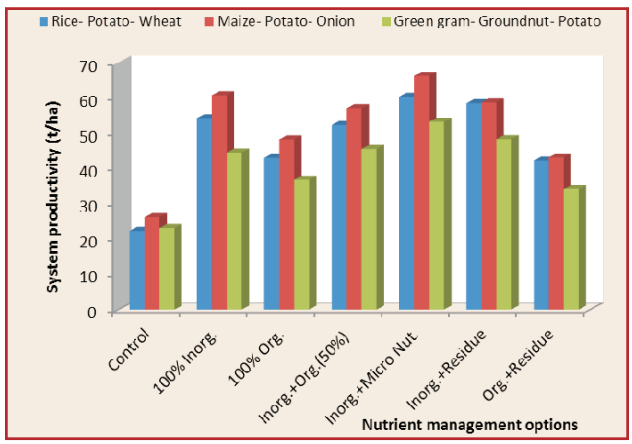


Fig. 1: System productivity of different cropping systems as affected by different nutrient management options

Potato crop recorded higher tuber productivity (30.9- 32.7 t/ha) with inorganic source and secondary & micro nutrients in all crop sequences, which was comparable to inorganic + crop residue incorporation. Significant decline in tuber yields was observed with organic nutrition (18.6- 40.0%) in this crop in different systems over inorganic plots.

Organic farming in Potato Production

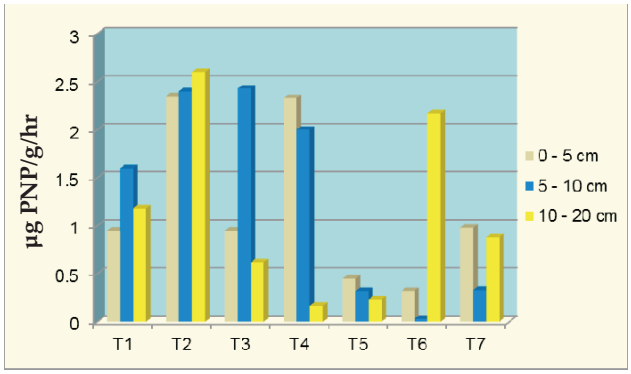
Main focus has remained on developing production technology for organic farming and supply of sufficient quantity of nitrogen for maintaining tuber yields. Complete replacement of inorganic nutrition with vermi-compost exhibited deficit in tuber productivity (28.7-30.0%). Yields were not affected distinctly upto 50% replacement of inorganic nutrients with vermi-compost. Varieties like Kufri Anand and Kufri Chipsona-1 recorded comparable productivity with 50% inorganic- 50% vermi-compost and 100% inorganic fertilizers. Demonstration on organic farming has been started during this year at the campus. Conversion of land into organic farming (1000 m^2) has been initiated and same area has been marked under inorganic cultivation for comparison purpose.

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

Estimation of impact of organic and inorganic sources of nutrients on soil physical, chemical and biological properties exhibit significant variations in soil bio-chemical properties after eight crop cycles. Incorporation of crop residue as well as use of organic manure, with or without fertilizers improved organic carbon content of soil, microbial biomass carbon, dehydrogenase activity. Carbon sequestration rate was higher in crop residue incorporation plots as compared to inorganic treatment alone. Among cropping system, Potato-Wheat- Rice and Potato- Onion- Maize showed higher Carbon stocks in soil than Potato-*Moong* bean- Groundnut sequence. Integrated application of organic amendments (vermi-compost, crop residue) along with chemical fertilizer could be the best management practices for enhancing carbon sequestration in soil and sustainable crop productivity. Alkaline phosphatase activity increased significantly with 100% inorganic NPK or 50% inorganic NPK+ 50% organic NPK in Potato- Wheat- Rice and Potato-*Moong* bean- Groundnut crop sequence (Fig. 2 and 3). While in Potato- Onion- Maize system, alkaline phosphatase activity was greater in 100% organic NPK and 100% organic NPK+ crop residue treatments (Fig. 4).

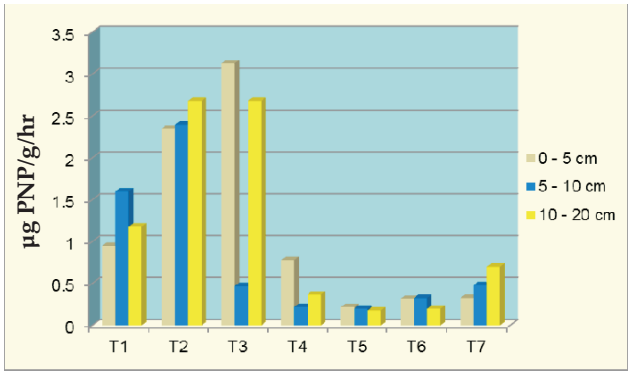
Pest and disease dynamics

In all three systems, Potato- Wheat- Paddy, Potato- Onion- Maize and Potato- *Moong* bean-Groundnut, incidence of apical leaf curl (16.2, 7.4 & 11.6%) and hopper burn (8.7, 5.8 & 1.8%) in potato crop were significantly lower with 100% organic nutrition as compared to 100% inorganic nutrition for apical leaf curl (18.0, 8.6 & 14.2%) and hopper burn (10.5, 7.8 & 3.2%), respectively. Population trend of thrips on groundnut, stem borer damage in maize and leaf folder damage in rice did not show any significant differences among various treatments. However, less thrips population (3.6-4.3/plant) was recorded in 100% organic treatment as compared to 100% inorganic (5.8-6.7/plant). Similarly, leaf folder incidence was lower in 100% organic treatment (0.3-1.84%) over 100% inorganic plots (2.37-3.45%) in rice crop. While high incidence of stem borer was also recorded in maize in 100% inorganic nutrition (2.84%) as compared to control (1.67%) or 100% organic nutrition (0.72%). Incidence of whitefly was lower in *Moong* bean during the crop season. Groundnut crop has fungal disease problem as there was severe attack by fungus *Aspergillus* sp. in all the treatments during rainy season.



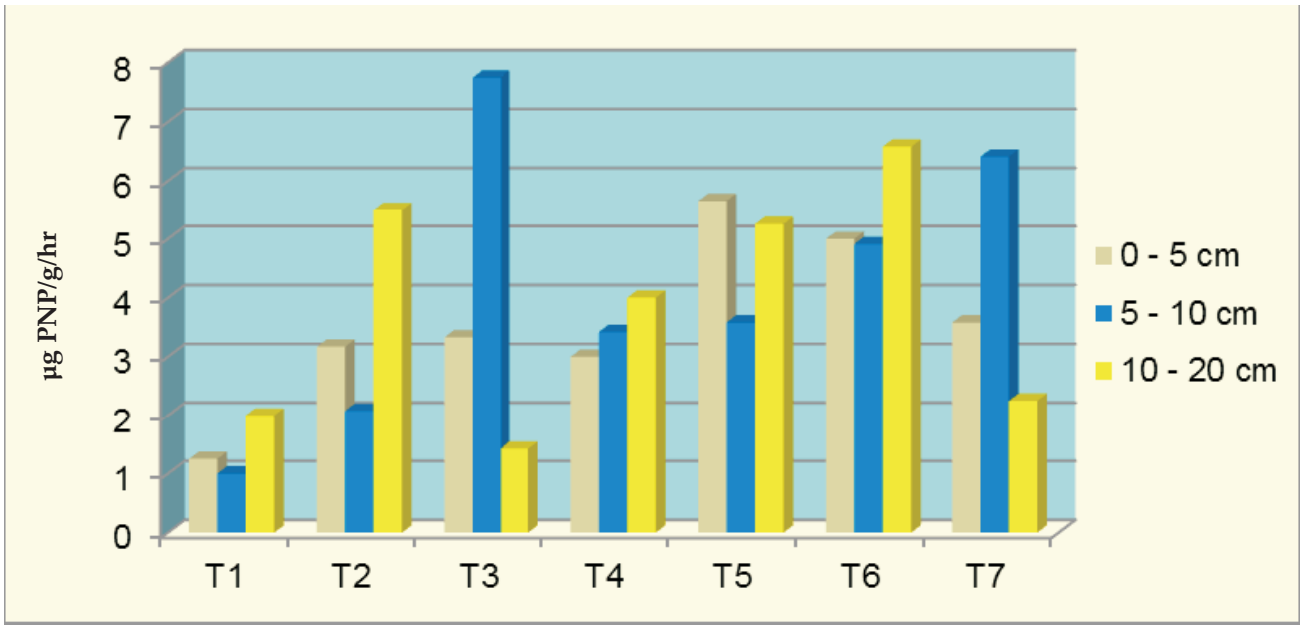
Treatment

Fig. 2: Alkaline phosphatase activity in Potato– Wheat– Paddy system



Treatment

Fig. 3: Alkaline phosphatase activity in Potato– *Moong* bean– Groundnut system



Treatment

Fig. 4: Alkaline phosphatase activity in Potato– Onion– Maize system

T_1: Absolute control, T_2: 100% NPK (Inorganic), T_3: 100% NPK (Organic), T_4: 50% NPK (Inorganic) + 50% NPK (Organic), T_5: 100% NPK (Inorganic) + Secondary nutrients, T_6: 100% NPK (Inorganic)+ Crop Residue and T_7: 100% NPK (Organic)+ Crop Residue.

Climate Change Impact and Adaptation Strategies for Potato Crop

The agricultural sector represents 35% of India's Gross National Product (GNP) and as such plays a crucial role in the country's development. Climate is the primary determinant of agricultural productivity. Concern over the potential effects of long-term climatic change on agriculture has inspired a focus on research during the recent past. Potato is one of the important crop concerning the livelihood of lakhs of farmers in India. In Indo-Gangetic plains, which accounts for about 80% of potato acreage in the country, the potato season which extends from October/ November to January/ February would be warmer by about 0.8 – 1.2 °C during 2010 – 2039 and by 1.5 – 3.2 °C and 2.2 – 5.4 °C by 2040- 2069 and 2070- 2099, respectively. The current level of CO_2 (400 ppm) in the atmosphere, the main GHG, is 35.4% higher than the pre-industrial level and is rising sharply and predicted to be 543 and 789 ppm in year 2050 and 2080, respectively. In the light of these expected climatic changes, there is a need to assess the potato production scenario, including productivity, disease and pest situation, as affected by temperature and CO_2, for developing effective management strategies.

Climate change impact on potato productivity in Bihar and adaptation strategies

Impact of climate change on potential potato productivity has been studied in Punjab and Uttar Pradesh during previous years using models. This year the study has been extended to Bihar, which is the third largest producer of potato in India. The study was carried out using WOFOST crop growth simulation model. For simulation, three potato cultivars (Kufri Badshah, late; Kufri Jyoti, medium and Kufri Pukhraj, early) were selected on the basis of their maturity group. The analysis was done for baseline scenario (2000) and for future climate scenarios of the years 2020 and 2055 using A1FI scenario of temperature (SRES A1FI pathway) and atmospheric CO_2 (based on the Bern-CC model for A1FI scenario). These three potato cultivars account for about 90% of total acreage in Bihar.

The potato productivity varied largely within the state under baseline scenario (26.6 to 45.8, 23.9 to 45.3 & 24.2 to 49 t/ha, for Kufri Badshah, Kufri Jyoti & Kufri Pukhraj, respectively). The average productivity of Kufri Badshah, Kufri Jyoti & Kufri Pukhraj in 29 districts of Bihar was 38.7, 37.2 and 39.1 t/ha, respectively. For these cultivars, the extrapolated results have shown a baseline productivity of 40.7, 38.7 and 40.8 t/ha. A decline in potato productivity was observed on moving from south-west, north east and north-west to south-east direction in Bihar. The south-eastern districts, Lakhisarai, Monghyr and Jamui had the lowest baseline productivities for all the three potato cultivars for which WOFOST model was run. Under the future climate, model results have shown on expected decline in the productivity of Kufri Badshah, Kufri Jyoti & Kufri Pukhraj to the tune of 5.9, 5.8 & 6.5% in 2020 and 10.0, 11.1 &13.1% in 2055, averaged over 29 locations. In general, in 2020, the lesser reduction in Kufri Badshah productivity is expected in western part of Bihar (0- 5%). In case of Kufri Jyoti and Kufri Pukhraj, the south-western districts Kamur, Rohtas, Buxur and Aurangabad could see little productivity changes (0- 5%) in 2020 as compared to rest of the state where, productivity is likely to fall by 6- 10%. The area with higher decline is roughly 77% for Kufri Jyoti & 90% for Kufri Pukhraj.

The simulation results have shown that Kufri Badshah is the cultivar which is likely to see the least reduction in productivity in 2055. While 70 to 89% of the geographical area is likely to witness a decline in productivity of Kufri Jyoti and Kufri Pukhraj within the range of 11 to 15%, only 21% of the geographical area could fall under this category for Kufri Badshah.

In case of all the potato cultivars, it is observed that under both the future climates, the decrease in the productivity is more in those pockets which are already having poor productivity. Conversely, the area with high productivity (north-western, north-eastern and south-western districts) might see a lesser decline in productivity in future climates (Fig. 1).

Model results for Nalanda and Aurangabad have shown that in the south- west part of Bihar, 10 days earlier potato planting from normal will off-set the climatic effect on potato productivity to great extent. While the mean productivity under normal date of planting is expected to be decline by 6.1 and 11.4% in 2020 and 2055, respectively. A 10 days earlier planting might bring down these figures in south-west Bihar to 3.2 to 3.6% in 2020 and 6.6 to 9% in 2055. Although, shifting of date of planting could not be suitable option in rest of Bihar. Use of Kufri Badshah in place of Kufri Jyoti & Kufri Pukhraj in these areas is a better option for farmers to compensate of yield losses in future climates.

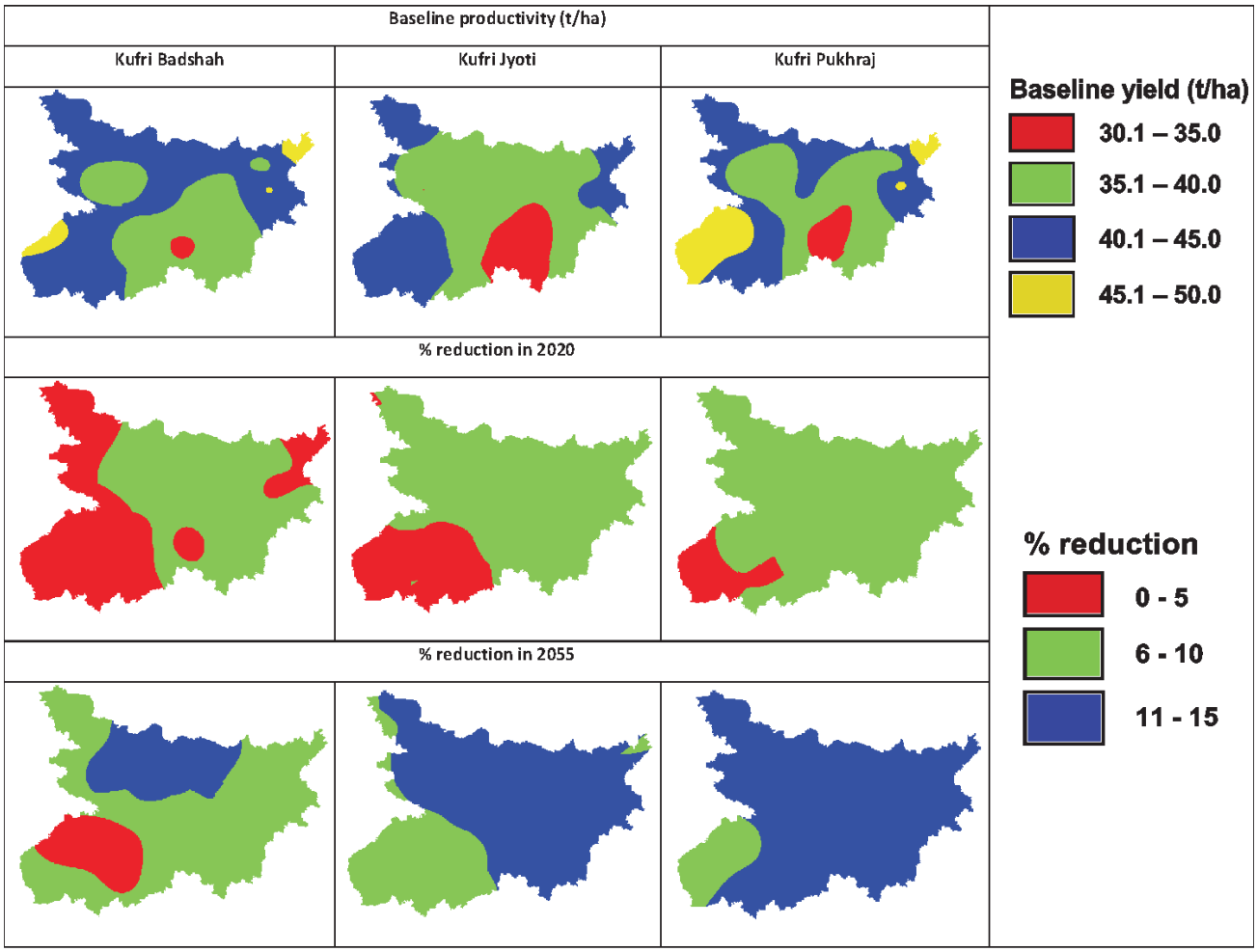


Fig. 1: Potential productivity of different potato cultivars in Bihar under baseline and changes in future climatic scenario

Climate change that includes global warming and increased climatic variability, is likely to affect agricultural diseases and insect-pest/ vector dynamics. Therefore, for effective management of diseases and pests which may emerge problematic in future climate; impact of climate change on the changes of the complex of insect-pests and diseases that affect potato crop in different regions need to be assessed.

Potential impact of climate change on potato late blight outbreak in West Bengal using JHULSACAST model

West Bengal is the second largest potato producing state of India. The occurrence of late blight in this state is frequent and significantly affects the potato productivity once every two-three years. Likely warmer future climate are going to affect the incidence of late blight, thus the potential impact of climate change in potato crop due to late blight appearance and number of chemical sprays required to control it in West Bengal were analysed in a study using JHULSACAST. The model was run using districts level data on minimum and maximum temperature (°C) of Indian Meteorological Department's normals (years 1971 to 2000) for baseline (year 2000) and future climate scenarios (years 2020 and 2055) for 11 districts of West Bengal. Hourly temperature (°C) data required for JHULSACAST was derived from minimum and maximum temperature (°C). Kriging method was used to interpolate data over geographical area of districts.

The model predicted earliest late blight appearance during 4th to 11th December in baseline scenario (2000) which is expected to be delayed by 3 to 15 days in 2020 under favourable relative humidity (Fig. 2). The delay in late blight appearance in 2020 is expected due to increase in temperature by 1.08 over the baseline year 2000. The total number of late blight favourable days ranged from 65 to 88, depending upon the geographical location, with a mean of 73 days in the baseline year (2000) during the potato crop season. However, due to delay in appearance of late blight in the season and reduction in late blight favourable period towards the end of the season, the total late blight favourable period is likely to be reduced by the 3 to 15 days (mean 7.6 days) in the future climate (2020) (Fig 3). The study further shows that if there is no change in the population structure of the *Phytopthora infestans*, the mean number of sprays required to control late blight is likely to reduce from 5.5 in 2000 to 4.2 in 2020 (Fig. 4).

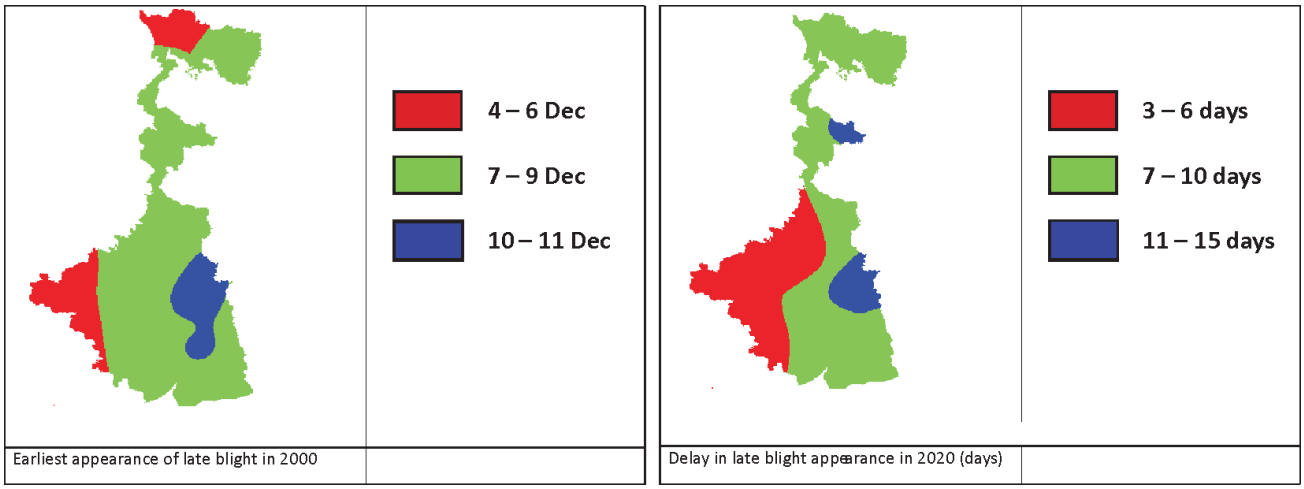


Fig. 2: Earliest appearance of late blight in 2000 and delay in appearance in 2020 (days) in west Bengal

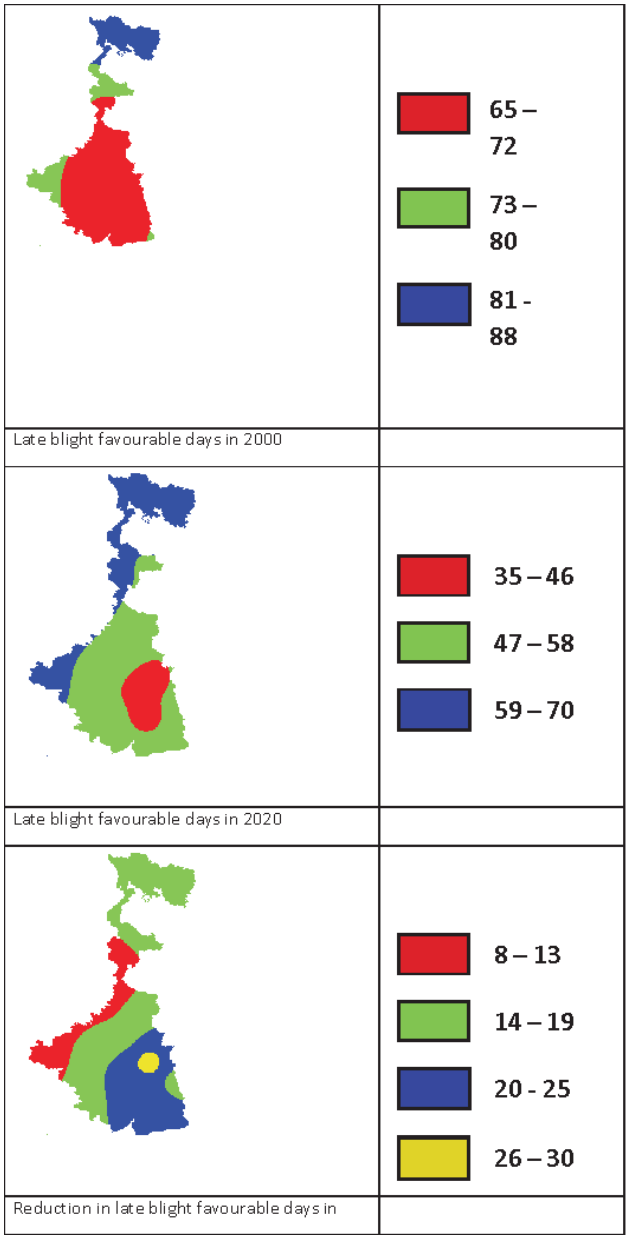


Fig. 3: Number of late blight favourable days under different scenario in west Bengal

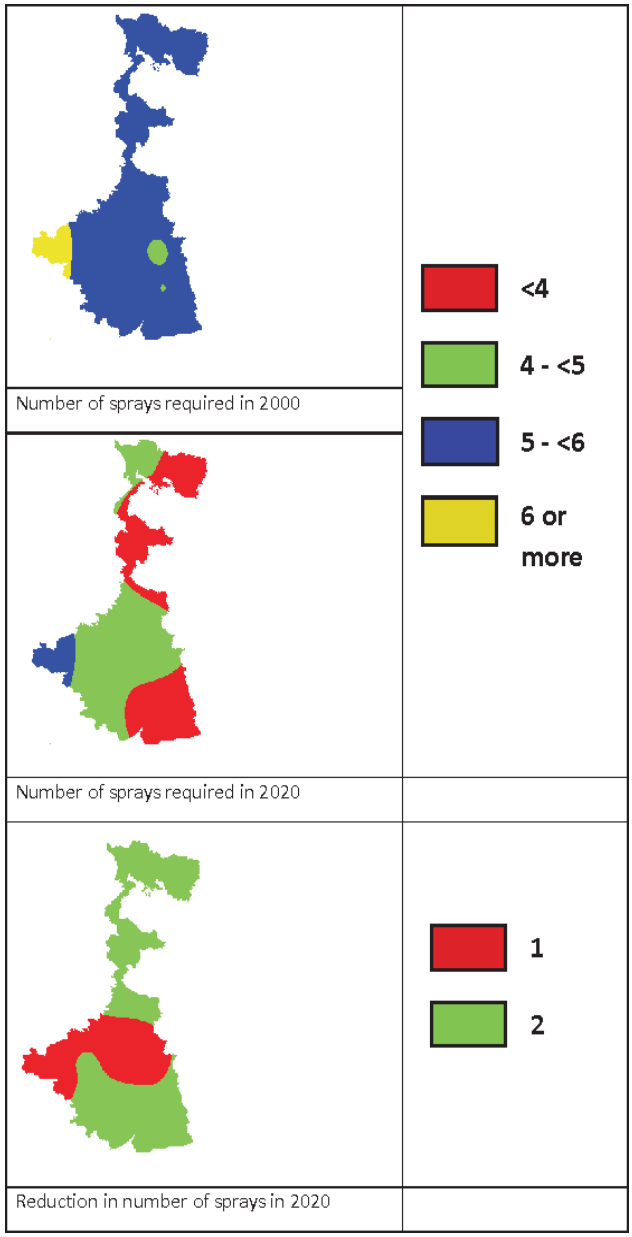


Fig. 4: Number of sprays required to control late blight in 2000 and 2020 (days) in west Bengal

Phytophthora infestans is known as a cool climate pathogen. Temperature is an important weather parameter, which affects epidemiological components of the pathogen. Previous year study indicated that the some isolates of *P. infestans* could grow *in-vitro* even at 30 °C (after establishment of the isolates at 18 °C). Therefore, a study was done to see the effect of higher temperature on epidemiological components of *P. infestans*. Results revealed that incubation period and latent period were more at 30 °C than the 28 °C, however lesion area was less developed at 30 °C than 28 °C in detached leaf test.

Climate analogues and late blight appearance

Climate analogues (place where today's climate is similar to the given future climate of a place of interest) are important means to study behaviour

of late blight occurrence in future climate scenarios of the similar analogues. Therefore, observations of late blight appearance in different climate analogues were studied. It was observed that at similar analogous late blight appeared at different dates. At Jalandhar (31.326 ^{0}N, 75.579 ^{0}E) late blight appeared on first week of February, 2014 while it's analogous at Baghpat (29.274 ^{0}N, 77.191 ^{0}E) it appeared on last week of February, 2015. The difference in the number of days in late blight appearance between Jalandhar and Baghpat was more during 2013-14, while in 2014-15 difference between both analogous was less. It was observed that delay in appearance of late blight was due to prevalence of lower temperature during the season.

In case of potato pests, it was observed that in Mathura (30 year future climate), aphids and whitefly were the common pests, but their incidence and intensity were different in similar analogue to the Gwalior (26.233 ^{0} N, 78.25 ^{0}E). The whitefly and aphids in low intensity were first recorded in October and 3rd week of December, respectively at Gwalior whereas in Mathura aphids were first recorded during 4th week of December with low intensity. Thrips were observed active during crop growth at Gwalior while absent in December in Mathura. The average population (215/ 100 compound leaves) of *Myzus persicae* in village Amarpur (Gwalior) on cv. Kufri Chandermukhi during 2nd week of February was much higher than recorded in villages- Pura, Jogishra, Baldev and Lohaban of Mathura on cvs Kufri Bahar, Kufri Chipsona-I, Kufri Chipsona-III (84-90/100 compound leaves). The variability in incidence of insect pests might be due to variation in maximum and minimum temperatures, humidity and rainfall at both the places during crop period.

Yield loss assessment due to late blight

Late blight causes significant yield losses every year in India. Yield loss assessment model is not available for assessing loss caused due to late blight in different weathers conditions particularly on different background of cultivars. An experiment was conducted for generating yield loss data due to late blight on two different varieties (Kufri Bahar and Kufri Chipsona-I) planted on three different dates for developing yield loss assessment model. Yield losses varied due to variation in date of appearance of late blight and its severity, which were affected by climatic factors, dates of planting and the variety (Figs. 5 & 6). These data will be further used for development of yield loss assessment model.

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

Bacterial wilt or brown rot caused by *Ralstonia solanacearum* is a destructive disease of potato prevalent in many parts in India. The pathogen survives through infected tubers, plant debris and in soil. Studying the survival behavior of this pathogen in soil at varying temperatures will help us to visualize the new potato growing areas where this pathogen may establish with the increase in global warming. Therefore, an attempt was made to study the survival of *R. solanacearum* strain RS-2 (potato race, phylotype II bv 2) *in-vitro* in soil (both in sterilized and unsterilized soil) at different temperature regimes. The previous year study indicated that, the strains RS-2 (potato race, phylotype II bv 2) was able to survive up to 17 months at 20 - 28 ^{o}C and up to 8 months at 32 ^{o}C in sterilized distilled water. An experiment on survival of *R. solanacearum* strains RS-2 (phylotype II bv 2) in sterilized and un-sterilized soil at 20, 24, 28, 32, 37 and 40 ^{o}C temperatures was initiated in September 2014 under controlled conditions. The CFU (Colony forming unit) count for each strain at monthly intervals revealed that, the pathogen could survive for one month at 40 ^{o}C, two months at 37 ^{o}C, four months at 32 ^{o}C and six months at 20 – 28 ^{o}C in sterilized soil. However in un-sterilized soil, the pathogen could survive only for one month at 37 ^{o}C and 4 months at 20-28 ^{o}C, while no growth of *R. solanacearum* was

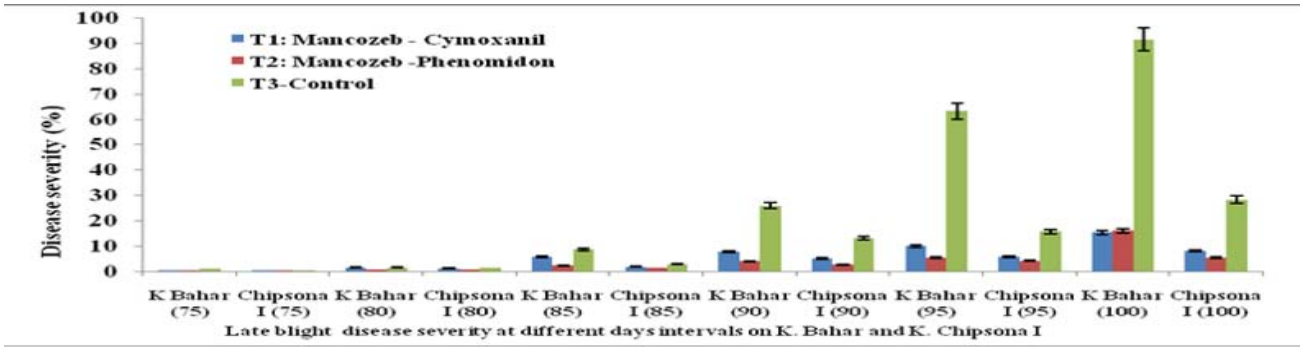


Fig. 5: Late blight disease severity at different days interval on Kufri Bahar and Kufri Chipsona I at sowing on 2nd Nov, 2014

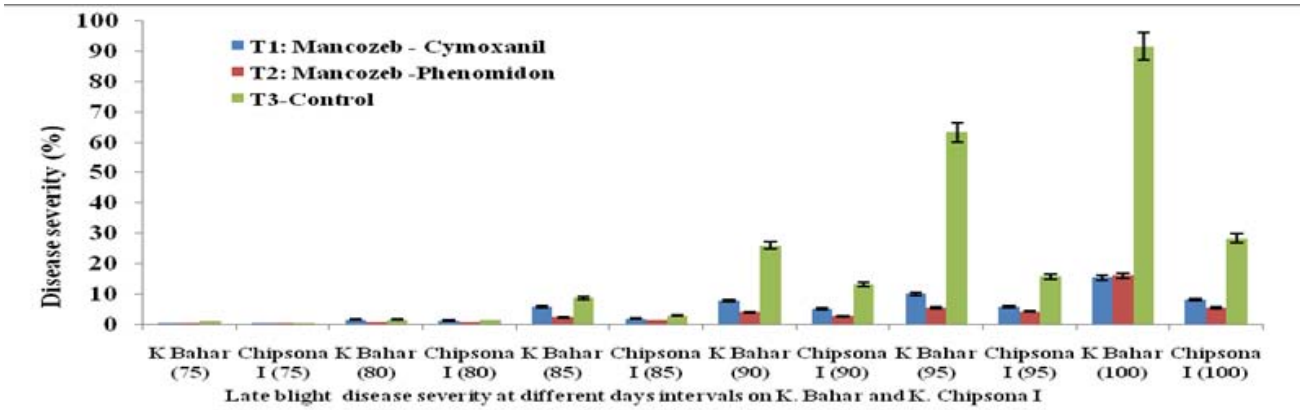


Fig. 6: Late blight disease severity at different days interval on Kufri Bahar and Kufri Chipsona I at sowing on 17 Nov, 2014

observed at 40 °C after one month and at 32 °C and above after two months.

Effects of weather factors on incidence of insect vectors and transmission of disease under protected and un-protected condition at Gwalior

Potato is grown in many parts of North-central and North-western parts of India as early cash crop to fetch high remunerative price in the market. However, this crop is affected by a number of insect pests; the most important among these are thrips (*Thrips palmi* Kerny) and whitefly (*Bemisia tabaci* G). With the increasing temperature due to global climate change, the incidence of thrips is expected to increase in Central India specially its hot spots like Gwalior. Keeping the importance of thrips as a vector for transmission of stem necrosis disease (Tospo virus) in early planted potato crop in Central India, field experiment was carried out to collect the information on incidence of thrips and stem necrosis in relation to weather parameters. The data revealed that highest thrips population (40.8/5 plants) was recorded in the month of November, resulting high incidence of stem necrosis disease (40.75%) in 15th September planted crop under unprotected condition (Fig. 7). However, low incidence of thrips (24.6/5 plants) and stem necrosis disease (21.48%) was

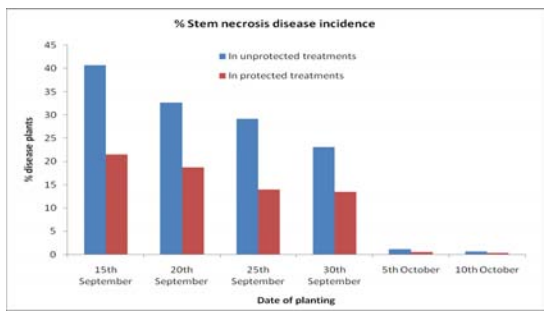
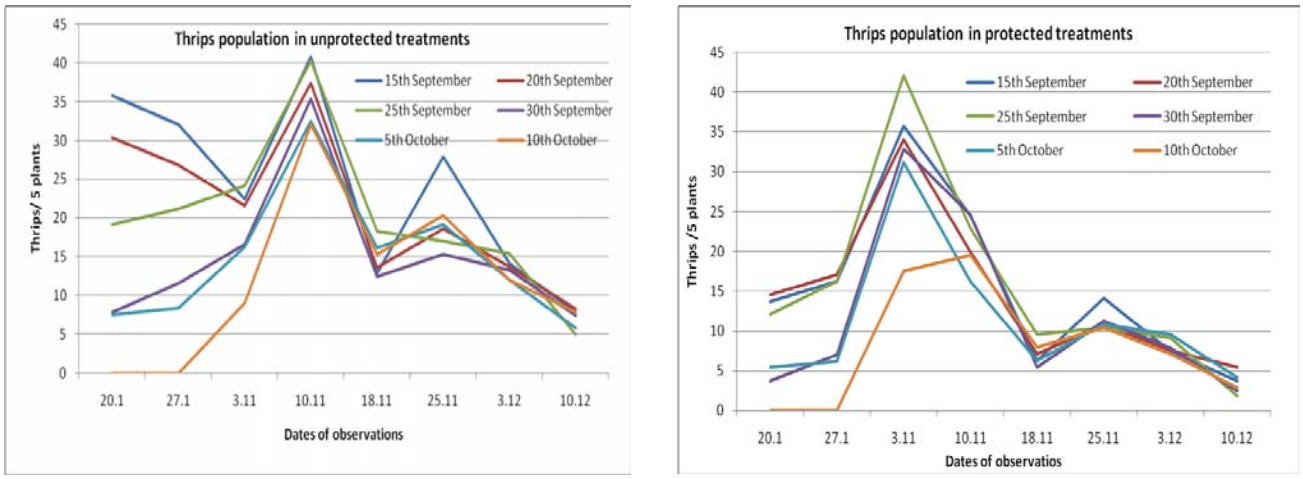
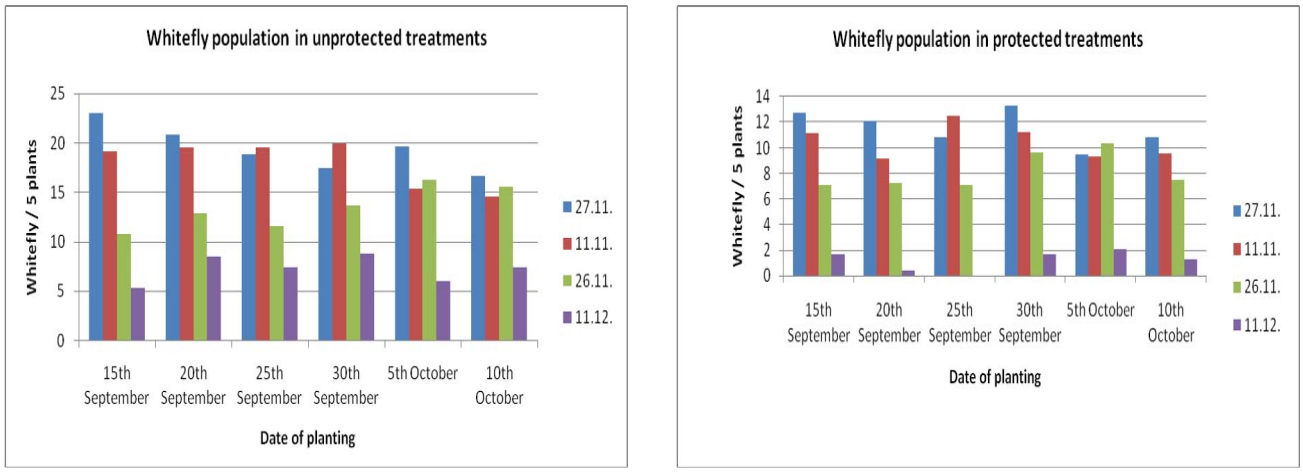


Fig. 7: Incidence of stem necrosis at different dates of planting in Gwalior with unprotected treatments and protected treatments



A B

Fig. 8: Thrips population at different dates of planting in Gwalior (a) unprotected treatments (b) protected treatments



A B

Fig. 9: white fly population at different dates of planting in Gwalior (a) unprotected treatments (b) protected treatments

recorded in protected condition (Fig. 8a & b). The high temperature (30-35 ^{0}C) and dry weather during early October is favorable for the development of stem necrosis disease. Thrips and whitefly activity also trigger on early crop due to high temperature and moderate humidity. Similarly, whitefly was low in protected treatments of planting dates as compared to unprotected crop (Fig. 9a & b). In early planted crop, significantly low total tuber yield (11.18 t/ha) was recorded as compared to late planted crop (21.84 t/ha) under unprotected conditions, where as the yield level varied (13.26-23.23 t/ha) under protected conditions. The correlation study revealed significant positive correlation with incidence of thrips and incidence of stem necrosis disease; however it showed a negative correlation with tuber yield. The potato yield showed significant difference among the different dates of planting. The data revealed that weather parameters (temperature, humidity, rainfall) plays a role in buildup of thrips, whitefly population on potato crop and the crop will require better management tactics right from planting to reduce the incidence of vectors in this region.

Effects of weather factors on incidence of sucking insects at Modipuram

The early potato cultivation in Indo-Gangetic plains, suffers huge losses due to sucking pests. In last few years weather conditions remained erratic and hence change in behavioral pattern of insects have been noticed in early crop. Therefore, an experiment was conducted to assess impact of weather parameters (temperature & humidity) on sucking pests on the potato crop planted on 4 different dates during September/October. Observations were recorded on number of *Bemisia tabaci*, *Amrasca b. biguttula*, *Aphis gossypii*, per cent hopperburn and per cent mite burn in unsprayed plots of each date of planting. The data thus generated will be used to develop management practices for control of insect pests of early planted crop (Fig 10).

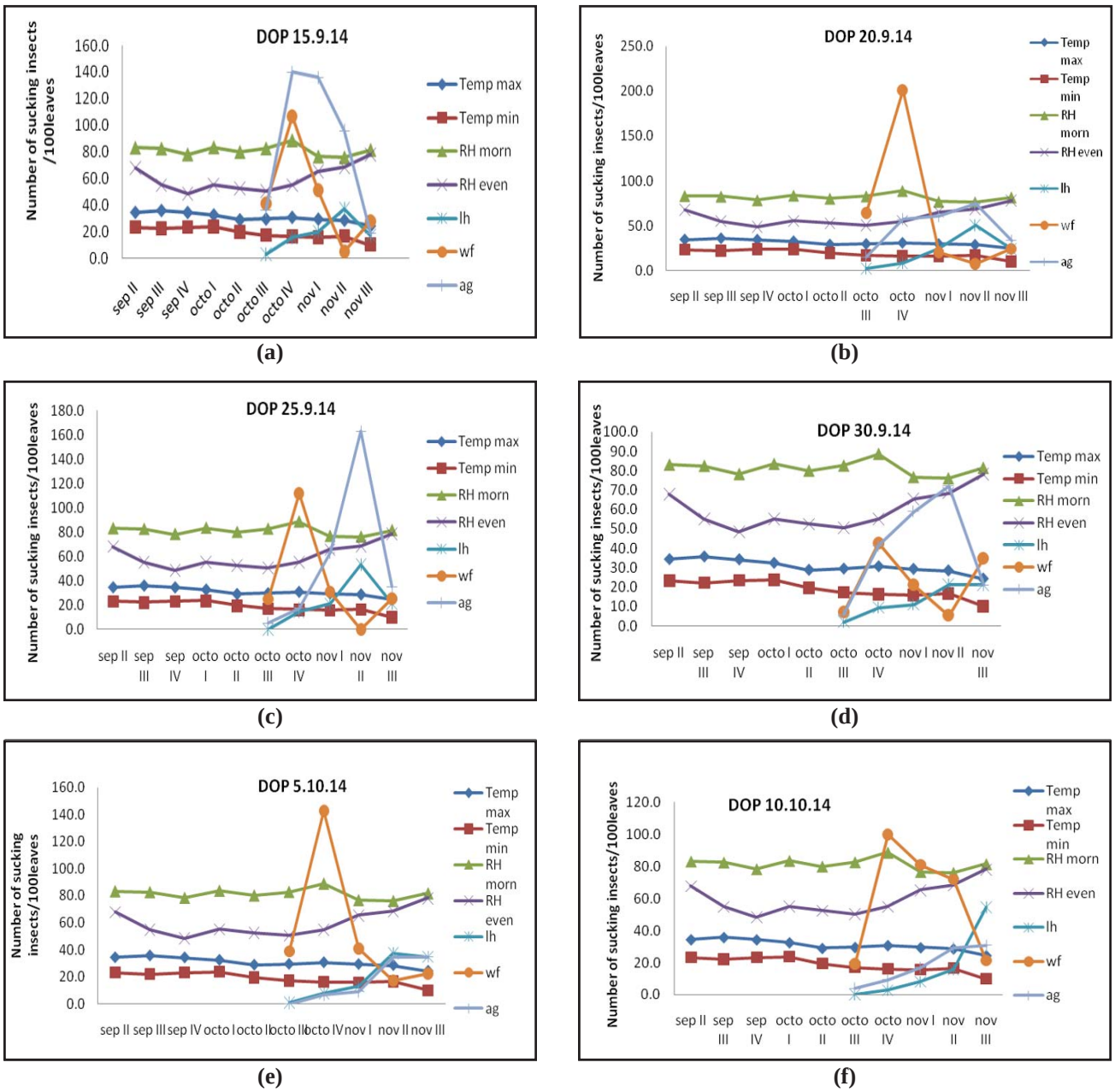


Fig.10: Fluctuation in number of sucking insects in different dates of planting

(lh: Leaf Hopper, wf: white fly, ag: *Aphis gossypii)*

CO_2 concentration in the atmosphere is increasing steadily and has reached a level of almost 400 ppm now. This increase is likely to continue in the future as well, affecting the environment and climate. Open top chamber (OTC) facility was created at CPRS Jalandhar to study the effects of increased levels of CO_2 (600 ppm) on potato growth and yield. Plant height, which increased linearly from emergence till about 60 DAP, was about 10% higher under elevated CO_2 compared to control (Fig. 11). The number of branches was about 25% higher under elevated CO_2 (Fig. 12). Fresh as well dry weight of all plant parts increased with time and both fresh and dry weights of all plant parts were higher in plants grown under elevated CO_2 concentration compared to controls (Fig. 13-16). Leaf area increased up to 70 days in control and up to 80 days under CO_2 enrichment and declined

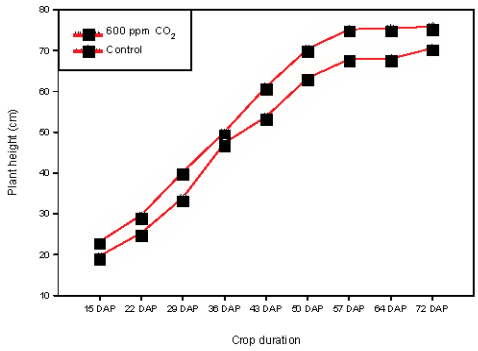


Fig. 11: Plant height under 600 ppm CO_2

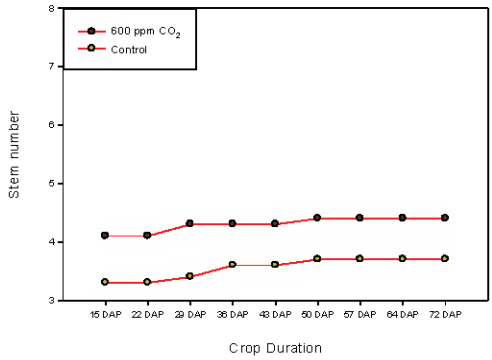


Fig. 12: Stem number per plant

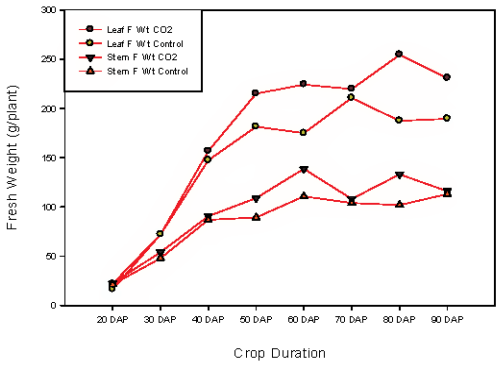


Fig. 13: Leaf and stem fresh weight

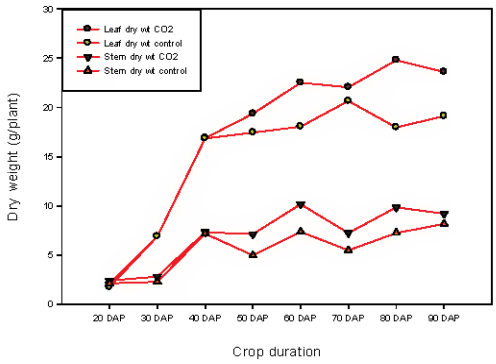


Fig. 14: Leaf and stem dry weight

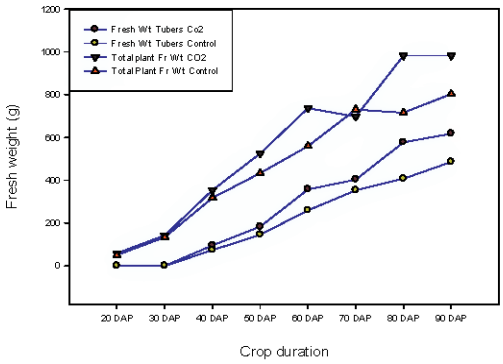


Fig. 15: Tuber and plant fresh weight

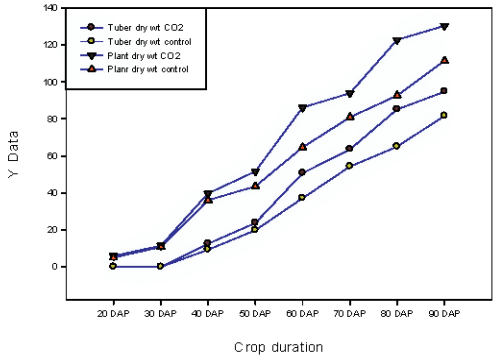


Fig. 16: Tuber and whole plant dry weight

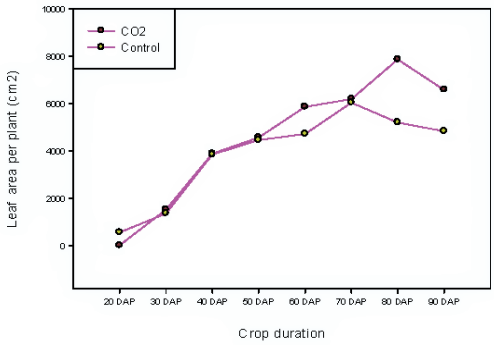


Fig. 17: Leaf area per plant

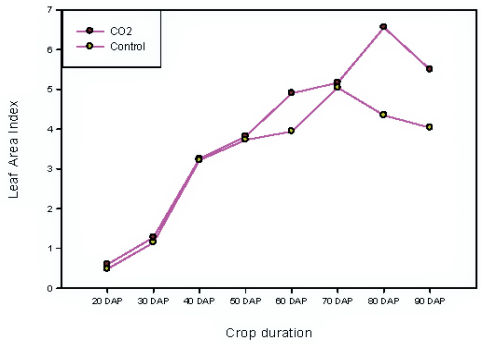


Fig. 18: Leaf Area Index

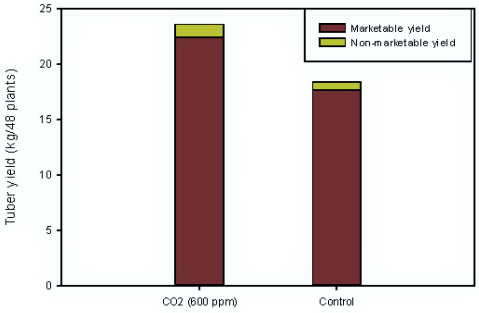


Fig. 19: Tuber yield under 600 ppm CO_2

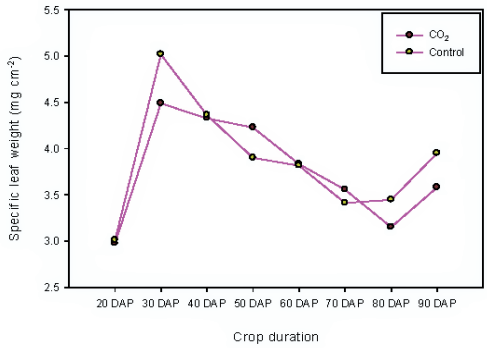


Fig. 20: Specific leaf weight (md/cm²)

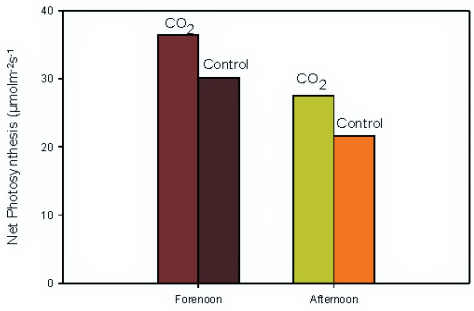


Fig. 21: Net photosynthesis under 600 ppm CO_2

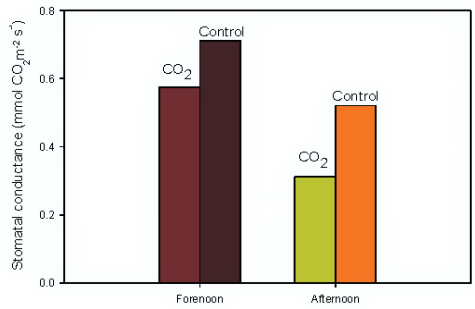


Fig. 22: Stomatal conductance under 600 ppm CO_2

thereafter. There was no difference in leaf area between two treatments up to 40 DAP (Fig. 17). The trend in leaf area index was similar to leaf area in both the treatments. The maximum LAI in control plants was 5.0 at 70 DAP whereas under CO_2 enrichment it reached 6.6 at 80 DAP (Fig. 18). Specific leaf area was maximum at 30 DAP and then it declined under both the treatments. The specific leaf weight was greater in control plants (Fig. 20). Total tuber yield per OTC was 23.5 kg under CO_2 enrichment and 18.3 kg in control. The increase in yield due to CO_2 enrichment was about 28%. The proportion of small size nonmarketable tubers was 1.2 kg under CO_2 enrichment compared to 0.7 kg under control conditions (Fig. 19). At 40 DAP the rate of net photosynthesis under CO_2 enrichment was 21% higher while at 80 DAP it was about 5 times higher than the control (Fig. 21), Even in CO_2 treatment photosynthesis was higher at 80 DAP compared to 40 DAP. Stomatal conductance was lower in CO_2 treatment compared to controls at 40 DAP whereas the trend reversed at 80 DAP (Fig. 22).

Farm Machines for Potato Cultivation

Farm machines and equipments have a special role in potato cultivation since it is a short duration and input intensive crop. There is a need to reduce the labour requirement and human drudgery through development of suitable equipment and machines for all types of farmers, from small and marginal farmers to those having big farms. Therefore, present programme was conceptualized with the immediate objectives to develop potato graders for small to medium farmers and for experimental plots, development of combine harvester and to develop and improve aeroponic systems for seed potato production.

Development of potato combine harvester

Although the machines are available and used for mechanical harvesting of potato, but the picking and collection of dug tubers is regularly carried out manually. Apart from being full of drudgery, it is also a time and labour consuming operation. The acute shortage of labour is being faced by the potato growers now-a-days, especially at the time of harvesting. The project was undertaken to develop a small, compact and low cost potato combine harvester, to eliminate manual picking/ collection, to save upon labour and time, thereby reduce the cost of operation and human drudgery involved in tuber collection. Two different prototypes of tractor operated potato combine harvester were developed in the past (1) to dig and collect tubers in a trolley (Prototype-I) and (2) to dig and collect tubers in bags/crates (Prototype-II)

A 2-row tractor operated trailed type potato combine harvester (Prototype-II) with provision for inspection and simultaneous collection of tubers in bags/ crates was developed and tested during last year. It was improved and field evaluated during the year under report. The problems identified in the prototype were removed by re-designing and re-fabrication of some of the systems. The accumulation of tubers and soil in both side deflectors behind primary chain conveyor was avoided by providing new tuber deflectors. The rubber flap was provided on to absorb impact and slow down the fall of tubers in the cage wheel, to check the tuber damage. The rear check wall of MS sheet was covered with 3mm thick litlon sheet. The hexagonal nuts used were replaced with round head bolts whenever required to check damage to the tubers .The wooden platform was removed, made to the size as per requirement and refitted .This lowered the height by 200mm for better holding of bags for filling of tubers. The sharp edges were identified and were removed or grounded. The hitch point of harvester was lowered for better transport of the machine on uneven paths. The safety of workers standing on machine was ensured by providing enclosure made of angles and pipes. An inclined small ladder made of GI pipes and MS angle iron was provided for safe climbing of workers on machine platform and also a provision is made to lift and lock the ladder to close the gate for safety of workers during operation of harvester. The same ladder was also used in an inclined position to unload the filled bags. The speed of the cage wheel was increased by suitable changes in the size of sprockets, for fast and better handling and sieving of dug material. The curved sheet to check fall of tubers from cage wheel during operation was redesigned and provided with litlon foam cover to reduce tuber bruising due to abrasion. The circular rods of cage wheel were covered with 10mm PVC tube to reduce tuber damage due to impact of fall from the primary rod conveyor and abrasion damage during the rotation of the cage wheel. The bases of all the 12 buckets were covered with litlon foam for safe handling of

tubers during upward movement of tubers. The belt type trash separator system was improved further by providing the rubber fingers on the belt in a staggered manner to catch hold of large and heavier vines and weeds to drop them behind the machine but allow the tubers to roll down the belt to inspection conveyor. The chutes of bag holding devices were also provided with the cover of 3 mm thick litlon sheet to check tuber damage. Two number of diabolo rollers were also provided to see the impact on reduction of clods, while working in clod forming soil conditions (Fig. 1).

Fig. 1: A view of the prototype of Potato Combine harvester

Field evaluation and testing

The improved prototype was run at no load condition. The speeds of different sub systems were optimized under simulated conditions. The field trial and testing was also carried out in the actual field conditions, on the potato crop variety Kufri Badshah, especially raised for testing of the prototype machine (Fig. 2). The performance of cage wheel type vertical conveyor and other systems was found to be satisfactory. The design of the trash separator was found to be effective to separate out the weeds from the dug tubers. The rubber fingers provided were although effective to separate out weeds, but they also carried the tubers along with and threw at the rear of the machine. These were removed and prototype was re-evaluated. The trash separation system was

Fig. 2: Prototype of potato combine harvester during field operation

found to work satisfactorily. There was tuber damage by the sheet provided to receive and supply tubers to the cage wheel. The sharp edges were covered with rubber sheet which checked the tuber cutting. The transmission system *viz.*, chain and bevel gears showed the problem of mis-alignment which was removed. The diabolo rollers improved the separation of tubers from soil mass, by reducing size of clods and their sieving. The spillage of tubers and damage was considerably improved over the past year. The field performance of the prototype is shown in the Table 1.

Table 1: Field performance of the improved prototype potato combine harvester (Prototype-II)

S. No	Item	Performance
1.	Type of soil	Sandy Loam
2.	Potato variety	Kufri Badshah
3.	Speed of operation	2.3 Kmph
4.	Effective field capacity	0.21 (ha/hr)
5.	Soil separation efficiency	82%
6.	Clod reduction efficiency	65%
7.	Tuber bruising	3.2%
8.	Field losses	1.6%
9.	Labour requirement	4-6 person
10.	Tractor power requirement	45 HP

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

Grading is an important operation as it fetches high price to the grower and improves packaging, handling and causes an overall improvement in the marketing system. Grading of potatoes in India is generally done manually either by hand picking or through sieves. Manual sorting is based on traditional visual quality inspection performed by human operator, which is tedious, labour intensive, time consuming, slow and non consistent. Therefore the farmers are looking forward to have an appropriate crop grading machine in order to alleviate the labour shortage and obtain a better quality of agricultural products. The present work was undertaken to develop a power operated potato grader for grading potatoes into four size grades. The grader was designed to grade the horticultural produce on the basis of size as per buyer's requirements. The grader is made of locally available material to keep the cost low. Operational cost and ease in operation, was focused in development, keeping in view the throughout labour requirement, mobility and future repair and maintenance. The materials used for the fabrication of different parts of the machine were M.S. angle iron, M.S. flat, M.S. rod, M.S. sheet, M.S. shaft, rubber sheet, wood, ball-bearing, V-belt, V-pulley, and miscellaneous small items. All the joints were made by welding to make the machine strong, rigid, and to reduce the vibration at the time of operation. The major systems of the grader are mainframe, grading mechanism and power transmission system. Main frame was developed keeping in view the static and dynamic loads during operation and transportation. The main frame of the grader consists of a rectangular box made mainly from 35x5mm angle iron. Two numbers of axles along with two pairs of solid rubber lined transportation wheels of diameter 300 mm each provided at front and rear sides of the frame helps the grader for transporting it to a desired place with the help of a tractor. Two pairs of adjustable supports were fitted below the front and rear corners of the frame for stability of the grader and for changing its inclination during operations as well as for parking. Grading mechanism of this grader mainly consists of a GI wire that has been given the shape of a square. These wires have been locked together to look like a square wire mesh. For getting different grades of tubers, square wire mesh of different sizes has been provided. Grading unit consists mainly of three numbers of grading sieves having 52 mm, 32 mm & 20mm size square openings made out of 8 SWG MS wire. Both ends of the wire belt have also been clamped together with the help of GI sheet clamps thus making it an endless screen. Whereas the wire belts having 52 & 32 mm size opening moves along the length of the grader, the other wire belt having 20 mm size opening moves perpendicular to it. These grading sieves were properly aligned so as to keep a check on their sideways movement. Proper care has been taken to disallow any loosening of the wires of the grading belts during operation. Twelve numbers of wooden drive and driven rollers have been fitted with bearings (number 6205) and brackets at appropriate locations in the grading belts for proper movement and tightness of these grading belts during operation. Conveyor belt system (*take in* conveyor) has been provided for uniform feeding of potatoes to the grading mechanism. The design of the take in conveyor was made keeping in view the functions to perform, fabrication facilities and skill, simplicity of the design, social acceptability, knowhow of the end users, trend of the local industry. *Take in* conveyor consisted of driving shaft, driving drum, rubber belt, frame of the conveyor and power transmission system etc. Rubber belt (750 mm wide & of 4 ply rating) with retainers (angle iron of size 25x25x3.15 mm) constitutes the tuber feeding system. Height of this conveyor belt system is adjustable up to 308 mm. A pair of

telescopic arms made out of 25 mm diameter MS bar and pipe was attached to the lower side of the conveyor mechanism for changing the inclination of the belt for efficient conveying of the potatoes. A power transmission system was developed to transmit the required power from prime mover to the gear box or other parts of the grader. Chain, sprockets and belt & pulley, shafts etc have been used in the power transmission system to give drive to grading and conveyor belt mechanisms. The designed output capacity of this grader is about 5-6 t/hr. This grader has been designed to grade the material in the four different size grades *viz.* Large (>52 mm), Medium (32-52 mm), Small (20-32 mm) and Very small (<20 mm).

Design, development & evaluation of small grader

Design and development work of various systems/mechanisms of the small grader (Rubber rollers type) for experimental plots and for small farmers, was carried out. It consists mainly of mainframe, grading rollers and power transmission systems. The main frame of the grader consists of a rectangular box of size 1090 mm X 740 mm made from 38 x 38 x 5 mm angle iron. Two slotted channels (1070 mm long) have been prepared by joining a pair of 38 x 38 x 5 mm angle irons in such a way that 10 mm slit along the length was left. These channels have been bolted at the top of four vertical angle irons acting as pillars. Provision has been made for changing the slope of these channels. Hollow rubber rollers (40mm length, 96 mm maximum diameter & hollow within) resembling the shape of a tambourine /reel and having square hole (21 mm diameter) in the centre, mounted on steel shafts (21 mm square) constitute the grading mechanism of this prototype. These shafts with rubber rollers have been supported by ball bearings (6204Z) at its ends. Bearing brackets of such 9 shafts have been bolted in slot of these channels. These shafts revolve about their own axis in the same direction thereby conveying forward the tuber material received on them. The potatoes will drop through the gap between the corresponding adjacent shafts according to their size and shape, for proper grading of the produce. This grader has been designed to grade the potatoes in three categories of grades *viz.* <25 mm, 25-50 mm, and >50 mm. However the grades having different limits can be obtained by adjusting the gap between the revolving shafts. The designed output capacity of this grader is around 1.0-1.4 t/hr when operated manually.

Evaluation of different grow chambers under aeroponic system

For further refinement of aeroponic technology for producing potato minitubers an experiment with three grow boxes and four cultivars was repeated. Three grow boxes are as follows-

Grow box I is made of 10cm thick brick walls, box II made of 5 cm thick Styrofoam sheet and box III is constructed with a 200 micron black polythene sheet. All these chambers are covered with styrofoam sheet of thickness 5 cm. The nutrient solution parameter and spray time were kept same in all the grow boxes. Only difference was of root zone temperature variation (Fig.3). Response of different cultivars when planted on 29th of Nov at CPRS Jalandhar is shown in figure 4, 5 and 6. In terms of average number of minitubers produced per plant it was maximum in styro box (73.52) followed by brick box (71.58) and poly box (67.57). On per plant basis yield was maximum in brick box (214.55 gm) followed by styro box (209.59 gm) and poly box (176.63 gm).

Designing of systems for plant holding and drudgery free picking of mini tubers

In aeroponic system of growing potatoes, plant growth/height is usually more as compared to

field grown crop and length of plants sometimes reaches 80-100 cm depending on varieties. These lengthy shoots are difficult to manage especially while harvesting of tuber. To resolve this issue two approaches were tried. One was plant holding cage approach and another was netting approach. Six prototypes of plant holding cages were fabricated. Prototype overall specification are 115x58x30 cm and is made of aluminium angle iron, grill and flat fastened with fasteners. These cages were put one each over the styro trays (Fig. 7)

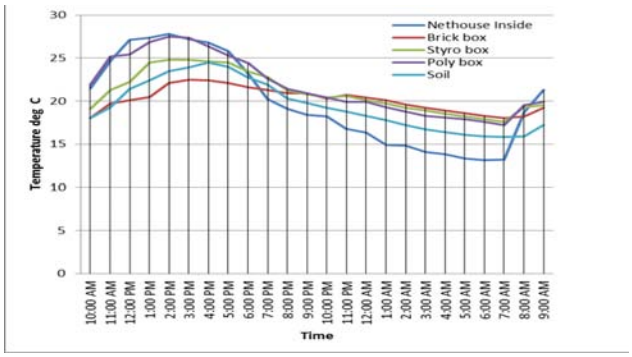


Fig. 3: Variation of temperature in root zone in different grow boxes

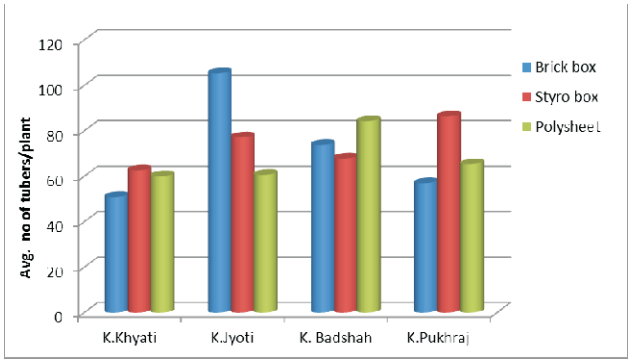


Fig. 4: Minituber number/plant in different grow chambers

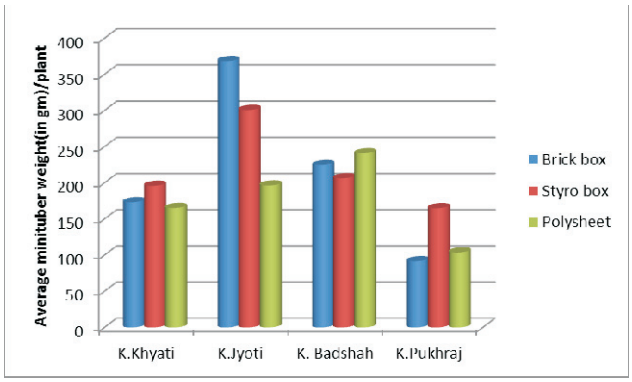
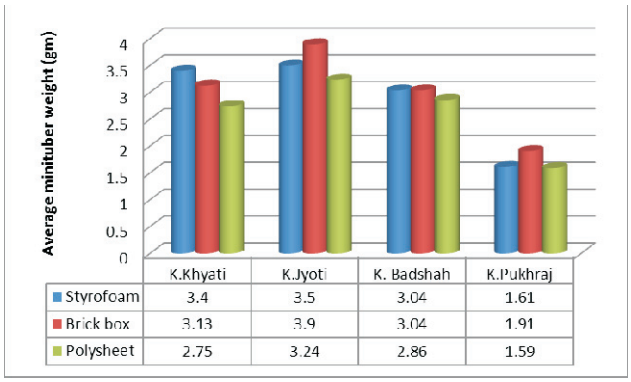


Fig. 5: Production of minitubers/plant by weight



	K.Khyati	K.Jyoti	K. Badshah	K.Pukhraj
Styrofoam	3.4	3.5	3.04	1.61
Brick box	3.13	3.9	3.04	1.91
Polysheet	2.75	3.24	2.86	1.59

Fig. 6: Average weight/per mini tuber in different grow chambers

Fig. 7: Plant cage to prevent lodging & easy picking of tubers

Fig. 8: Portable aeroponic systems installed at CPRS Jalandhar

having 32 plants each, 15 days after planting. These holding devices were found quite useful and did not allow plant to lodge down to the sides and intermingle with plants over side trays if height is up to 60 cm. In other approach netting was provided on units of three plant trays consisting of total 96 plants. Steel frames were fabricated for supporting these nettings which ultimately hold plants straight and don't allow them to lodge. In this system three trays were lifted together for picking of tubers. This system enabled fast picking without damaging plant shoots and root system. Further refinement is still required.

Multilayer use of sensing and dosing system for pH monitoring and control

Maintaining pH in nutrient solution chambers in aeroponic system of growing crops has always been a challenging job as pH keeps changing regularly. To address this problem sensing and dozing instruments are installed in every single solution chamber. A simple methodology of multilayer use of sensing and dosing system was developed wherein with only one system up to four chambers can be monitored and pH can be maintained to the desired level.

Designing of a machine for grading aeroponically produced Minitubers

For grading of minitubers (1-6 gm wt.) produced through aeroponics two grading sieves were made. These are made of PVC of thickness 3 mm having overall dimensions of 50x40x10 cm (LxWxH) and are drilled with holes of size 11 mm and 16 mm. Holes were made in a zig- zag fashion to keep the stresses evenly distributed. Sieves were manually used for grading of 5500 minitubers. Grading was found satisfactory and there was no bruising observed. Sieves will be tested on long term basis on all the varieties being grown in aeroponic system.

Testing of a portable aeroponic system for experiments

Portable aeroponic unit designed last year (Fig.8) was tested on long term basis (for 110 days) by conducting an experiment on K. Jyoti. This unit consists of basic subsystems *viz.* grow box cum nutrient solution chamber, misting unit having two nozzles, pumping unit, a filter, electrical controls, gauges and electronic timer. Grow box is a moulded insulated unit which is used both for growing plants and for storage of nutrient solution. During this testing performance of pump, nozzles, electrical system and other components was quite satisfactory but temperature of grow box was unusually high. Prototype will be improved to reduce root zone temperature in coming season.

Division of Plant Protection

Management of Late Blight

Pathogen population structure

Late blight appeared on 7th July, 2014 on cv. Kufri Jyoti in Shimla however; on tomato it was detected in the month of May, 2014 in Bahl Valley of Mandi district where its severity ranged from 10-25%. Overall, the severity of potato late blight in Himachal Pradesh ranged from 25-90% depending upon the cultivar raised and plant protection measures adopted. In western Uttar Pradesh the disease appeared in Sambhal district at Kurkavali on 6th January, 2015 on cv Kufri Bahar with 5-40% disease severity. In Meerut, Hapur and Amroha districts blight appeared late (during second week of January) and severity ranged from 5-60%. Late blight was observed on 14 July, 2014 on cv. Kufri Jyoti with 5-50% severity at Tavaradevareakoppal, Salegame Hobli in Hassan district of Karnataka. In Hassan, disease severity ranged from 2-100% and about 20-30% yield losses are expected. Up to 20% disease severity was observed during kharif in Chickmagaluru district of Karnataka.

P. infestans isolates collected from Himachal Pradesh, Meghalaya, Bihar, Madhya Pradesh, West Bengal, Punjab, Uttar Pradesh and Uttarakhand, were analyzed for mating types, prevalence of physiological races and sensitivity to metalaxyl. Results revealed that A2 mating type is dominant in the hills and A1 mating type in sub-tropical plains. This trend of mating type is being observed for several consecutive years implying that the mating types have established in the respective regions. However, isolates from Uttar Pradesh, Karnataka and Uttarakhand belonged to the both mating types probably, because of seed movement from hills to plains and *vice-versa*. The pathogen population analyzed was composed of most complex races possessing all the reported 11 genes. Comparison of *P. infestans* population for metalaxyl sensitivity in different parts of the country revealed that none of the isolate has shown tolerance at 400 ppm while most of the isolates exhibited tolerance at 300 ppm. Besides, ploidy status of *P. infestans* (100 isolates) collected from Himachal Pradesh, Meghalaya, Tamil Nadu, Punjab, Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal and Karnataka was determined using Feulgen cytophotometry method and results revealed that *P. infestans* population in the country are polyploid consisting of diploids-tetraploids. However, frequency of different ploidy levels varied from region to region. The frequency of diploids, triploids and tetraploids was 86, 10 and 4%, respectively. In the hills (North-western, north-eastern and southern hills), frequency of diploids was highest (85%) followed by triploids (14%) and tetraploids (1%). The same trend was observed in sub-tropical plains while in plateau and in Madhya Pradesh only diploids were found.

Migration has played a major role in spread of new genotypes of *P. infestans* across the globe during last three decades. Mitochondrial haplotyping technique enabled to track specific lineage, providing a robust marker tool. Mitochondrial haplotyping of 72 isolates collected from Himachal Pradesh, Meghalaya, and Karnataka was done with primer F2-R2 (digested with *Msp*I) and F4-R4 (cut with *Eco*R1) to determine the lineage. Results revealed that all the isolates belonged to the Ia haplotype. Similarly, a subset of population consisting of 24 isolates from UP, Karnataka and Uttarakhand was analyzed with primer P3F1 & P3R1 digested with *Eco*R1yielded I haplotype (Fig. 1). Further for conformation (Ia/Ib), when same set of population were analyzed with primer P2F4 & P2R4 (digested with *Msp*1), it yielded only Ia haplotype. The result tends to suggest that the new population which was introduced during 2002 has displaced the old population (Ib) in most of the regions.

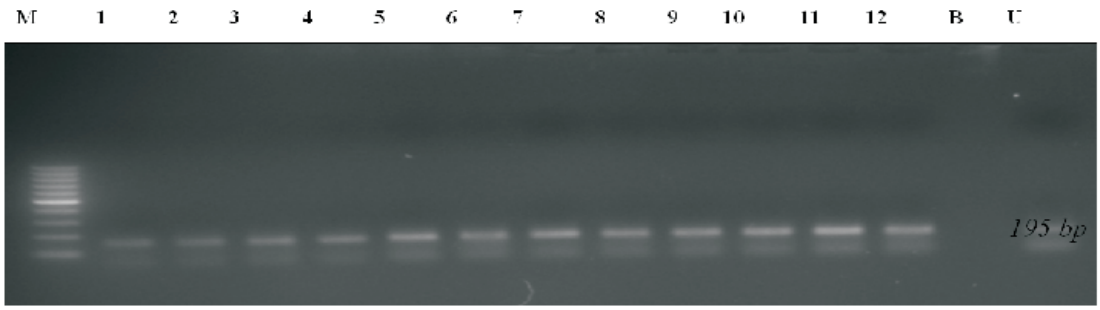


Fig. 1: Mt haplotyping with primer P3F1 & P3R1 digested with EcoR1, Lane: 1-12 *P. infestans* isolates M: 100bp, B: Blank, U: Undigested Product

Simple sequence repeats (SSR) are very useful markers for diversity analysis. SSR markers being co-dominant can distinguish between dominant and recessive alleles. Two primers i.e. Pinf SSR1 and Pio4 were used for genotyping a subset of population (225 isolates) collected from UP, Uttarakhand, Karnataka, HP, Meghalaya, Tamil Nadu, West Bengal, Punjab, Bihar and Rajasthan. Results revealed that two alleles (229 and 245 bp) were observed with primer Pinf SSR1(Fig. 2) while three alleles (164, 172 and 186 bp) were observed with primer Pi04 (Fig. 3). The SSR markers analysis to study diversity in the core collection comprising of 318 isolates is in progress to identify new more aggressive, virulent physiological races of *P. infestans.*

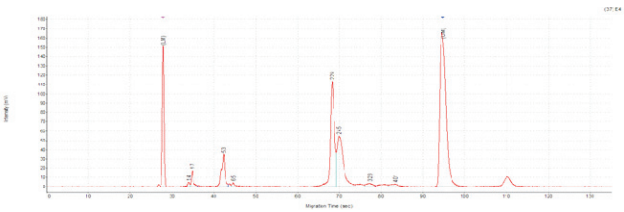


Fig. 2: Diversity depicted by SSR genotyping of *P. infestans* isolates using PinfSSR1 primer

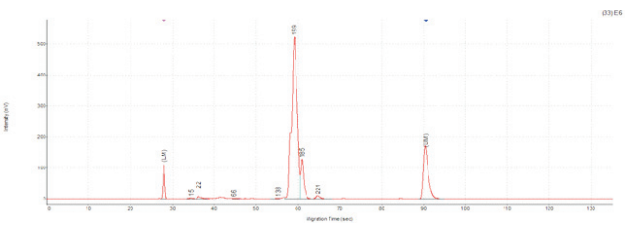


Fig. 3: Diversity depicted by SSR genotyping of *P. infestans* isolates using Pio4 primer

Development of lateral flow device (LFD)/ dipstick for detection of *Phytophthora infestans*

P. infestans cell wall based protein gene was cloned and purified protein was customized last year to develop polyclonal antibody. This year customized antiserum was evaluated by measuring its titre and efficacy in detecting *P. infestans* using DAC-ELISA. The expression of antibody was detected 2 fold over buffer control in mycelium, sporangium and zoospores as well as in infected leaf samples. Data indicated that the produced recombinant antiserum was efficient and accurate in determining negative and positive samples in ELISA tests. Therefore, this antiserum is suitable for certification programs of potatoes due to its low cost, high specificity, feasibility and its endless supply from recombinant bacterial clones carrying the CBD genes for this oomycete. However, when its cross reactivity was tested with other *Phytophthora* spp. it reacted with *P. capsici* also. Since there is no reports so far in literature that *P. capsici* attacks potatoes, therefore, this can be safely used to detect *P. infestans* in potato samples.

Silencing of transposable elements in *P. infestans* to reduce pathogen dynamism

Genome size of *P. infestans* (240 Mb) is several folds larger than *P. sojae* (95 Mb) and *P. ramorum* (65 Mb) because of its 74% repeat region consisting of total

21 families of transposons making the pathogen highly dynamic. It has been proved beyond doubt that, the dynamism in *P. infestans*is mainly due to the movement of transposable elements. Nearly 33% of the genome is covered by transposable Long Terminal Repeats which is almost 1/3rd of the genome. Gypsy-Ty3_is well characterized and is independent transposable element and code for its own tranposase enzyme which has been targeted for silencing in *P. infestans* using RNAi technology (Fig. 4).

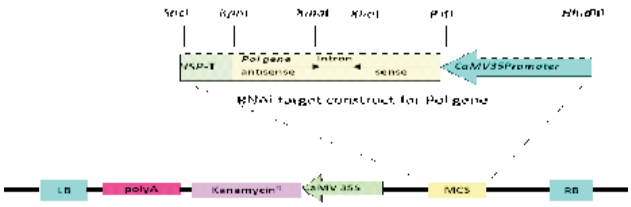


Fig. 4: pRI101 binary construct targeting *P. infestans* Pol gene, for plant transformation (pRI101-RNAi-Pol)

The RNAi construct (of transposable elements) inserted at multiple cloning sites of binary plant transformation vector pRI101under the control of constitutive promoter CaMV 35S (Fig. 5) has been constituted.

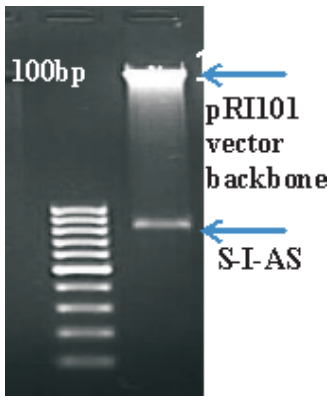


Fig. 5: Restriction digestion analysis pRI101: *Phytophthora infestans* transposable element using XbaI-SacI confirming presence of gene construct

Whole genome sequencing of *Phytophthora infestans* A2 mating type

Complete mitochondrial genome of *Phytophthora infestans*, A2 mating type was sequenced. The genome size of 37,845 bp, possesses a GC content of 22.38% which is slightly higher than all A1 types. A total of 61 protein coding genes are predicted on strands which included twenty six transfer RNA (one tRNA coding for an unknown amino acid), 2 ribosomal RNA, and 18 respiratory protein coding genes. The gene order of A2 mating type was consistent with that established in all A1 types, despite of high level of polymorphism in both coding and non-coding regions. The highest variation was observed in non-coding region. A large spacer flanked by the gene coding for tRNA-Tyr (*trnY*) was found that varied in size with all A1 types (Fig. 6). The mt DNA of A2 mating type was found to have 60.49% homology with *P. andina*. Homology study of complete *cox1* gene sequence revealed the relationship among 50 different *Phytophthora* species.

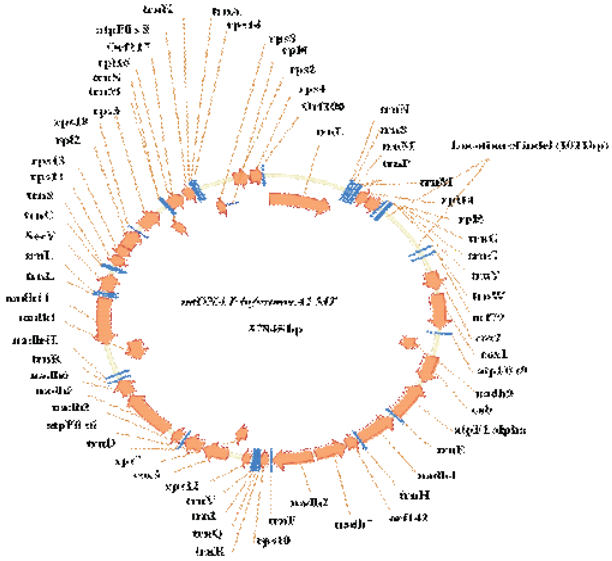


Fig. 6: Mitochondrial genome map of *P. infestans* A2 mating type (Ia)

Understanding the effector proteins associated with potato-*Phytophthora infestans* interactions through microarray approach

To determine the cellular circuitry during potato-*P. infestans* interactions and their complex nature

of effector proteins and interaction with signaling pathways, cDNA microarray was performed, in a single 12X135K Nimblegen array slide containing 39,083 potato protein coding genes as well as 18,034 genes of *P. infestans* using *P. infestans* challenge inoculated resistant (Kufri Girdhari) and susceptible (Kufri Bahar) cultivars (Fig. 7a). The transcriptomic analysis revealed a large set of protein coding genes besides many unexpected hypothetical genes, which have never been associated with the immune and pathogenicity response. Out of 39,083 potato protein coding genes, 5,308 genes were up-regulated in resistant cultivar. Out of 5,308 genes, 11 genes (>5 fold expression) and 30 genes (>5 fold) were highly up-regulated at 24 hrs and 72 hrs, respectively. On the other hand, in susceptible cultivar only *P. infestans* effector genes expression was determined at higher level. Venn diagrams were used to identify genes expressing in Kufri Girdhari and Kufri Bahar during infection. Thus, 29 genes up regulated in Kufri Girdhari on 72 hris and 10 genes on 24 hris (Fig. 7b). But only one gene was common in both resistant and susceptible cultivars at 24 hri and 72 hri stages. All these genes belong to signal transduction, biotic stress, cell rescue and metabolism pathways. This comprehensive transcriptional analysis provided useful information on nature of host and pathogen effector proteins in defense and counters defense activities and provides a framework in developing resistant varieties.

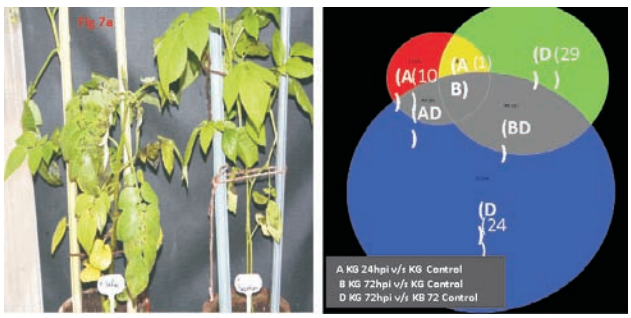


Fig 7a: Phenotyping of Kufri Girdhari and Kufri Bahar for late blight

Fig. 7b: Venn Diagrams showing differentially expressed transcripts in Kufri Girdhari and Kufri Bahar at 24 hrs and 72 hrs of pathogen contacts

Disease epidemiology

Validation of INDO-BLIGHTCAST: INDO-BLIGHTCAST -a pan India model, developed last year to predict the first appearance of late blight disease, was validated this year across the country. The weather data were collected from hills (Shimla, HP), tarai region (Pantnagar, Uttarakhand) and Indo-Gangetic plains (Faizabad, UP; Dholi, Bihar; Kalyani, WB) during *kharif* and *rabi* season (as the case may be) and run for prediction of late blight appearance. The model predicted late blight accurately and it appeared within stipulated time (15 days) at each location. JHULSACAST model has been validated during December 2014- January 2015. According to this model the probable date for appearance of late blight was 28 December, 2014 to 7, January 2015 and disease actually appeared on 6 January, 2015 at Sambhal district in UP.

Disease Management

Multilocation testing of botanical and rhamnolipid based formulation against *P. infestans* Different concentration (2.5, 3, 4, 5, 7, 9, and 11%) of botanical formulation was tested with rhamnolipid bioformulation (0.25%) for its phytotoxicity on potato leaves using detached leaf and whole plant methods. No phytotoxicity was observed at 4% concentration of botanical and 0.25% rhamnolipid. Therefore, this combination was tested under field conditions in Shimla hills

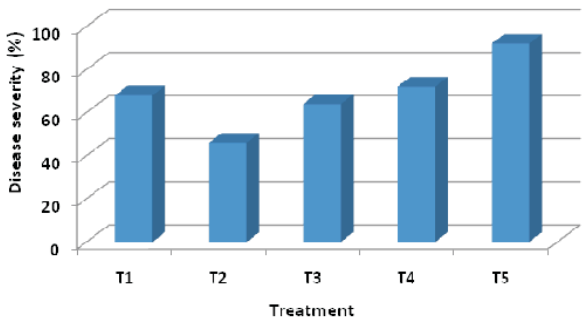


Fig. 8: Efficacy of botanical + rhamnolipid formulation against late blight in field conditions at Shimla (T1: Mancozeb, T2: Chlorothalonil, T3: Propineb, T4: Botanical+rhamnolipid, T5: Control)

against standard contact fungicides. Results revealed that minimum terminal disease severity (46%) was observed in chlorothalonil treated plots followed by propineb (64%), mancozeb (68%) and botanical+rhamnolipid (72%) as against 92% in untreated plots (Fig. 8).

Similarly, studies were also conducted at Modipuram and results revealed that minimum terminal disease severity (38.50%) was observed in chlorothalonil treated plots followed by mancozeb (41.50%), propineb (48.50%), rhamnolipid+ botanical (45.88%), rhamnolipid (54%) and botanical (56%) against 85% in untreated control (Fig. 9).

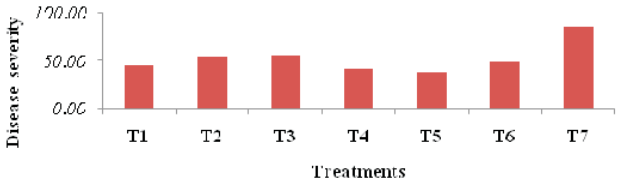


Fig. 9: Evaluation of bio- based formulation against late blight of potato at Modipuram. T1: Rhamnolipid (0.25%) + Botanical (3%) T2: Rhamnolipid (0.25%) T3: Botanical (3%) T4: Mancozeb (0.2%), T5: Chlorothalonil-0.2%, T6: Propineb-0.2%, T7- Control

Evaluation of chemicals against *P. infestans* under field condition

It is known that *P. infestans* changes quickly under fungicides selection pressure. Therefore, new fungicides need to be tested regularly to decide spray schedules for managing the disease. In this effort an experiment was conducted for three years for suitable spray schedule. Amongst eight treatments tested, treatment combination mancozeb (0.2%) - mancozeb (0.2%) + dimethomorph (0.2%) - mancozeb (0.2%) + dimethomorph (0.2%) recorded lowest diseases severity (24.33%) against control (96.00%). Since, efficacy of fungicides may be affected by different population of *P. infestans,* therefore, the experiment was repeated during current crop season. Amongst six treatments , Iprovaliadacarb +propineb, famoxadone+ cymoxanil and dimethomorph based fungicides were effective against new isolates of *P. infestans.* However, dimethomorph based and cymoxanil based fungicides were effective against both old and new isolates of *P. infestans*. Therefore, these fungicides could be used for management of late blight for both the isolates population of *P. infestans*.

Fungicides and varietal resistance in Hassan (Karnataka) and Shillong (Meghalaya)

An experiment was conducted at ARS, Madenur, Hassan, Karnataka for evaluation of five different chemical fungicides for management of late blight along with untreated control in potato cv. Kufri Jyoti in *kharif* season. Among the treatments, prophylactic spray (just at the time of canopy closure) with mancozeb @ 0.2% followed by azoxystrobin @ 0.1% + mancozeb @ 0.2% and one more spray with mancozeb recorded lower disease intensity (50.0%). The next best treatments were prophylactic spray with mancozeb @ 0.2% - fenamidone+ mancozeb @ 0.3% - one more spray with mancozeb @ 0.2% (60%) followed by prophylactic spray with mancozeb @ 0.2% - dimethomorph + mancozeb @ 0.3%- one more spray with mancozeb @ 0.2% (68.0%). Five potato varieties *i.e.*, K. Jyoti, K. Himalini, K. Surya, K. Pukhraj and K. Girdhari were screened at Hassan, Karnataka against late blight without any spray of fungicides. Results revealed that K. Girdhari recorded the minimum intensity of late blight (27.00%) followed by K. Himalini (57.50%), K. Pukhraj (70.00%), K. Surya (75.00%) and K. Jyoti (75.00%). However, K. Surya was the top yielder (17.22 t/ha) followed by K. Himalini (15.83 t/ha).

To know the effect of host resistance and fungicide spray on late blight development, an experiment was laid out at CPRS, Shillong during summer season using Kufri Girdhari, K. Megha K.

Himsona, K. Himalini, K. Giriraj, K. Jyoti, K. Kanchan and K. Shailja. Blight appeared at 103rd days of crop age in Kufri Girdhari and at 89th days of crop age in K. Megha in sprayed and unsprayed. Minimum terminal disease severity was recorded in K. Girdhari (6.5 & 7.5 %) followed by K. Megha (22.5 & 35%), K. Himsona (62.5 & 70 %) and K. Himalini (70 & 75 %) in sprayed and unsprayed crop, respectively; while in other varieties it was cent per cent in both the conditions. Area under the disease progress curve (AUDPC) was lowest on K. Girdhari (22.75 & 26.25) followed by K. Megha (253.75 & 402.5), K. Himalini (934.5 &1333.5), K. Himsona (813.75 & 1162), K. Giriraj (1347.5 & 2082.5), K. Jyoti (1382.5 & 2117.5), K. Kanchan (1277.5 & 1951.25) and K. Shailja (1333.5 &2073.75) in sprayed and unsprayed crop, respectively. There was no significant difference in AUDPC and yield of sprayed and unsprayed crop of K. Girdhari whereas significant differences (variety and spray) were recorded in K. Megha, K. Himalini and K. Himsona. The highest tuber yield was obtained in K. Girdhari (34.08 t/ha) and K. Himalini (33.48 t/ha).

Screening of *P. infestans* effector proteins and defence related gene expression in potato in response to SAR activators

Last year we screened two SAR activators (BABA and phosphorous acid) against late blight and both were found effective in management of late blight. These two chemicals were again evaluated this year and results revealed that these chemicals @2g/l significantly reduced (40 & 60%) disease severity. Induced expression of defence genes by BABA and phosphorous acid was also studied. The expression of the defence related genes and *P. infestans* effector proteins α-1,3 glucanase, PR-1 protein, phytophthora inhibitor, protease

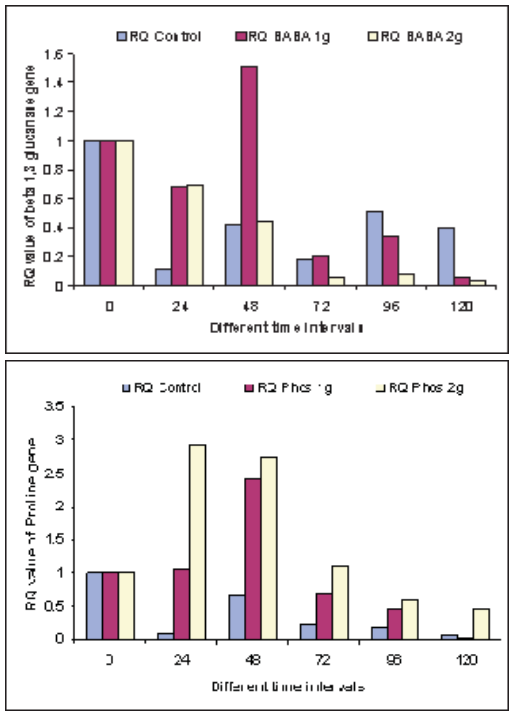


Fig. 10a: Effect of BABA and phosphorous acid treatment on the expression of cyclophilin gene during *P. infestans* infection of potato

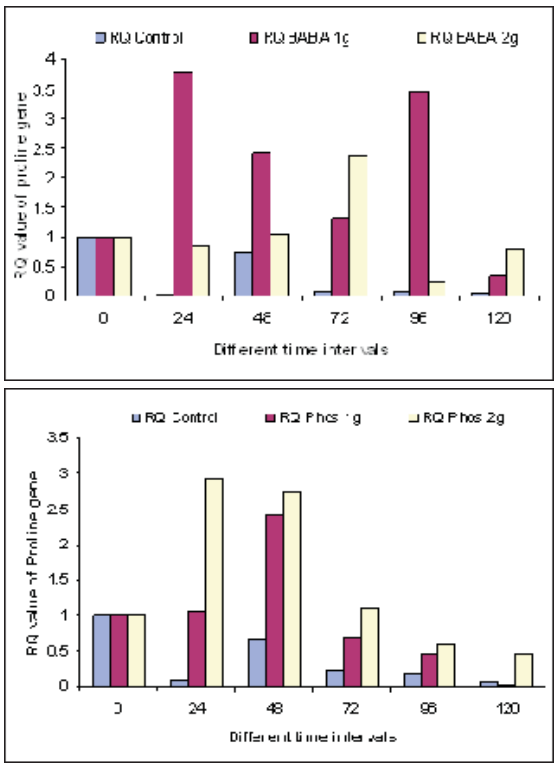


Fig. 10b: Effect of BABA and phosphorous acid treatment on the expression of proline gene during *P. infestans* infection of potato

inhibitor, xyloglucanase, thaumatin protein, steroid binding proteins, proline, endochitinase and cyclophilin genes were analysed by real time polymerase chain reaction-based approach by quantifying total RNA. All these defence related genes and *P. infestans* effector proteins were up regulated in response to *P. infestans* infection with the SAR activator treatment compared to unsprayed (Figs.10a &10b).

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

A total of 86,202 hybrid TPS were produced from 70 successful crosses attempted among selected late blight resistant parents at Kufri/Shimla/Shillong. About 15,750 seedlings of 17 crosses were screened against late blight under controlled conditions at Shimla and 1219 resistant seedlings were selected. The highest number of resistant seedlings were obtained in the cross CP-2379 x Kufri Himsona (15%) followed by CP-2379 x Kufri Girdhari (10.9%), CP-2379 x CP-4051 (9%) and CP 3087 x HR 9-5 (7.7%). At Shillong, 324 clones have been selected from 24 crosses based on tuber characters and resistance to late blight. In the initial stages (F_1C_1 to F_1C_4), 1003 genotypes were evaluated under natural field conditions at Kufri and Shillong for their disease resistance and adaptability and 296 clones were selected.

Evaluation of advanced generation hybrids

Seven F_1C_5 hybrids were evaluated in replicated trial with Kufri Jyoti (sprayed and non- sprayed), Kufri Girdhari and Kufri Himalini as controls. Four hybrids *viz.*, SM/03-45, SM/08-12, SM/09-123 and SM/09-33 yielded significantly better than the best control, K. Himalini, besides 2 hybrids SM/09-01 and SM/09-161 also yielded higher than the best control and the above 6 hybrids were selected for further evaluation

SM/03-23

during the next year. Five F_1C_6 hybrids were evaluated in replicated trial along with Kufri Jyoti (sprayed and non-sprayed), Kufri Girdhari and Kufri Himalini as controls. Hybrid, SM/03-23 yielded significantly better than the best control, K. Girdhari, besides 3 hybrids, SM/03-13, SM/03-70 and SM/05-75 also yielded higher than the best control and were selected for further evaluation during the next year. The late blight resistance in these hybrids was also at par with the best control, Kufri Girdhari.

Six advanced generation (F_1C_7) hybrids were evaluated in replicated trial along with Kufri Jyoti (sprayed and non-sprayed), Kufri Girdhari and Kufri Himalini as controls.

SM/01-07

SM/02-07

The hybrids, VMT 5-1, SM/03-32 and LBY-18 outyielded the best control variety, Kufri Himalini yielding 83.6%, 56.4% and 19.6% higher. Besides, two hybrids *viz.*, SM/01-07 and SM/02-01 yielded at par/ better with the best control Kufri Himalini and were selected for confirmation of results. At Ootacamund, seven hybrids were evaluated during summer crop season in replicated field trial along with K. Girdhari and K. Jyoti (sprayed & unsprayed) as controls. K. Girdhari (25.7 t/ha)

was the highest yielder and none of the hybrids could outyield the best control. At Shillong, five potato hybrids *viz*., LBY-15, LBY-16, LBY-17, LBY-24 and SM/92-338 along with checks Kufri Jyoti, Kufri Girdhari and Kufri Himalini were evaluated for yield and late blight resistance in autumn season of 2014-15.

Evaluation of medium maturing late blight resistant hybrids at Kufri

Three Late blight resistant hybrids (SM/00-72, SM/00-191 & SM/00-120) along with three controls i.e. Kufri Jyoti (both sprayed and unsprayed), Kufri Himalini and Kufri Girdhari were evaluated in a replicated trial in F_1C_7 generation. Hybrid SM/00-120 yielded statistically at par with the best control Kufri Himalini and was at par in resistance with the best control, Kufri Girdhari.

Evaluation of advanced hill hybrids under sub-tropical plains to identifying a photo-insensitive/ day neutral hybrid at Modipuram

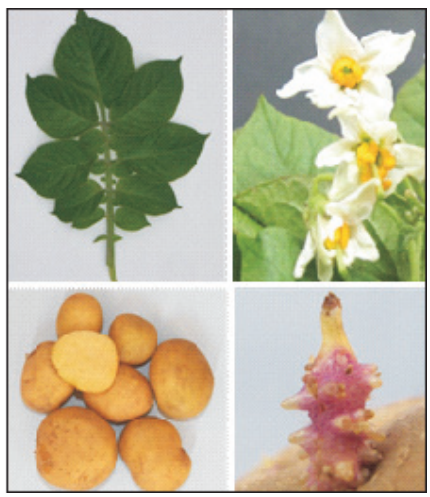
Twelve late blight resistant hybrids were evaluated in a replicated trial in the plains at CPRIC, Modipuram for adaptability along with Kufri Jyoti, Kufri Bahar, Kufri Sadabahar, Kufri Girdhari, Kufri Surya, Kufri Lauvkar and Kufri Himalini as controls. The results revealed that hybrids, SM/00-120, SM/01-07 and VMT 5-1 yielded significantly higher than the most prominent cultivar of the country, K. Jyoti and statistically at par with the highest yielding control Kufri Bahar. Besides, hybrid SM/00-42 yielded higher than Kufri Jyoti also. Based on their performance, three late blight resistant advanced hybrids *viz*, SM/00-120, SM/00-42 and VMT/5-1 were introduced in AICRP (P).

Pyramiding multiple disease resistance using marker assisted selection

Potato cultivars having multiple disease resistance are urgently required to boost production. Among biotic stresses, late blight, viruses and nematodes are the most devastating causing potato yield diminution across the country. With the advent in molecular markers based research, it is feasible to combine multiple resistance genes using Marker Assisted Selection (MAS) in the breeding programmes. Elite parental lines possessing multiple disease resistant genes (LB, PVY & PCN) were hybridized among complementary parents to stack multiple genes. Twenty five crosses were attempted among parents possessing multiple

SM/00-120

VMT 5-1



VMT 5-1

resistant genes. About 6648 hybrid TPS were obtained from 9 successful crosses to stack multiple disease resistance genes. 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. This programme is also expected to produce superior parental lines with multiple disease resistances. In F_1C_1 generation, a total of 698 clones were selected from 11 different crosses and selections were done based on tuber traits. The F_1C_2 generation advancement was carried out in rabi season at Modipuram and a total of 287 clones possessing desirable agronomic parameters were selected.

Molecular Characterization, Detection and Management of Potato Pathogens

Screening of germplasm accessions for virus resistance

Sixty one germplasm accessions were tested for PVY and PVX resistance through mechanical inoculation and tested by DAS-ELISA. Sixteen CP nos. were found having combined resistance to PVX and PVY, 29 CP numbers to PVY and 11 CP numbers to PVX, respectively. Five CP numbers were found susceptible to both the PVY and PVX.

Testing of potato viruses under Standard Operating Procedure for Accredited Test Laboratory (NCS-TCP) through DAS- ELISA

Seven hundred and eighteen samples of M/s Technico Agric Science Pvt Ltd. Baddi, Distt. Solan (HP), and Pepsico India Holding, Channo, Distt. Hoshiarpur (Punjab) were tested for the presence of PVX, PVS, PVY, PVA, PVM, and PLRV by DAS- ELISA and ToLCNDV-potato by PCR under Accredited Test Laboratory (NCS-TCP). 515 samples from Pepsico India Holding, Channo, Distt. Hoshiarpur (Punjab), M/s TechnicoAgric Science Pvt Ltd. Baddi, Distt. Solan (HP), Dayal Seed Pvt Ltd., Partapur, Meerut, District Horti-culture Officer, Uchani were also tested for viruses through DAS-ELISA/ PCR under non-ATL.

Post entry quarantine testing

Twenty one samples were planted in the glass house and tested for the presence of PVT, PYDV, AVB, APMoV, APLV, TRV, TRSV and *Clavibacter* through DAS-ELISA and for PSTVd through RT-PCR.

Survey and screening of potato samples by DAS – ELISA, EM and PCR

Surveys were undertaken at different potato growing areas in Western U.P. (Modipuram, Dabka, Mawana road, Joya, Amroha, Sambhal and Moradabad), Ooty, Hassan district in Karnataka, Faizabad and Kanpur in UP. Potato crop showing variable symptoms like mosaic, yellow mosaic and curling of apical leaves were collected and processed for DAS-ELISA, EM and PCR for presence of different viruses. ELISA results showed that PVX, PVS, PVY, PVM, and PLRV were the most common viruses associated with the collected samples.

GLAD-*Potato virus M* (PVM)

A study was initiated to detect *Potato virus M* (PVM) in infected potato leaves by immune-gold electron microscopy. A good concentration of filamentous flexuous long particle coupled with several colloidal gold (CG) nano particles revealing the presence of PVM (Fig. 1). More than one IgG-CG complex was associated with each

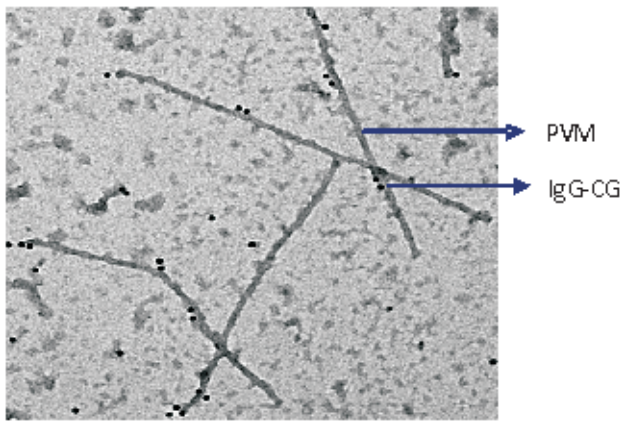


Fig. 1: Immuno-gold electron microscopic detection of potato virus M: Filamentous flexuous long particles of PVM coupled with IgG-CGcomplex

PVM particle indicating its successful conjugation with gold particles. Since only the homologous virus will be decorated with IgG-CG complex, it can be used for specific detection and diagnosing a targeted virus even in mixed infection of viruses with similar morphology.

Development of uniplex and multiplex RT-PCR technique for detection of *Potato virus Y* strains

Uniplex and multiplex RT-PCR detection techniques using primers specific to PVY^{O}, PVY^{N}, PVY^{NTN} and PVY universal primer (which can detect all the strains of PVY) were developed and validated by running across the infected samples collected from potato fields (Fig. 2).

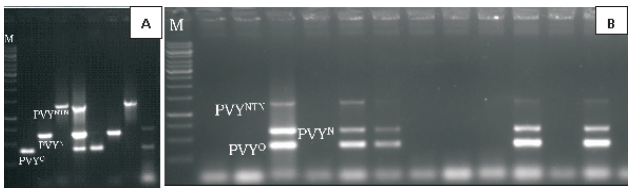


Fig. 2: Uniplex and multiplex RT-PCR of PVY strains (A) and evaluation multiplex RT-PCR technique by running across the samples collected from geographical locations

Real Time PCR for detection of potato viruses

Mixed infections are common in potato and the same samples are being tested for viruses separately. This demands more cost, time and labour. So, duplex qRT-PCR assay was standardized to simultaneously detect two viruses *viz*. ToLCNDV-Potato and PVX/PLRV. In duplex qRT-PCR assay, a melting peak of PVX/PLRV, which confirmed the amplification of both the targets (Fig. 3).

Transgenics for virus resistance

The replication associated proteingene (AC1) of the virus is being used for engineering pathogen derived resistance against ToLCNDV-potato in two popular potato cultivars Kufri Pukhraj and

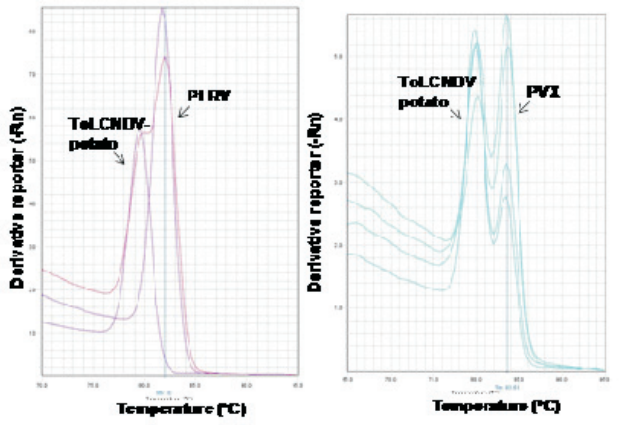


Fig. 3: Duplex RT-qPCR detection of ToLCNDV-potato along with, PLRV (a) and PVX (b)- Melting curve analysis showing the melting peaks of amplicons

Kufri Badshah. Event PCR analysis was carried out in two transgenic lines GTLC2-127 and KPLC2-53. The results indicated that the transgene was found integrated in two sites in chromosome 11 & one site in chromosome 3 in transgenic line GTLC2-127 and in chromosome 7 & 3 in transgenic line KPLC2-53.

Characterization of PVS CP genes

Molecular characterization of 50 isolates of PVS from different parts of the country was done through RT-PCR. CP gene was amplified, cloned in TA cloning vector and subsequently confirmed through restriction digestion analysis. We found our PVS isolates are quite distinct (92-93% similarity with ordinary strains and 83-80% similarity with Andean strain) from available PVS strains in NCBI database with regard to coat protein region. While within Indian strains 0-2% differences were recorded in the nucleotide sequence of CP gene.

Potato virus Y and its strains

The serious problem of *Potato virus Y* (PVY) has amplified with the emergence of new genetically recombinant and serologically different strains. This indirectly augmented the difficulties to identify or detect and manage the virus. So, it is very much essential to investigate the strainal

diversity of PVY in India so as to develop suitable and sensitive diagnostic and management techniques. Therefore, to resolve the problem, we investigated the presence of PVY strains in India by collecting potato leaf samples from different geographical locations *i.e.*, from Himachal Pradesh, Punjab, Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Rajasthan, Maharastra, Meghalaya, Tamil Nadu, Madhya Pradesh and Karnataka. These samples were examined by optimized uniplex and multiplex RT-PCR and found the presence of PVY strains (PVY^{O}, PVY^{C}, PVY^{N} and PVY^{NTN}) in majority of the places.

Groundnut bud necrosis virus (GBNV)

During a field visit in the month of July, 2014 we observed potato plants with stem necrosis disease and the same was confirmed by RT-PCR based detection confirming *Groundnut bud necrosis virus* (GBNV) as the causal agent. A full length coat protein (CP) gene of GBNV was PCR amplified and sequenced. Analysis showed that the query has 97% homology with the reported isolate of GBNV from Nellore (A.P; JF968415.1), Tirupati (A.P; HQ324115.1), Jalna (M.H; DQ375811.1) and GBNV isolate from Kanpur (U.P; JX524450.1).

Analysis of genes expressed during ToLCNDV-potato infection in potato cultivars using micro array

ToLCNDV-potato resistant (Kufri Bahar) and susceptible (Kufri Pukhraj) cultivars were planted in glass house and inoculated with the virus, ToLCNDV-potato. The inoculated plants were observed for symptoms and samples were collected at 10, 15, 20, 25 and 30 DAI. Symptom expression was started 15 days after inoculation in Kufri Pukhraj thereafter it increased to severe symptoms whereas it was delayed upto 35 days and only mild symptom was observed in Kufri Bahar. Gene expression analysis was carried out in samples (15 DAI) using Roche nimblegen microarray system. Analysis indicated that a total of 680 genes and 1934 genes were > 2 fold upregulated in Kufri Bahar and Kufri Pukhraj, respectively in response to ToLCNDV-potato infection (Fig. 4). Some of the genes were unique to the cultivar Kufri Bahar in which 32 genes expressed >10 fold higher in control plants, 2 genes in inoculated plants over Kufri Pukhraj control while 36 unique genes were over expressed in inoculated plants of Kufri Pukhraj.

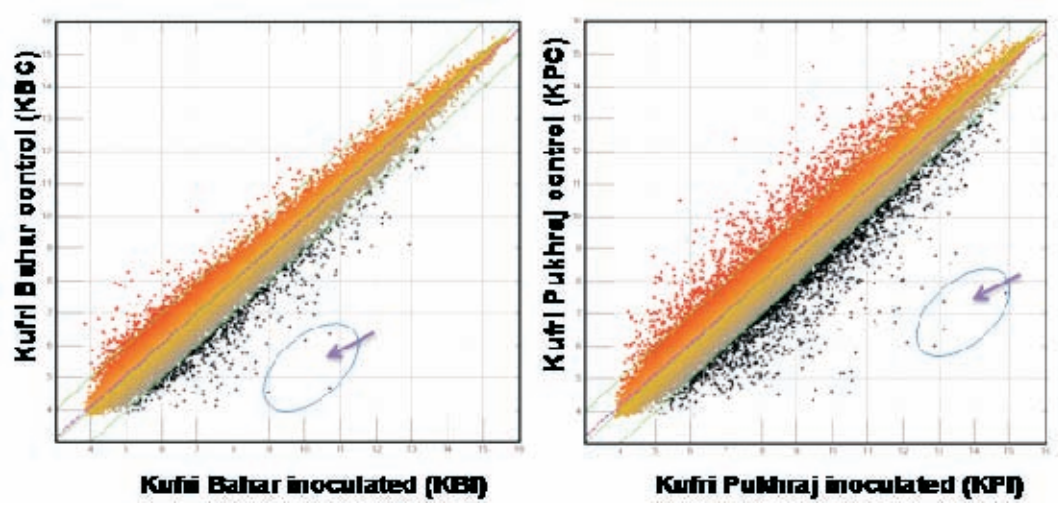


Fig. 4: Scatter blot analysis showing up and down regulated genes in potato plants inoculated with ToLCNDV-potato (circle indicates >15 fold up regulated in Kufri Bahar and >50 fold up regulated in Kufri Pukhraj)

Characterization, Detection and Management of Major Soil and Tuber Borne Pathogens of Potato

Soil and tuber borne diseases of potato such as bacterial wilt, common scab and black scurf are prevalent in many potato growing areas of the country and affect quality and marketability of the produce. These diseases not only cause economic losses but also spread far and wide through infected seed tubers which form the bulk of planting material. Bacterial wilt of potato caused by *Ralstonia solanacearum* is a limiting factor for potato cultivation in many parts of the country. With increase in global temperature, the disease is likely to spread to new areas and therefore, needs efforts to manage this disease on top priority. Breeding varieties for resistance against the pathogen has failed due to enormous variability present in the pathogen. This variability in this pathogen needs to be investigated in detail as understanding local pathogen diversity is the foundation of a successful breeding and integrated management programme. Similarly, identification and molecular characterisation of *Streptomyces* species associated with common scab and characterization of *Rhizoctonia solani* isolates causing black scurf disease of potato needs to be carried out to place the management practices of these diseases on sound footing. Besides, other safe and effective methods for management of these diseases need to be developed.

Fig. 1: Bacterial wilt infected potato tubers (brown rot symptoms); left: dirty white slimy bacterial mass oozing from infected tuber's eye, right: vascular browning of tubers with tiny drops of slimy bacterial mass

Characterization and detection of soil and tuber borne pathogens of potato

Collection of isolates

Thirty isolates of *R. solanacearum* (15 from East Khasi Hills, 5 from Raipur Chhatisgarh and 10 from Hoogly West Bengal) and eight isolates of *Streptomyces* species (from Patna) were collected during the current year. These isolates were purified and maintained in the laboratory.

Biovar and phylotype determination of *R. solanacearum* isolates

Based on differential ability of strains to acidify culture media containing a panel of carbohydrate substrates, biovar of each isolate was determined. The study revealed that out of 15 isolates from East Khasi hills of Meghalaya, 11 (73.3%) belonged to biovar 2 and 4 (26.7%) to biovar 2T of the pathogen. All the 10 isolates from West Bengal and 5 from Chhattisgarh were categorised as biovar 2 of *R. solanacearum*.

The phylotype specific multiplex PCR (Pmx-PCR) confirmed all the 30 isolates (15 from East Khasi Hills, 10 from West Bengal and 5 from Chhattisgarh) to be *R. solanacearum* as expected 280-bp fragment resulted in all the isolates following PCR amplification using the *R. solanacearum* specific universal primer 759/760. Of the 15 isolates from East Khasi hills, 11 (73.3%) belonged to phylotype II and 4 (26.7%) to Phylotype IV. Whereas all the 10 isolates from West Bengal and 5 from Chhattisgarh belonged to phylotype II of the pathogen.

Molecular characterization of *Streptomyces* species strains isolated from potato scab lesions

The phylogenetic analysis of 16S rRNA gene sequences of 43 *Streptomyces* strains revealed that

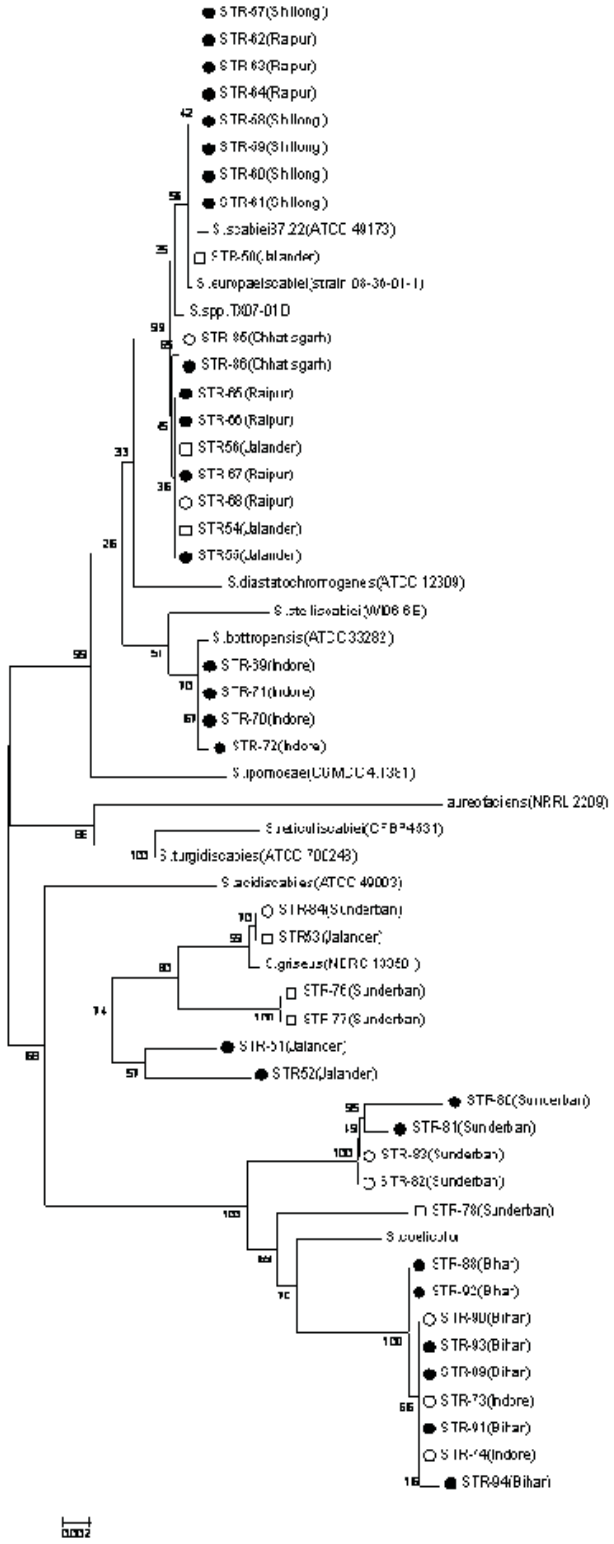


Fig. 2: The phylogenetic neighbour-joining tree based on the partial 16S rRNA gene sequences of 43 *Streptomyces* strains (36 pathogenic and 7 non-pathogenic) and *Streptomyces* species reference strains, generated using MEGA-5 software

among 36 pathogenic strains, 8 strains clustered with reference strain ATCC 49173 (*S. scabies*), 4 with reference strain ATCC 33282 (*S. bottropensis*), 1 with reference strain NBRC 13350 (*S. griseus*), 7 strains closely clustered with reference strain TX07-01D (*Streptomyces* spp., American pathogenic strain) and 10 strains were closely clustered with reference strain Y00411 (*S. coelicolor*). The rest 6 pathogenic strains did not cluster with any of reference strain. Among the 7 non-pathogenic strains, 2 clustered with reference strain TX07-01D (*Streptomyces* spp, American pathogenic strain), 1 with reference strain 08-36-01-1 (*S. europaeiscabie*), 1 with reference strain NBRC 13350 (*S. griseus*) while remaining 3 non-pathogenic strains did not cluster with any reference strains. The study revealed that diverse species of *Streptomyces* are associated with common scab disease of potato in India.

Multiple displacement amplification-polymerase chain reaction assay for detection of *R. solanacearum*

Compared to direct PCR assay, multiple displacement amplification-PCR could detect *R. solanacearum* up to 10^{-5} dilutions and was 1000 times more sensitive than direct PCR as direct PCR could detect *R. solanacearum* up to 10^{-2} dilutions only.

Management of major soil and tuber borne pathogens of potato

Screening of potato accessions for bacterial wilt resistance

Five potato accessions namely SS 1732, SS 1724-6, SS 1848-20, SS 1725-44, SS 1659-2 along with Kufri Jyoti as control, screened under glass house, were found susceptible to *R. solanacearum* (strain R3bv2) after 30 days of inoculation.

Screening of tomato accessions for bacterial wilt resistance

Among the five tomato accession screened in pots in glass house, Hawaii 7998 and Arka Alok were

found apparently resistant to *Ralstonia solanacearum* (r3bv2) after 21 days of inoculation compared to Palam Pink, Arka Abha, Utkal Urvashi and Pusa Ruby (check) who collapsed completely.

Development of safe and effective methods for management of major soil and tuber borne pathogens

A field experiment was conducted in randomised block design at CPRS Patna to see the efficacy of neem, mustard and castor cake powders in the management of common scab and black scurf diseases of potato. Cake powders (500 g) were applied in two split doses i.e. 50% at the time of planting in furrows and 50% at the time of earthing-up. Neem cake powder was found most effective in reducing the black scurf incidence and severity to 23.9 and 9.2%, respectively, compared to 88.7% incidence and 37.5% severity in control.

Management of *R. solanacearum* through biotechnological approaches

To analyse the molecular mechanisms of disease susceptibility, we screened cv. Kufri Jyoti showing susceptibility to *R. solanacearum* for the expression of lipid signaling pathway gene (PAP) (inhibitor for accumulation of reactive oxygen molecule and hypersensitive reaction) and cDNA was cloned from the infected tissues and confirmed their sequence homology (100%) by PCR cycle sequencing and NCBI BLAST analysis. Real time PCR analysis showed 2.5 fold higher expression of PAP transcript compared with non-infected tissues (Fig. 3). This confirmed that expression of PAP might contribute to disease susceptibility by inhibiting the accumulation of reactive oxygen molecules.

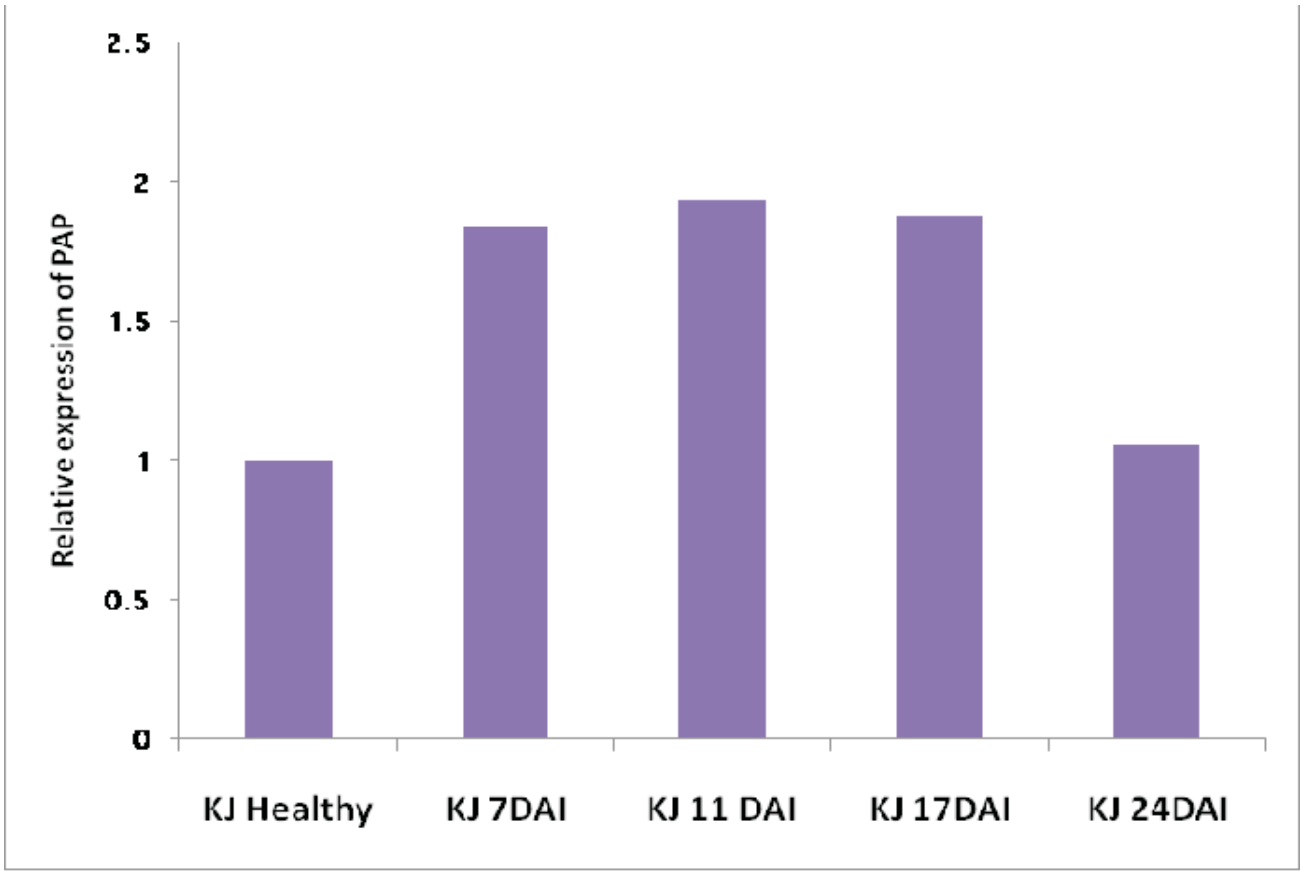


Fig. 3: Relative expression of PAP gene in *Ralstonia solanacearum* infected Kufri Jyoti potato cultivar

Population Dynamics and Management of Potato Pests

Monitoring and mapping of vector population on potato

Aphids are polyphagous pests of cereals, pulses, oilseeds, ornamentals, plantations and vegetables including potato. Aphids are known to cause indirectly, huge economic losses by transmitting important potato viruses such as PVY, PLRV, PVA, PVM and PVS under Indian conditions. Aphids were monitored in timely sprayed seed potato and unsprayed potato crop at Modipuram. *Myzus persicae* crossed the critical level after third week of December (24.12.2014). Whitefly population was very high on early crop up to second week of November. Manual field surveys and yellow sticky/yellow water traps were employed to map aphid population from different potato growing areas of India namely Patna, Kanpur, Kalyani, Shimla, Modipuram, Jalandhar, Hoshiarpur, Ludhiana, Pantnagar and Gwalior. Aphid species associated with potato were identified using taxonomic approaches as well as molecular techniques. Mitochondrial COI gene specific markers were used in PCR amplification (Fig. 1) and species identity was confirmed by matching the sequences generated with reference sequences of NCBI. A total of thirteen species of aphids have been found to appear on potato of which *Myzus persicae* and *Aphis gossypii* are the most common species. During the year under report, aphid species namely, black bean aphid, *Aphis fabae*, green citrus aphid, *Aphid spiraecola*, oleander aphid, *Aphis nerii*, corn aphid, *Rophalosiphum maidis*, glasshouse potato aphid, *Aulacorthum solani* and groundnut aphid, *Aphis craccivora* were found on potato.

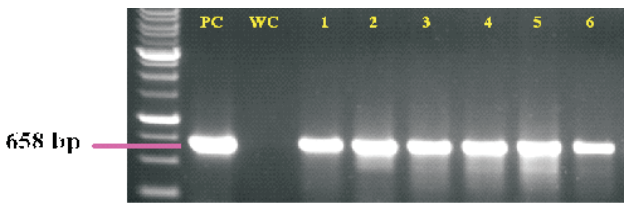


Fig. 1: PCR amplification of COI specific gene of aphids

Uniplex and duplex RT-PCR detection of PVY and PLRV from field collected aphids

Aphids are the principle vectors of most important and economically damaging viruses *viz.*, *Potato leaf roll virus* (PLRV) and *Potato virus Y* (PVY). The detection of viruses from plants as well vectors is crucial for healthy seed potato production and in this context, a standard uniplex RT-PCR assay was developed to detect PLRV and PVY from field collected aphids of Shimla, Jalandhar, Modipuram, Patna, Pune and Shillong. In PCR assay, specific bands of 464 and 395 bp corresponding to PLRV and PVY were observed (Fig. 2 & 3). The RT-PCR results revealed that the aphids collected from potato fields in Shillong carried both PLRV and PVY but in other locations only PVY was detected.

In addition to uniplex, a duplex RT-PCR assay was also standardized using the primers specific

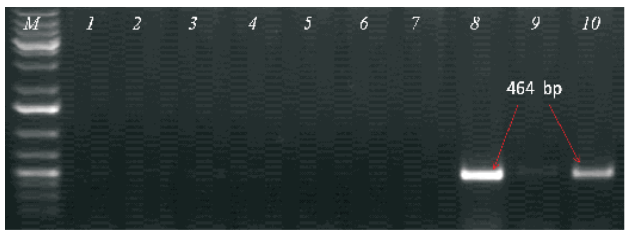


Fig. 2: Detection of PLRV in aphids. M-1 kb ladder, 1-water control, 2- Shillong 1, 3- Shimla, 4- Jalandhar, 5-Modipuram, 6- Patna, 7- Pune, 8-Kodaikanal, 9-Shillong 2, 10-Shillong 3

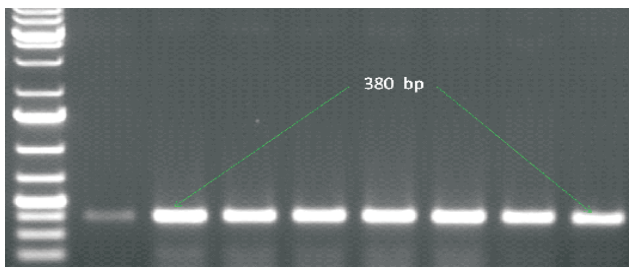


Fig. 3: Detection of PVY in aphids. M-1 kb ladder, 1-Pune, 2-Positive control PVY, 3-Solan, 4-Patna, 5-Jalandhar, 6-Shillong 1, 7- Shillong 2, 8- Modiapuram

to coat protein genes of PLRV and PVY for their detection in aphids simultaneously. The developed assay was used to detect PLRV and PVY in aphids collected from potato fields of Kodaikanal, Shillong, Pune, Shimla, Jalandhar and Patna. The duplex RT-PCR protocol could successfully detect PLRV and PVYsimultaneously in aphids. The results were confirmed by screening aphids for PVY and PLRV from Kodaikanal and Shillong (Fig. 4).

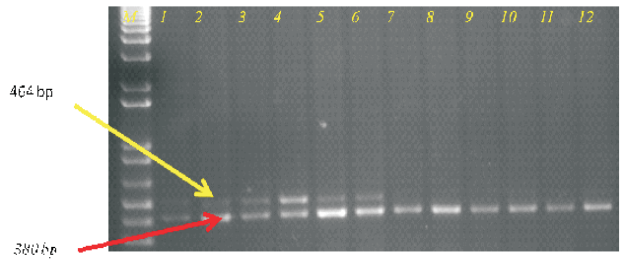


Fig. 4: Duplex RT-PCR detection of PLRV and PVY in aphids

M-1 kb ladder, 1-Positive control (PLRV and PVY), 2- Kodaikanal, 3- Shillong, 4- Shillong, 5- Shillong, 6- Shillong, 7- Shillong, 8- Pune, 9- Shimla, 10- Jalandhar, 11- Patna, 12- Solan, 13-water control.

Effect of non-edible seed oils on insect vectors and disease incidence

The population of whitefly remains low when sprayed with non-edible oils. Minimum incidence of whitefly was observed in the neem oil treated crop (2.33 to 5.0/10 plants) during second week of October to first week of December with 22.1% of PALCV incidence followed by karanj oil treated crop (3.33 to 6.66). The population of whitefly varied (1.0-3.0/10 plants) in imidacloprid treated plots as compared to control plots (8.67-13.33/10 plants) with disease incidence of 30% (Fig. 5 & 6).

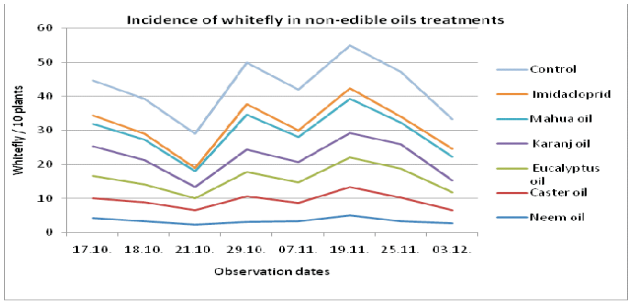


Fig. 5: Effect of non edible oil on incidence of white fly population

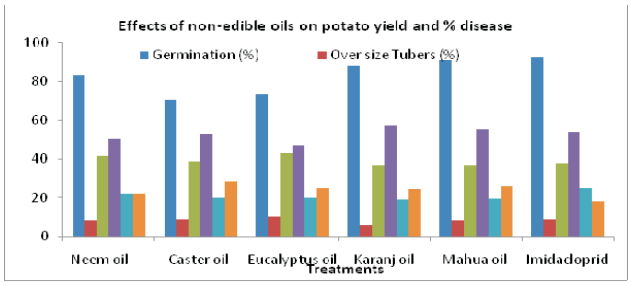


Fig. 6: Effect of non edible oil on potato yield and disease incidence (%)

However, mean total tuber yield did not differed significantly among the treatments.

Incidence of insect vectors on potato cultivars under sprayed and unsprayed conditions

The population of whitefly and aphids remained low on potato cultivars under protected condition. They did not differed significantly on potato cultivars under sprayed and unsprayed conditions. The maximum mean incidence of whitefly (16.33/ 5 plants) was recorded on K. Pukhraj when crop was 45 days old followed by K. Anand and K. chipsona-1 (15.33/ 5 plants) under unprotected condition. Total tuber yield differed significantly among potato cultivars under protected and unprotected conditions (Fig. 7, 8, 9, 10). K. Garima recorded the highest mean tuber yield (32.52 t/ha) and (29.91 t/ha), respectively under protected and unprotected conditions. K. Khyati recorded maximum increase in tuber yield 2.13 t over control with cost benefit ratio 1: 2.64 followed by K. Garima.

Effect of catch/barrier crops on incidence of insect vectors in potato

The lowest incidence of aphids and whitefly on potato plants were recorded when mustard crop (Fig. 11) was planted towards south direction with comparatively low incidence of diseased plants followed by mustard planted towards

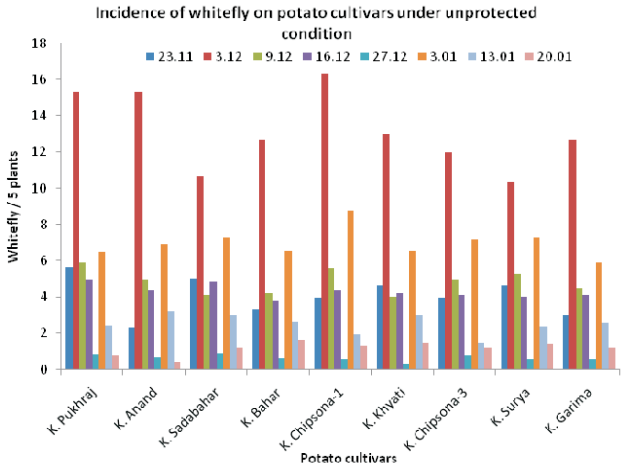


Fig. 7:

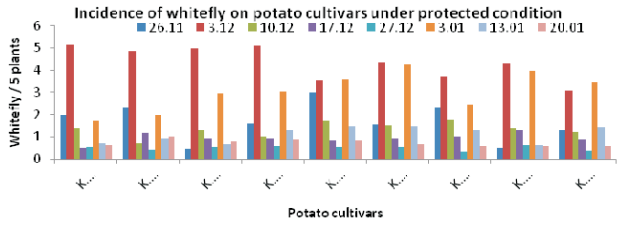


Fig. 8:

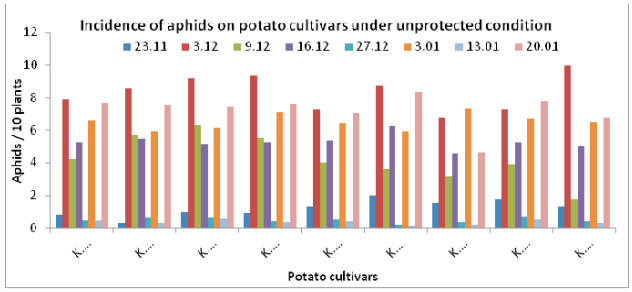


Fig. 9:

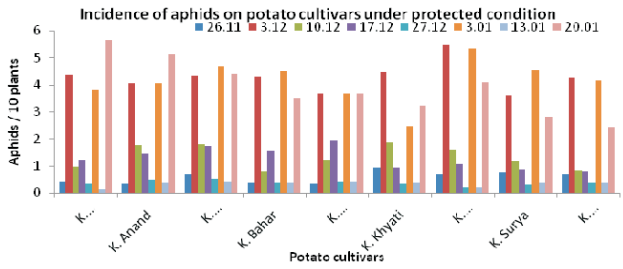


Fig. 10:

Fig. 11: Aphid population on mustard crop in potato field

north direction. Mustard crop effectively reduced the incidence of vectors on main potato crop. Maize as a barrier crop was found to be less effective as compared to mustard as catch crop. Data revealed that mustard crop grown towards south direction recorded maximum catch of aphids.

Monitoring and management of potato tuber moth in stores

Potato tuber moth (PTM) incidence in stores was monitored at three locations namely Samula, Malan, Pathiar of kangra valley during June to August 2014. The average per cent incidence of PTM in untreated tubers was 4.97, 6.7 and 8.65 respectively for the above three locations. The potato tubers in stores were treated with chemicals such as CIPC, spinosad, neem, CIPC+ spinosad, CIPC+neem and spinosad+neem. Tubers treated with CIPC+spinosad and CIPC+neem were found to be effective than other treatment including control.

Management of Potato Nematodes

Breeding for combined resistance to late blight and potato cyst nematodes

During the year, 60,000 hybrid TPS were produced from 51 bi-parental crosses involving selected late blight and potato cyst nematode resistant parents. The targeted number of 75,000 hybrid TPS could not be achieved due to outbreak of late blight immediately after crossing. In the F_1 generation about 14,200 true seeds belonging to 9 cross combinations were sown in boxes. In initial evaluation trials, 978 hybrids were evaluated in observational rows/single hill along with Kufri Girdhari, Kufri Neelima, Kufri Jyoti and Kufri Swarna as check varieties. Of these, 386 hybrids were selected based on late blight and PCN resistance, as well as based on desirable tuber characters.

Fifty three advance generation hybrids were evaluated in four replicated trials along with Kufri Girdhari, Kufri Neelima, Kufri Swarna, Kufri Jyoti (sprayed and unsprayed) as checks. Of these, 48 hybrids were selected on the basis of agronomic traits and resistance to potato cyst nematodes and late blight. Two promising advance generation hybrids, OS/94-I-126 (12 t/ha) and OS/01-161 (10 t/ha) were found resistant to both species of potato cyst nematodes and field resistant to late blight.

Integrated management of potato cyst nematodes

During the year, field experiments were carried out to evaluate the effect of trap crops, non-host crops on PCN multiplication and evaluation of various management options for eradication of PCN.

Trap crops

As trap crop for PCN, *Solanum tuberosum* cv. Kufri Jyoti was evaluated throughout the year in all three seasons *viz.*, summer, autumn and spring in different combinations. The trap crop was destroyed before the completion of PCN life cycle (45 DAP) and the succeeding crop cv. Kufri Girdhari was sown after the trap crop. Maximum decrease in cyst populations was found in trap cropping for two seasons *viz.*, summer + autumn (51%) followed by three seasons *viz.*, summer, autumn and spring (50%). Trap cropping in autumn alone (10%) and spring alone (13%) caused the minimum reduction in cyst populations (Fig. 1).

a. OS/01-161

b. OS/94-I-126

Non-host crops

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 for their effect on survival of PCN. Radish recorded 19.32 per cent reduction in number of cysts and 15.95 per cent reduction in number of eggs per cyst. It was followed by marigold which recorded 17.08 per cent and 13.58 per cent reduction in number of cysts and eggs, respectively. It was followed by garlic, french beans and beet root which caused 16.02, 11.85 and 11.04 per cent reduction in number of cysts, respectively (Fig. 2).

Integrated management of PCN

An experiment was conducted to evaluate various management options for eradication of PCN in resistant variety Kufri Swarna. The combination of trap crop, solarisation, furadon and organic amendment reduced reproduction upto 50.6% in PCN (Fig. 3) and followed by same combination with biocontrol agents which recorded 39.9% reduction in population.

Non-solanaceous crops

This trial was conducted with 16 different intercrop combinations to study their effect on PCN dynamics in potato. Among the two intercrops, radish is more effective than marigold because, the Rf value of PCN in the plots intercropped with radish (2:1) is lower (Rf-0.63 to 0.78). Radish and marigold as a sole crop also

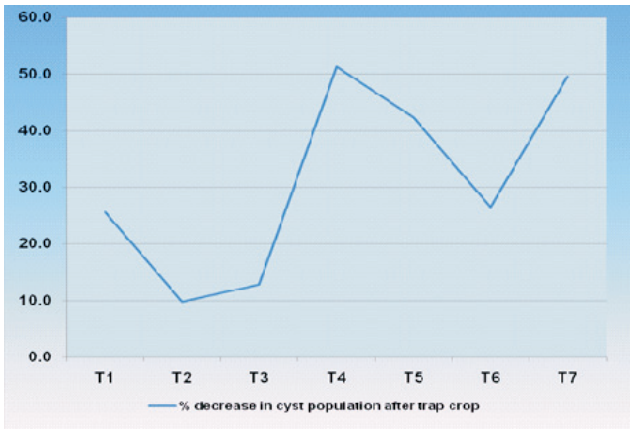


Fig. 1: Evaluation of trap crops on PCN

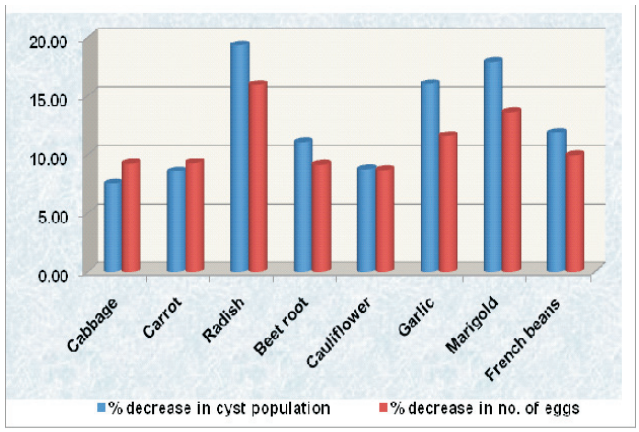


Fig. 2: Effect of non-host crops on PCN cysts and eggs

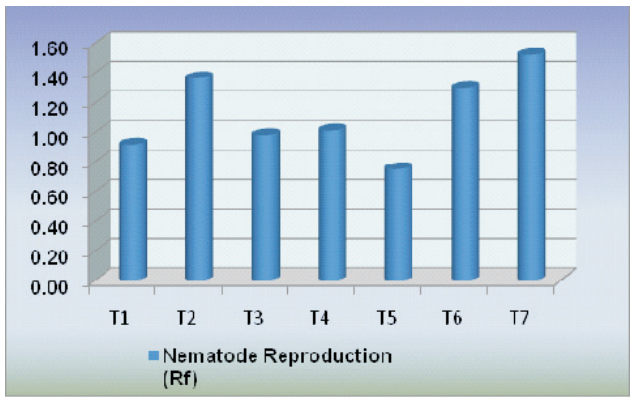


Fig.3. Evaluation of various management options for eradication of PCN

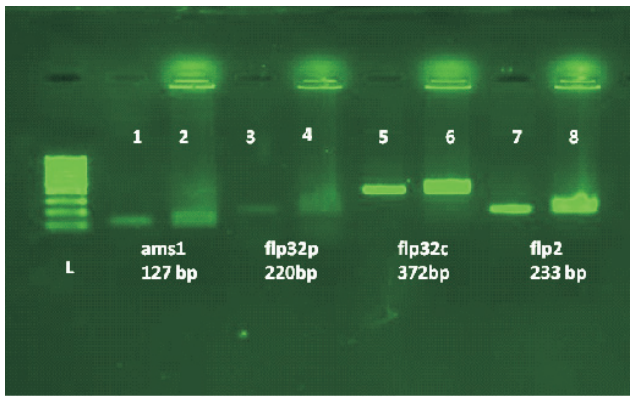


Fig. 4. Amplification of RNA (1, 3, 5 &7) and ds RNA (2, 4, 6 & 8)

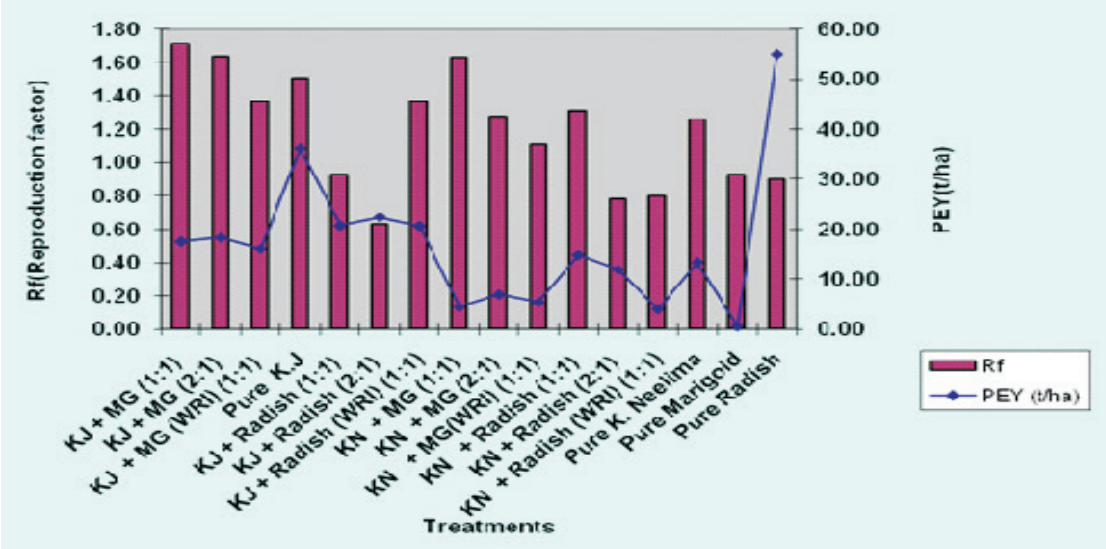


Fig. 4. Effect of potato based intercropping systems on PCN dynamics

effective in bringing down PCN population 0.90 and (0.93 Rf values respectively) (Fig. 5).

Transgenic approaches for management of PCN

Total four gene *viz*., ams, flp 32, flp 35, flp-12 responsible for chemosensory function, peptides in brain and ventral cord, G protein coupled receptor and normal neuro muscular function respectively were targeted for silencing to manage PCN. The dsRNA constructs were developed to target the above mentioned five genes. The ds RNA were fed to juveniles of PCN by RNAi soaking method. After 24 hours, it was found that flp 32 encoding motor function was interfered in tail and nervous system.

Survey for assessment of PCN dynamics in different crop seasons

A survey was conducted in the four taluks (Ooty, Kundha, Kotagiri and Coonoor) of Nilgiris district during the autumn crop season. Kollimalai area of Coonoor taluk recorded less population (3 cyst/100 ml) while maximum population (240 cyst/100 ml soil) was recorded from Porthyhada of Kunda taluk. In Ooty, the population ranged from 10-133 per 100 ml soil. In Kundha, the populations ranged from 44-240/100 ml soil. In Coonoor taluk it ranged from 3-68 /100 ml soil and in Kotagiri, it was 7-119/100 ml soil.

Division of Crop Physiology, Biochemistry and Post-harvest Technology

Nutritional Value of Potato and Potato Products

The programme aims at establishing the nutritional value of potato and the products made from potatoes. There are several misconceptions associated with potato consumption and to remove these misconceptions, it is pertinent to determine the various nutritional qualities of potatoes and even the anti-nutritional factors associated with potatoes or its products. The further aims are to develop the products/ processes resulting in high nutrition and or reduced anti-nutritional factors.

Flavouring compounds in Indian potato snacks

Flavouring compounds particularly umami 5′ nucleotides (AMP+GMP) were estimated from local potato products available in the market and processed potato products being sold by the retailers. Umami 5′ nucleotide content ranged from 2.63 (Aloo seekh) to 8.26 µg/g FW (fried lachcha) in local potato products (Fig. 1 & 3). In processed potato products, the content ranged from 2.72 µg/g FW (McCain smiles) to 14.75 µg/ g FW (Haldiram Aloo Bhujia) (Fig. 2 & 3). Along with aloo bhujia, umami 5′ nucleotides were also high in dehydrated aloo lachcha (11.14 µg/g FW) and dehydrated potato chips (10.13 µg/g FW) and low in McCain Smiles (2.72 µg/g FW) and McCain Potato Shortz (3.40 µg/g FW). The study suggests that the potato products prepared solely from potato contained higher levels of umami 5′ nucleotides compared to other products prepared by mixing potato with other cereals and vegetables.

Flavouring compounds in cooked potatoes

The AMP+GMP content ranged from 2.04 µg/g FW (Kufri Dewa) to 7.69 µg/g FW (Kufri

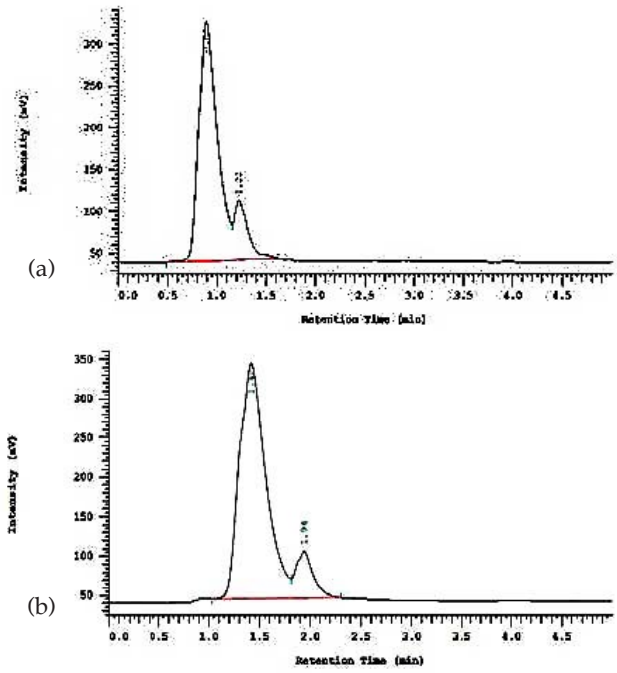


Fig. 1: HPLC chromatogram of AMP+GMP of (a) Aloo Seekh and (b) Fried Samosa

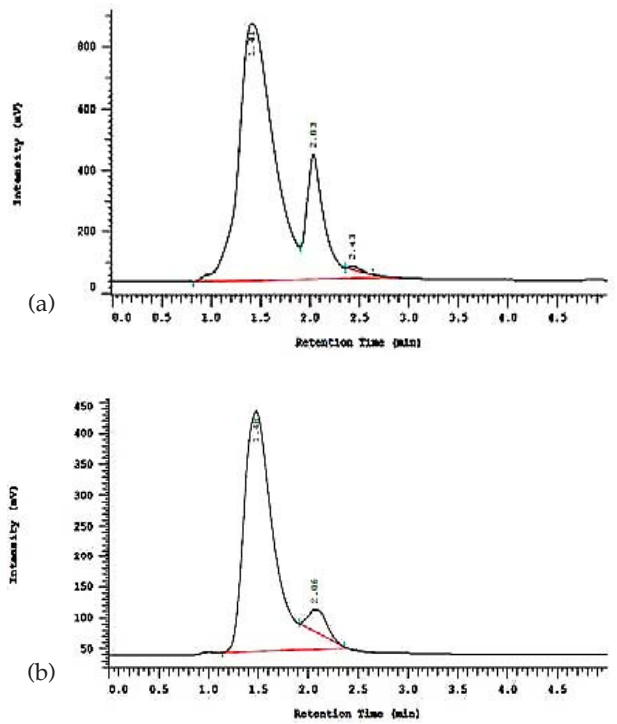


Fig. 2: HPLC chromatogram of AMP+GMP of (a) Aloo Bhujia and (b) McCains Masala Fries

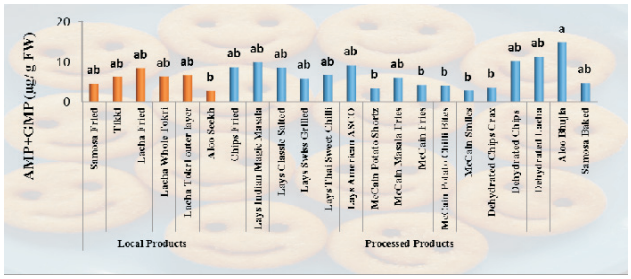


Fig. 3: Concentration of AMP+GMP (µg/g FW) in local and processed potato products

Chipsona-1) in raw tubers with the mean value of 4.60 µg/g FW in forty seven Indigenous potato cultivars (Fig. 4). After pressure cooking the content ranged from 1.47 µg/g FW (Kufri Chamatkar) to 12.75 µg/g FW (Kufri Frysona). The average content of AMP+GMP in forty seven potato cultivars was 5.92 µg/g FW after pressure cooking. Microwaved potatoes contained 2.67 to 8.87 µg/g FW umami 5′-nucleotides, with average content of 5.17 µg/g FW. On an average, overall there was 14% increase on microwave cooking and 31% increase in flavouring compounds (AMP+GMP) on pressure cooking.

Indirect estimation of Glycaemic index

a) Through α-glucosidase and α-amylase inhibitors

The natural forms of α-glucosidase and α-amylase inhibitors that we ingest through our daily diet have potential to prevent hyperglycemia helping manage the incidence of type II diabetes. The *in vitro* α–glucosidase inhibitory activity ranged from 0% to 52.8% in Indian potato cultivars and a large scale of variation has been observed amongst the 46 cultivars (Fig. 5). Out of all the tested cultivars, which included table as well as processing cultivars, the inhibitory activity was observed only in 14 potato cultivars which are used for table purposes *viz.* Kufri Anand, Kufri Arun, Kufri Khasigaro, Kufri Kuber, Kufri

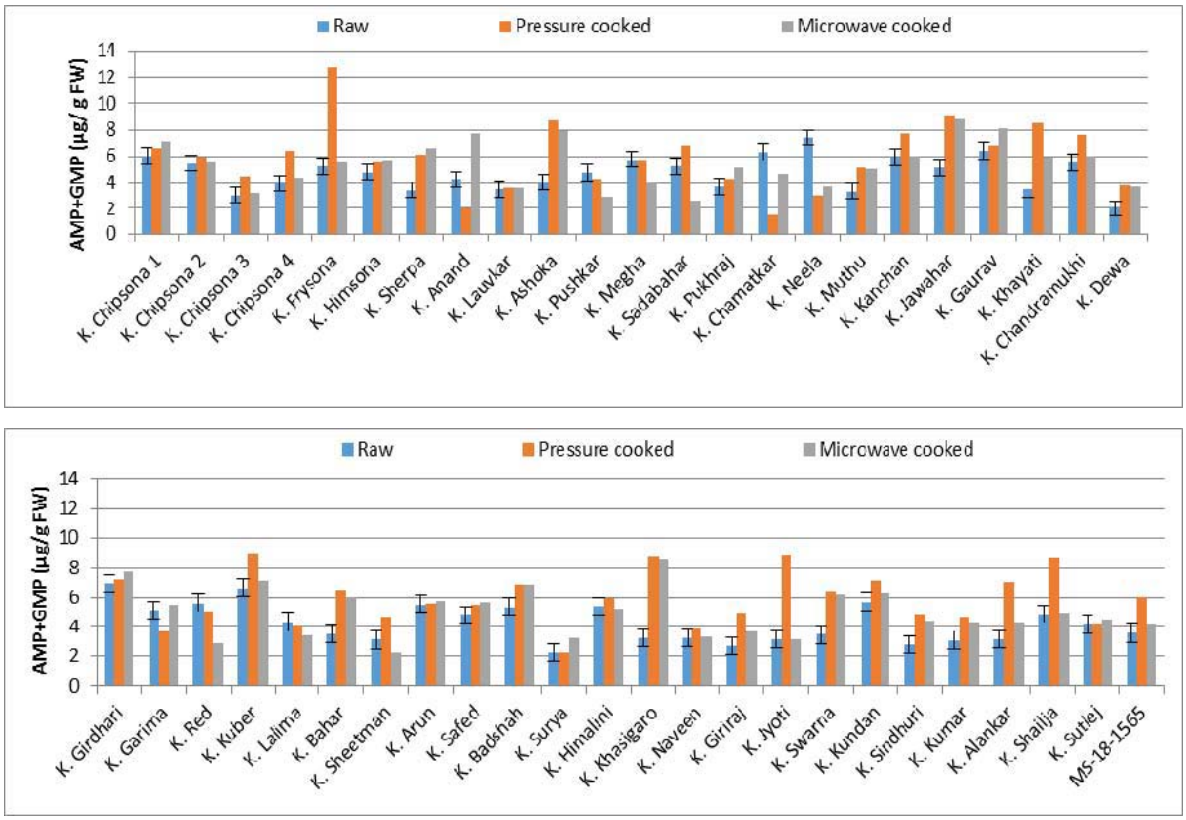


Fig. 4: Flavouring compounds in raw and cooked tubers of forty seven potato cultivars

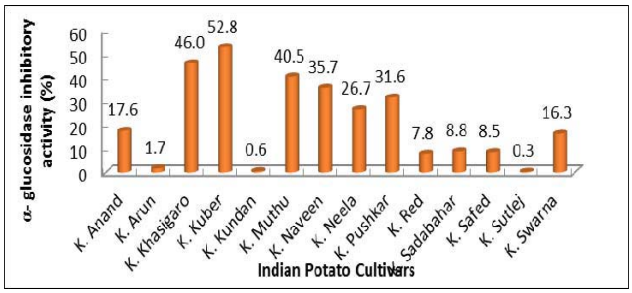


Fig 5. α-glucosidase inhibitory activities of Indian potato cultivars

Kundan, Kufri Muthu, Kufri Naveen, Kufri Neela, Kufri Pushkar, Kufri Red, Kufri Sadabahar, Kufri Safed, Kufri Satlej and Kufri Swarna. The α–glucosidase inhibitory activity was the maximum in Kufri Kuber. These inhibitors inhibit the breakdown of starch after consumption and absorption of glucose in the small intestine, respectively, and therefore, contribute towards management of hyperglycemia, linked to type II diabetes.

b) Through resistant starch and amylose content

Glycaemic index is inversely related to resistant starch (RS) content. RS III is the main form of RS present in cooked potatoes and is mainly derived from retrograded amylose. RS content in cooked tubers of Indian potato cultivars ranged from 1.22 to 1.93 mg/100 mg DW with highest value exhibited by Kufri Garima (1.93 mg/100 mg DW) followed by Kufri Giriraj (1.90 mg/100 mg DW), Kufri Girdhari (1.86 mg/100 mg DW) and Kufri Swarna (1.84 mg/100 mg DW) with the mean value of 1.53 mg/100 mg DW (Fig. 6).

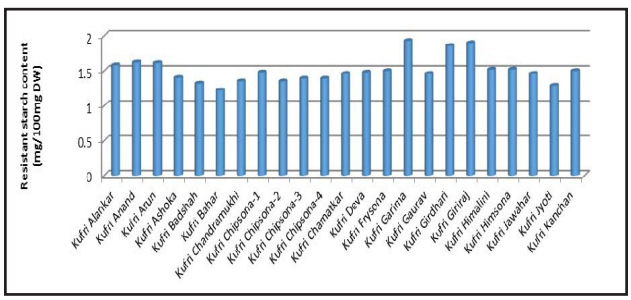


Fig. 6: Resistant starch content in cooked tubers of Indian potato cultivars

Amylose content in cooked tubers of Indian potato cultivars ranged from 10.8 to 27.6 mg/100 mg DW (Fig. 7). Amylose content was the maximum in processing cultivars *viz.* Kufri Chipsona-3 (27.6 mg/100 mg DW). Amylose is digested slowly compared to amylopectin, due to the formation of compact structure by linear chains of amylose. From health point of view, potato cultivars containing high RS and/or amylose content are superior due to the slow rise in blood sugar level. Ideal potato cultivars for diabetics are those which lead to slow release of sugars into the blood so that they do not cause any blood sugar spikes.

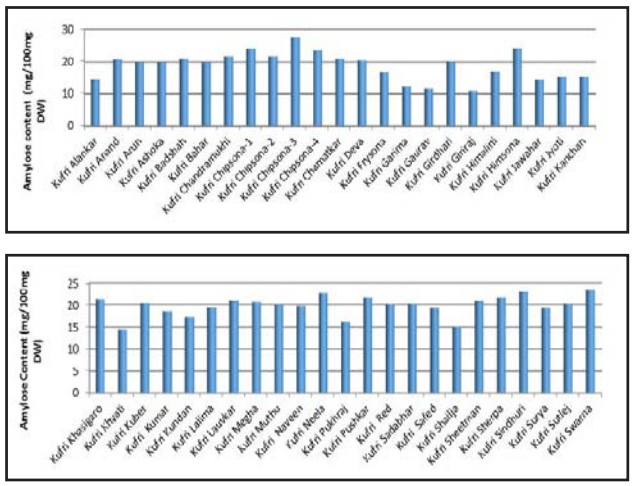


Fig. 7: Amylose content in Indian potato cultivars

Development of low fat potato chips

Microwave processing of potato chips was done without addition of oil keeping the fact of high fat content of potato chips in view. Microwave processing of potato chips was done using microwave power varied from 180 to 600 W using constant sample size (25g). Along with this, texture profile study of microwaved potato chips was also studied. Colour of microwaved potato chips was slight creamish yellow (L*: 69.38; a*: -2.31; b*: 19.22) which was quite similar to fried potato chips (L*: 64.60; a*: -2.09; b*: 17.51) (Fig. 8 & 9). It was found that at 600 W after 2.5 to 3.0 min of processing, potato chips gained the

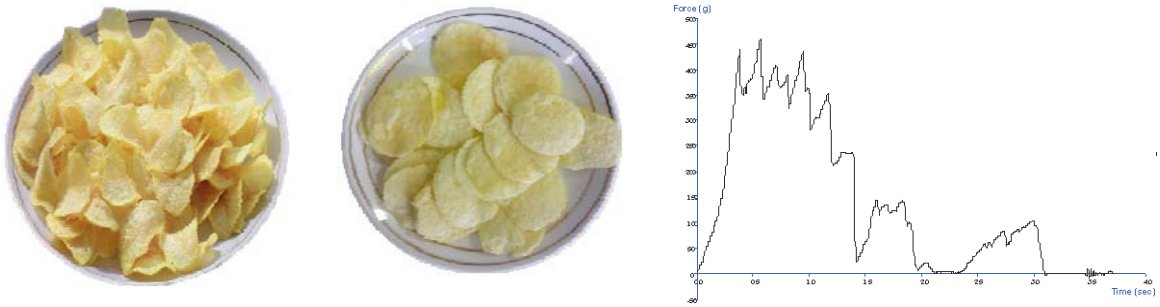


Fig. 8-10: Fried Chips; Microwaved chips; Texture Profile curve of microwaved chips

fructurability (452.21 g) and crispiness index (18 positive peaks) as that of commercial fried chips (Fig 10). Microwave processing was found suitable to process the potato chips with acceptable sensory scores (≥ 7.6 on 9.0 point Hedonic scale vs 8.0 of control preparation) with low fat content (~3.57% vs 35.5% in commercial preparation).

In another previous study, it was observed that osmotically dehydrated (OD) French fries with acceptable colour and taste could be made but these were less crispy as compared to Frozen French fries. This experiment was conducted again with different chemical concentrations on potato chips. OD dip treatments for 1, 2 and 3 hrs and convection heating treatments in microwave oven was done. Chips made after all OD dip treatments were crispy, good in taste and flavour and within the acceptable colour range. Whereas the microwave heating prior to frying deteriorated the quality of chips. OD treatments generally reduced oil content in chips and the best treatments recorded 29.75, 33.13, 31.64 and 32.37% oil content as compared to the control chips (40.99%) made by the conventional process.

Quick fat estimation in potato chips

A cost effective methodology was standardized for rapid estimation of fat in potato chips using solvent extraction principle keeping its high surface area to weight ratio in view.

Approximately, 0.50 to 0.75g (a) triplicate samples of potato chips were crushed and mixed with 25 ml of petroleum ether (B. pt. 40–60^{0}C). This mixture was centrifuged in two cycles for 2 min at 1,000 rpm and 35^{0}C, with in-between horizontal shaking of 5 sec. The mixture was then filtered through Whatman filter paper (No. 1). The final weight of the potato chips after extraction (defatted potato chips) was measured (b). The fat content in potato chips was calculated using the following expression:

$$\%Fat\ content = \left[\frac{a-b}{a}\right] \text{ x } 100$$

Using this methodology, the estimated fat content of commercial available chips (Lay's classic salted) and control samples was found to be 35.76% and 36.37%, respectively. The results were also validated through Soxhlet assembly (Socs Plus SCS 4 model made by Pelican Equipments, Chennai, India).

Drying kinetics of potato chips under microwaving

Microwave drying has been found to be a better option as compared to conventional hot air drying as it is rapid, more uniform, energy efficient for which food industry is always looking for. Microwave drying also reduces the drying time and prevents the food from enzymatic decomposition like browning for which potatoes are highly susceptible. Therefore drying kinetics study was done in potato chips. Microwave drying experiments for raw potato chips were performed at five different microwave output powers 180, 300, 450, 600 and 900W.

Mathematical modeling: The microwave drying data was fitted to 11 drying models i.e. Lewis, Page's, Modified Page, Henderson and Pabis, Diffusion, Two term, Logarithmic, Wang and Singh, Verma *et al.*, Modified Henderson and Pabis and Parabolic for different microwave power to describe the drying kinetics. Comparative study of different models was done in order to test the applicability of the same for microwave drying of potato chips. Parabolic model was found to be best fit to illustrate drying kinetics of potato chips in microwave heating followed by Diffusion and Verma *et al.* model.

Microwave drying of potato chips (average thickness ~0.0016 m) was done using different microwave power varied from 180W to 900W for constant sample sizes (25 g). Almost all drying of potato chips took place in falling rate period (Fig. 11).

The average drying rates were in the range of 3.12 x 10^{-4} to 2.72 x 10^{-2} kg H_2O/kg db at the experimental conditions (Microwave power ranged from 180-600 W for 5-6 minutes). For microwave drying of potato chips, 450 and 600 W was found to be more appropriate wattage in comparison with 180, 300 and 900 W due to higher drying rate (Fig. 11). At 180 W, products become soggy whereas at 900 W, as drying time increased, browning of potato chips occurred due to high heat generation.

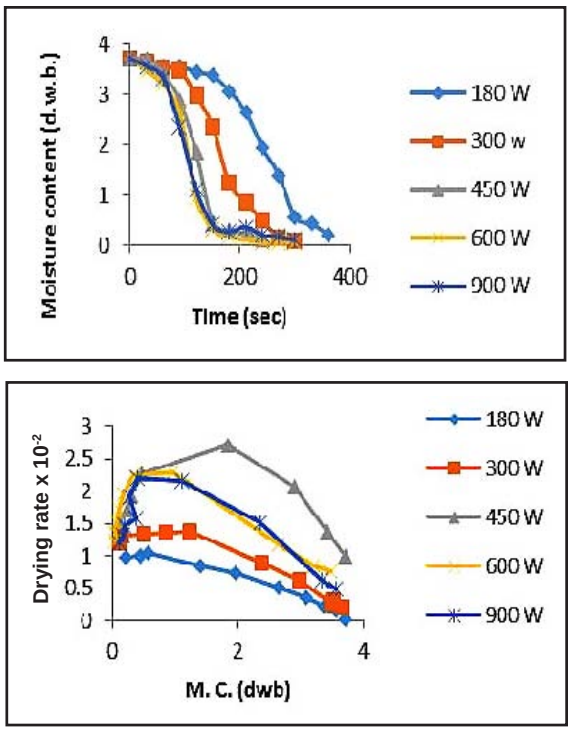


Fig. 11: Changes in moisture content and drying rate during microwave drying at different wattage

Mineral fortification of potato chips by vacuum impregnation

An experiment was planned to fortify potato chips with calcium and zinc minerals using calcium lactate and zinc sulphate as fortificants keeping their high bioavailability in view. Calcium and zinc fortification were done by vacuum impregnation assembly fabricated by Division of Food Science and Post Harvest Technology of IARI, Delhi (Fig. 12).

The effect of degree of vacuum level (30 to 90 mm Hg), calcium concentration (2 to 8 %), zinc concentration (1 to 3%) and restoration period (10 to 20 minutes) on fortification was determined using Response Surface Methodology. After optimization, it was confirmed that calcium lactate at 10.29%, zinc sulphate at 2.89%, vacuum level at 33.53 mm Hg with restoration period of 19.52 minutes can fortify potato chips that can fulfill 21% and 100% RDI need of calcium and zinc

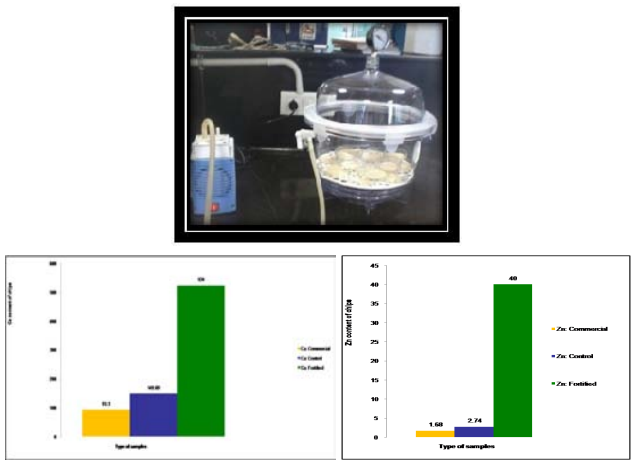


Fig. 12: Vacuum impregnation assembly and mineral content in various types of chips

in adult with 30 g serving which is RACC (Recommended Amount Customarily Consumed) for potato chips. The developed potato chips can be considered as rich source of calcium and zinc as in comparison, fortified potato chips had calcium and zinc content 3.5 and 14 times higher than that of control preparation (Fig. 12) with acceptable sensory scores (≥ 7.8 on 9.0 point Hedonic scale vs 8.0 of control preparation).

Fractionation study of potato haulms for nutrition

Fresh leaves/stem (1000g) was taken from experimental field of cv. K. Pukhraj were chopped and juice was extracted. The juice obtained after pressing leaves and stems was subjected to heat to 80°C to obtain coagulum. The leaf, stem, leaf fibre, stem fibre, leaf coagulum, stem coagulum, leaf whey and stem whey were analysed for their biochemical attributes. The results indicate that leaf coagulum comprises highest dry matter (22.64%) followed by stem coagulum (19.01%), leaf fibre (17.32%) and stem fibre (10.28 %). Leaf consists 12.36 % dry matter whereas stem has 8.63% dry matter (Fig. 13).

Leaf fibre (112.54mg/100g FW), coagulum (123.58mg/100g FW) and whey (22.69 mg/100g FW) contained more content of phenols as compared to stem portion. Very little differences were found in starch content of leaf and stem. Leaf fibre registered highest starch content (2.86%) among different fractions of haulm. Total sugar was found to be the highest in stem coagulum and minimum in stem whey. The study suggests that the potato haulms which are generally wasted may be utilized as microbial substrates due to its nutritional composition.

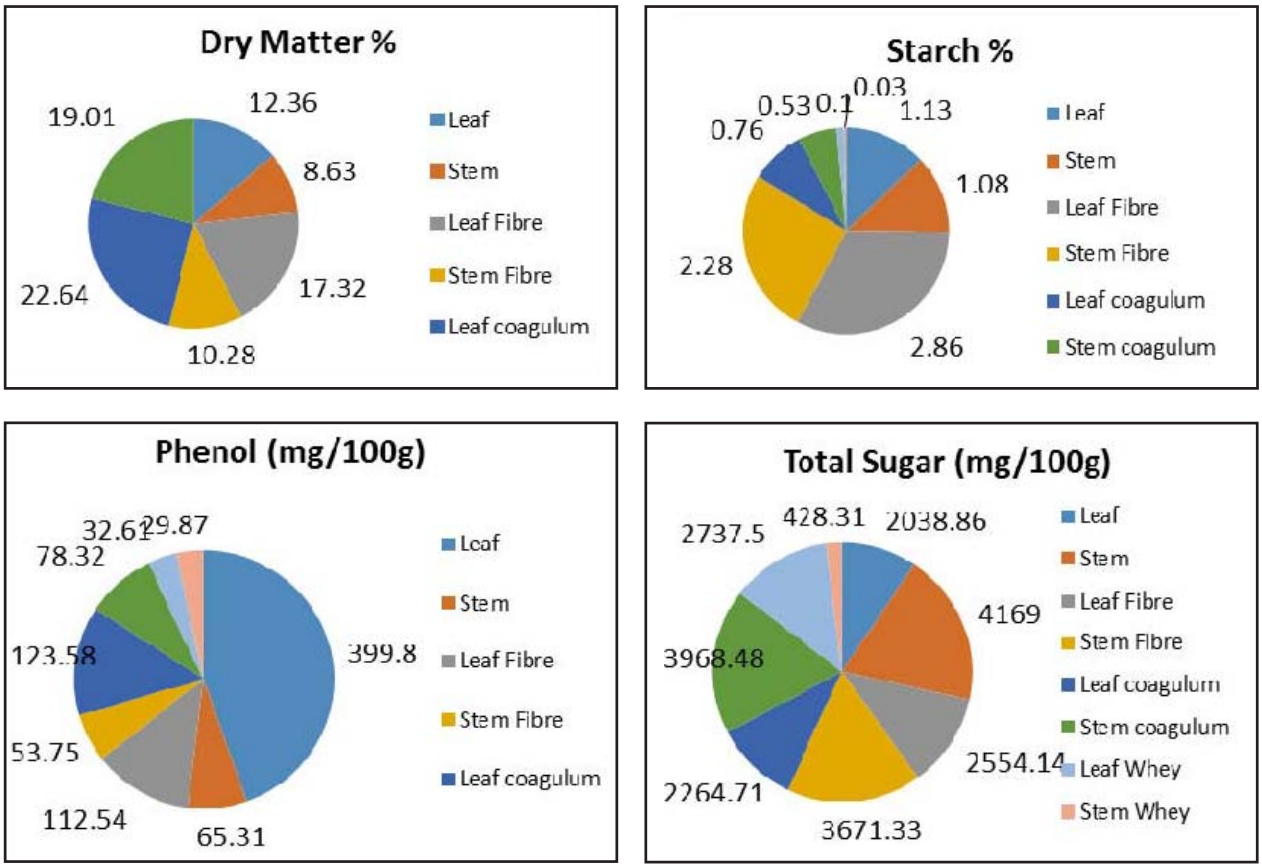


Fig. 13: Nutritional composition of haulms

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 an alternative method for sprout inhibition using a compound which is naturally occurring, has low mammalian toxicity and does not adversely affect the processing quality. Physiological and biochemical changes associated with dormancy release and during storage are being investigated for better understanding of the underlying processes in potato tubers.

A new cost effective methodology for estimation of total phenolics and % DPPH inhibition

A method for the estimation of total phenolics through ELISA plate reader was standardized and validated and the contents were at par with the total phenolics estimated by the earlier method (Fig. 1). The method is suitable for analysis of large number of samples to save time, cost and man power. Time saving method for the estimation of % DPPH inhibition for measuring the antioxidative potential of a cultivar, was also standardized through ELISA plate reader.

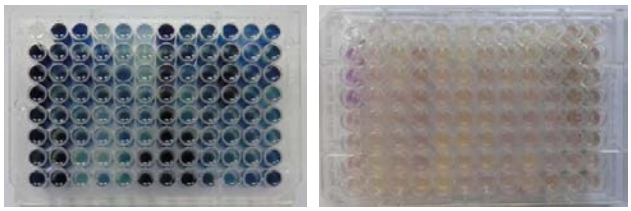


Fig. 1: Colour development of (a) total phenolics and (b) % DPPH inhibition in ELISA plate

Total phenolics changes during storage

Phenolic contents ranged between 25.4 to 39.5 mg/100g FW in freshly harvested tubers of thirty two Indian potato cultivars, with the least contents recorded in Kufri Sheetman (25.4 mg/100g FW) followed by the processing cultivar Kufri Chipsona-3 (25.7 mg/100 mg FW) (Fig. 2). Low phenolic content is desirable for processing to avoid product darkening. Phenolic contents increased during storage up to 180 days with a higher increase recorded at 12°C compared to 4°C. At both the storage temperatures, processing cultivars recorded least (Kufri Chipsona-3 at 4°C and Kufri Chipsona-1 at 12°C) and table purpose cultivars recorded highest phenolic contents (Kufri Badshah and Kufri Sutlej at 4°C and 12°C, respectively) (Fig. 2). Potato tubers contain several antioxidant compounds and total phenolics are the major one contributing to the total anti-oxidative activity. Increase in total phenolics during storage could be due to the activation of plant's defence mechanism to protect cells from

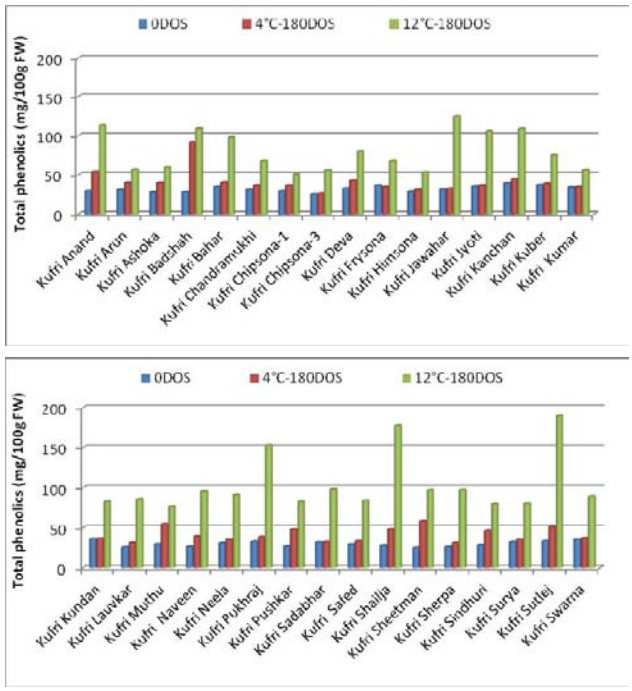


Fig. 2: Total phenolic content in thirty two Indian potato cultivars

membrane damage during senescent and low temperature sweetening.

Anti-oxidant system during storage

Our earlier studies showed higher ascorbate peroxidase (APx) activity and ascorbic acid (AsA) contents at low temperature (4°C) and supported the speculation that greater formation of active oxygen species at lower temperatures result in changes in membrane transport properties leading to more accumulation of free sugars. Higher APx and AsA contents were recorded in processing cvs. Kufri Chipsona-1 and Kufri Chipsona-3 along with low sugar accumulation during storage in comparison to Kufri Pukhraj, a table purpose variety.

Dehydroascorbate contents also decreased during storage and were higher in processing cultivars (Fig. 3). Glutathione reductase activity (GR) also remained consistently high in processing cultivars Kufri Chipsona-1 and Kufri Chipsona-3 than Kufri Pukhraj with poor storability (Fig. 4). Like APx, GR activity was also more pronounced at low temperature (4°C) than at elevated temperature (12°C).

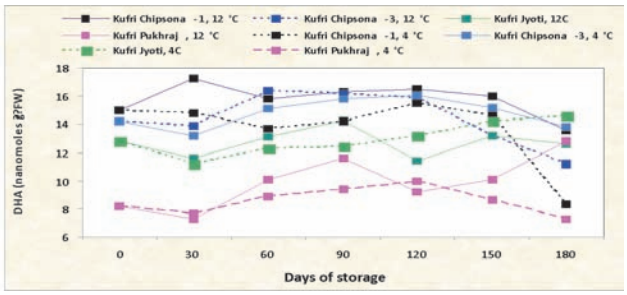


Fig. 3: Effect of storage temperatures on dehydro-ascorbate content

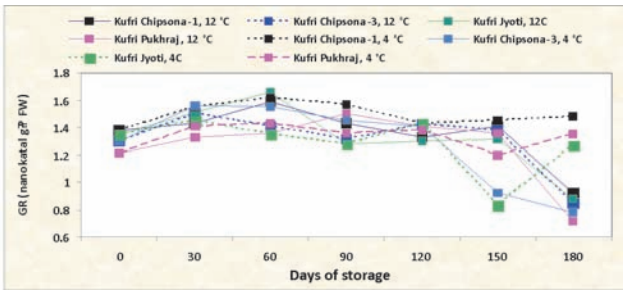


Fig. 4: Effect of storage temperatures on glutathione reductase activity

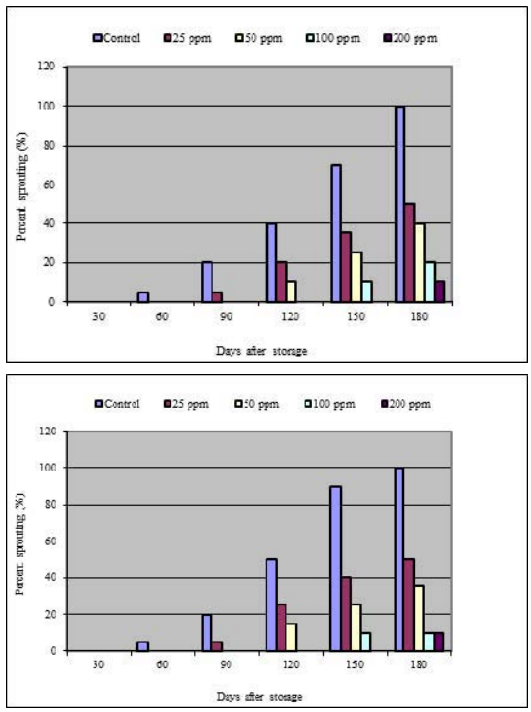


Fig. 5: Percent sprouting in tubers during storage at 12°C after treatment with two organic compounds (top: R-23; bottom: R-24)

Sprout suppression using organic compounds

With the increased awareness regarding use of safe chemicals in agriculture, it has become pertinent that alternative chemicals with no residual effect be used on crops. Chlorpropham (CIPC) is being used for sprout inhibition in potatoes and efforts are on to find non-toxic alternatives for the purpose. Two organic sprout suppressants *viz.* R-23 and R-24 were evaluated on freshly harvested tubers from Shimla in two parts.

In the first experiment different doses (25-200 ppm) of the two chemicals were evaluated in potato varieties, Kufri Jyoti (medium dormant) and Kufri Giriraj (short dormant) at 12°C storage for six months. The control (untreated) tubers started sprouting within 60 days of storage. In comparison, the treated tubers sprouted after about 90 days (at 25 ppm), 120 days (at 50 ppm) and 150 days (at 100 ppm dose). Treatment with 200 ppm recorded almost complete sprout

inhibition up to 180 days (Fig. 5). Weight loss in tubers was significantly reduced (7-11%) in treated potatoes in comparison to control tubers (13.1%).

In the confirmatory experiment, 200 ppm dose of R-23 and R-24 was evaluated on one quintal each of cv. Kufri Jyoti. The tubers after treatment were kept in sealed containers for 24 hrs and then stored in leno bags at 12°C for six months. Both the compounds were found equally effective. No sprouting was seen till 120 days (Fig. 6). Only 20-30% sprouting was recorded after six months of storage with significant reduction in sprout growth. Weight loss in potatoes also remained less than 10% (acceptable value) in both the treatments (9.4 to 9.8%). There treatment did not record any adverse effect on the processing quality of potatoes.

Fig. 6: Sprout suppression in potatoes with R-23 (200 ppm) after 120 days of storage at 12°C

Sprout suppression with naturally occurring volatile compounds

Preliminary screening experiments were conducted for evaluation of four naturally occurring compounds for sprout suppression at 24±2°C. Vapour treatment with menthone derived from *Mentha arvensis* induced complete sprout inhibition up to 100 days of storage in comparison to CIPC treated and control (untreated) potatoes which recorded 23.8 and 100% sprouting, respectively. Treatment concentration of 250 µl/l recorded the best results with minimum weight loss and nil rotting in potatoes (Fig. 7).

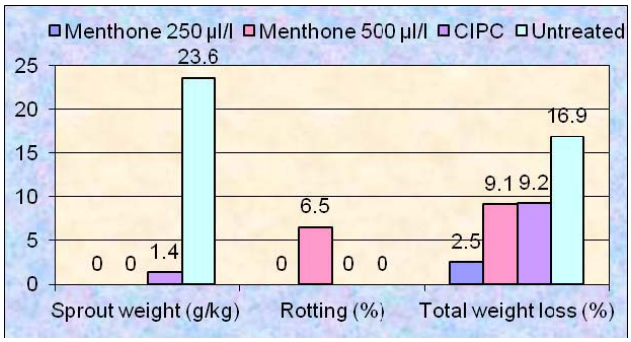


Fig. 7: Sprouting parameters in potatoes after treatment with menthone in comparison to CIPC after 100 days of storage

Physiological and Genetic Approaches in Managing Heat and Water Stress under Sub-tropical Environment in Potato

Hybridization and evaluation of clones for heat tolerance

Eighty nine crosses were attempted at Kufri between suitable parents having heat tolerance and earliness, out of which 65 were successful and yielded 49511 seeds. During winter 36 successful crosses at Modipuram yielded 1,34,335 seeds. 6120 seedlings were raised from19900 seeds of 10 crosses and 269 selections were made based on tuber characters like size, color, shape, synchrony, eye depth etc. Maximum selection were obtained from cross CP 3962 x YY-6 (143) followed by CP 3142 x Kufri Khyati (106). At Shimla 5000 seeds from 7 crosses were screened in a heated glass house and 152 selections were made. At Modipuram F_1C_1 to F_1C_3 were multiplied and evaluated during normal planting season and F_1C_4 to F_1C_6 were evaluated during early planting conditions under heat stress.

Screening for heat tolerance under controlled conditions

Seven advanced hybrids were tested for their ability to tuberize at 24°C night temperature by leaf bud cutting technique. At 24°C night temperature, the tuber formation was observed in 5 hybrids and Kufri Surya (Fig. 1). The technique was also used to study heat tolerance in five CIP clones.

Fig. 1: Screening for heat tolerance under controlled conditions

Performance of advance stage genotypes of heat tolerance at Pune and Ladol

At Pune (Maharashtra) 6 HT advanced hybrids were evaluated along with two control varieties in replicated trial under *Kharif* planting season. At 90 DAP significantly higher tuber yield was obtained in the Advanced hybrid HT/7-620 (26 t/ha) followed by HT/7-239 (21 t/ha) (Table 1). At Ladol (Gujarat) seven advanced hybrids were evaluated along with two control varieties in replicated trial under early *rabi* planting season at 75 and 90 DAP. Significantly higher tuber yield was obtained in the advanced hybrid HT/7-620 (35 t/ha at 75 DAP) and at 90 days crop duration HT/7-1329 (41 t/ha) followed by HT/7-620 (40 t/ha) was found to be significantly superior.

Table 1: Tuber yield (t/ha) of HT advanced hybrids at Pune and Ladol

Hybrid/ Variety	Pune under *Kharif* season	Ladol under	*Rabi* season
	90 DAP	75 DAP	90 DAP
HT/7-1105	15.97	27.44	38.59
HT/7-804	18.04	28.42	31.04
HT/7-620	25.55	35.27	40.19
HT/7-321	18.79	31.10	36.17
HT/7-239	21.46	32.56	33.91
HT/7-1329	18.33	27.23	42.33
HT/6-88	—	29.06	32.77
K. Surya	19.16	25.08	31.86
C.D. 5%	1.39	1.20	2.76

Biomass allocation pattern under heat stress in UP

Studies on plant biomass distribution were carried out using Kufri Bahar (popular variety of the region) and Kufri Surya (heat tolerant). The biomass allocation patterns estimated at 70 DAP in different plant parts are shown in Fig. 2.

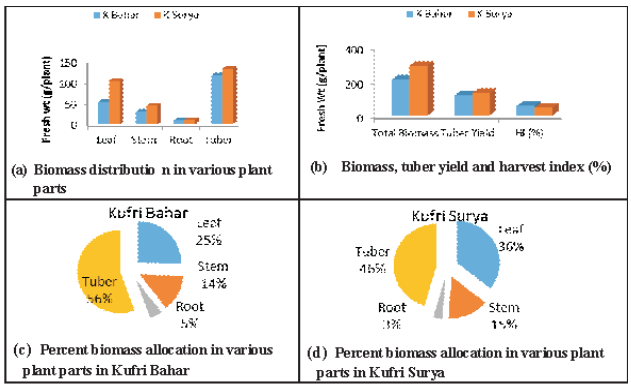


Fig. 2: Absolute biomass in various plant parts (a), (b) and percent biomass allocation in potato variety Kufri Bahar (c) and heat tolerant Kufri Surya (d) at 70 days in early crop

Evaluation of primary CRFs of paclobutrazol for dwarfism

Two controlled release formulations (PP-10 and PS-10) developed in collaboration with IARI were evaluated during early crop for third year. The farm grade plant growth regulator (CULTAR having Paclobutrazol 25%W/V, from Syngenta) was used as control. Kufri Surya was planted on 15/9/13 during heat stress conditions (temp: 34.6/23.7^{0}C, D/N and RH: 76/23.7%) and foliar spray treatments were given at 3-4 leaf stage at

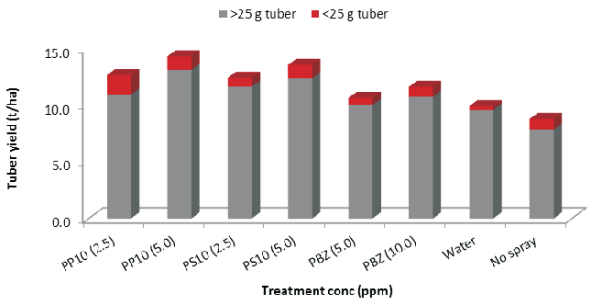


Fig. 3: Effect of primary CRFs of paclobutrazol on tuber yield in K. Surya at 75 DAP

35 DAP. The treatments were 2.5 and 5 ppm spray of CRFs and 5 and 10 ppm spray of paclobuterazol. Five ppm concentration of both the CRFs was most effective and improved yield of marketable tubers as well as total tuber yield significantly (Fig. 3).

Leaf hopper and mite burn resistant hybrid

Thirty five genotypes were screened during 2014 for their response to mite, *P. latus* and leafhopper, *A. biguttula biguttula* in early crop season. The data were collected on mite and hopperburn at 65 as well as 75 days. Mite burn symptoms were in the range of 0-50 per cent at 65 days and hopperburn could not be found in any of the genotypes only typical curling which occurs due to feeding of hopper was there. At 75 days after planting the range of miteburn was from 5-70 per cent. Genotype, HT/11-2912 had lowest miteburn (5%) and no hopperburn at 75 days.

Screening and evaluation for drought tolerance

About 42000 seeds from 17 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., 1201 clones each with 3-5 tubers were selected in WS 2014 series. Genotypes of different series (2010 to 2013) were planted for initial evaluation and selection and a total of 319 selections were made.

WS/2006 and WS/2007 series: Five hybrids were planted for evaluation in replicated split plot design under water stress and well-watered control. K. Bahar and K. Pukhraj were used as check cultivars. Irrigations were regulated to be in equal quantity of water, using Parshall Flume, in all the treatments. Total irrigations were four in control and three in stress plots. Besides, winter rains were received in 2 spells (17.5 mm on 14th Dec 2014 and 15.8 mm on 2nd Jan 2015). Photosynthesis (Pn) and related parameters were measured during stress period (1 week delayed

irrigation) and control plants. WS/07-113 had lower reduction in Pn and higher stomatal conductance. WS/7-131 maintained moderate Pn and low transpiration rate under stress. Hybrids WS/07-113 and WS/07-131 had better yield in control as well as under stress conditions. Both of these hybrids had lower drought susceptibility index and higher modified stress tolerance index (MSTI) (Fig. 4).

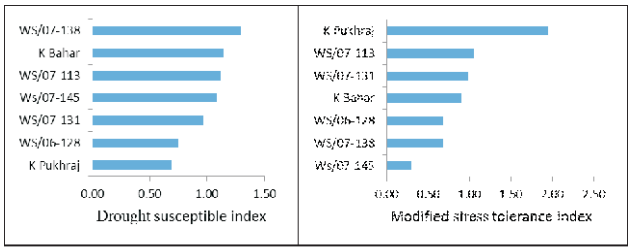


Fig. 4: Drought Susceptibility Index (DSI) and Modified Stress Tolerance Index (MSTI) in selected potato genotypes under water stress

DSI = (1-Yst/Ypt)/DI and DI=1-Ys/Yp, MSTI= k{(Ypt*Yst)/(Yp)2}, where : k=$(Yst)^2$/ $(Ys)^2$, Y_{st} -yield of cultivar under moisture stress condition, Y_{pt} -yield of cultivar under irrigated condition, Y_s -mean yield of all cultivar under moisture stress condition and Y_p- mean yield of all cultivar under irrigated condition.

WS/2009 series: A total of 10 genotypes were screened in field trial under reduced moisture regime. Leaf RWC was estimated for confirming stress responses. Random plants were excavated by using dynamometer (digital balance) and root pulling force (kg/plant) was recorded at 80 DAP along with control (Fig. 5). Considering the root pulling force, leaf RWC, crop vigour, tuber shape, uniformity and tuber yield a total of four genotypes *viz*. WS/09-605, 609, 625 and 710 were selected for further evaluation and selection.

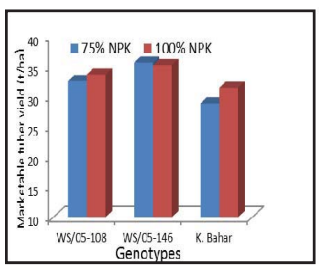
Evaluation of drought tolerant hybrids at Jalandhar

Ten advanced hybrids selected for drought tolerance from 2006 and 2007 crosses were evaluated along with three control varieties *viz*., Kufri Lauvkar, K. Pukhraj and K. Arun under water stress. Control plots (T1) were irrigated when evaporation in the open pan reached 20 mm. One stress treatment was given to second set of plots (T2) when evaporation in the open pan reached 40 mm. Controls received 4 irrigations and the stressed treatment received 3 irrigations. Rainfall during the crop season was 60.8 mm in three spells, two during October and one during the month of December. The crop was harvested at 90 DAP and tuber yield was recorded. Nine hybrids and two controls showed an increase in yield under stress conditions which is difficult to explain. On the basis of tuber yield 7 hybrids *viz*. WS/06-88, WS/06-109-A, WS07-131, WS/07-138, WS/07-145, WS/07-146 and WS/07-113 were selected for further trials.

Evaluation of advance hybrids for water stress tolerance

A field experiment was conducted consecutively in second year during 2014-15 for evaluating advance water stress tolerant hybrids (WS/05-108 & WS/05-146) against control Kufri Bahar with two fertilizer levels 75 and 100% of 240-80-150 N-P-K kg ha^{-1}. Hybrid WS/05-146 (38.8 t/ha^{-1}) and WS/05-108 (36.3 t/ha^{-1}) recorded significantly higher mean marketable tuber yield (18.6 & 11.1%)

Fig. 5: Estimation of root pulling force through dynamometers



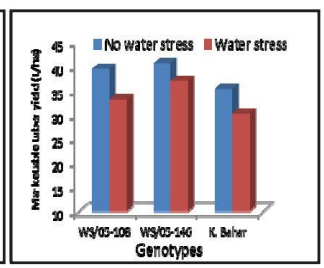


Fig. 6: Performance of genotypes under water stress

over control K. Bahar (32.7 t/ha^{-1}). Application of 75% of N-P-K was sufficient for both the hybrids as difference in tuber productivity was non-significant (Fig. 6).

Hybrids introduced into AICRP for multi-location trials

Two hybrids from the project were introduced into AICRP for multilocation trials. One of these hybrids is for heat tolerance and the other is for drought tolerance.

HT/7-1105 (Kufri Lauvkar x LT-1) produced 26%, 32% higher marketable and total tuber yields respectively over the best control K. Surya at 75 days early season crop at Modipuram. HT/07-1105 produced 22 t/ha total tuber yield over the best controls K. Jyoti (19 t/ha) and K. Surya (17 t/ha) at 80 days summer season crop at Satara district Maharashtra (2014). The hybrid produces attractive light yellow, ovoid tubers with shallow eyes & yellow flesh (Fig. 7). The hybrid possesses 20% dry matter, medium dormancy period and good keeping quality under country store conditions.

WS/05-146: Advanced hybrid WS/05-146 (Kufri Bahar X CP-1785) produced 33t/ha mean tuber yield as compared to 28 t/ha in Kufri Bahar which is distinctly higher (19%) under mild water stress conditions. WS/05-146 had 16% higher mean tuber yield (36.6 t/ha) as compared to 31.6 t/ha in Kufri Bahar under well watered (control) conditions. Hybrid WS/05-146 recorded highest Drought Tolerance Index (DTI) under deficit irrigation regime. Hybrid WS/05-146 had lowest Drought Susceptibility Index (DSI) and yield reduction (YR) under deficit irrigation regime. WS/05-146 had higher mean water use efficiency (1.358 q tuber/ha-mm) and lesser water requirement (0.737 ha-mm/q tuber) as compared to Kufri Bahar. The hybrid possesses good keeping quality under country store conditions (Fig. 8).

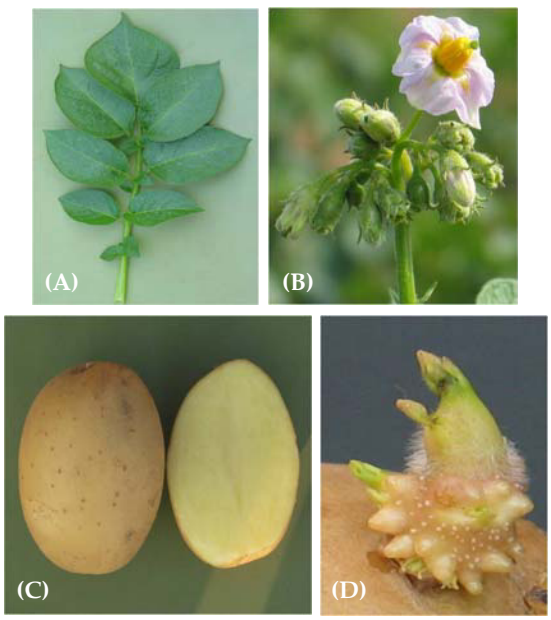


Fig. 7: HT/7-1105: Leaf (A), Inflorescence (B), tubers (C) and sprout (D)

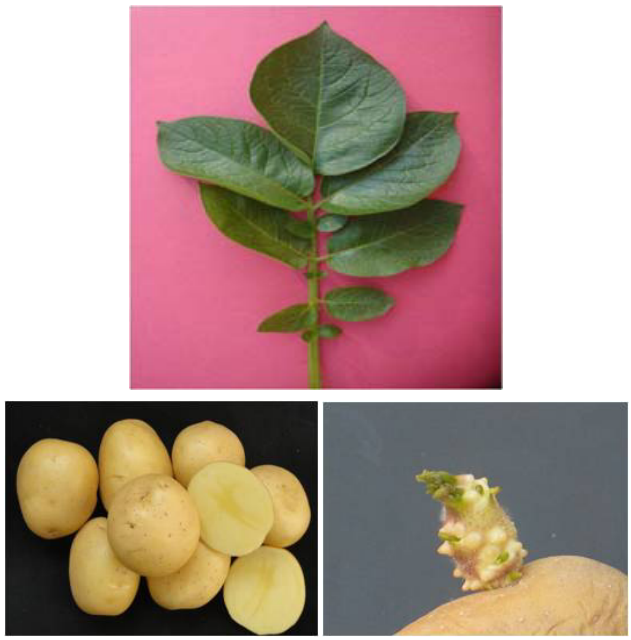


Fig. 8: Leaf, tubers and sprouts of WS/05-146

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 accounts 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, it is essential to have a scientifically sound seed production system through which high degree of health standard of the seed crop is maintained. In this context seed technology division in the institute was set up with mandate to produce disease-free basic seed of notified varieties developed by the institute. A program entitled "Production of breeder seed of potato through conventional and high- tech system" was started under Revolving Fund Scheme to meet this objective. The nucleus and breeder seed is being produced at five different regional stations located in different regions of the country. The division has also started several seed 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 nucleus and breeder seed production and supply status of breederseed for the plains in 2013-14 and hills 2014-15 along with various seed research are as below.

A. Seed Production (Plains) during 2013-14

1. Conventional Seed Production System

Stage-I: A total production of 19.54 tons was achieved in stage-I from an area of 2.25 hectare in plains (*Table*-1). During 2013-14, the average production was 10.13, 7.28, 7.53 and 9.58t/ha at Modipuram, Jalandhar, Gwalior and Patna respectively. In hills a total production of 17.40 quintals was achieved in stage-I from an area of 0.12 hectare and the average production was14.5t/ha at Fagu.

Stage-II: A total production of 103.97 tons was achieved in stage-II from an area of 6.81 hectare in plains (Table-1). The average production was 14.42, 22.84, 13.10 and 15.21t/ha at Modipuram, Jalandhar, Gwalior and Patna respectively. In hills a total production of 5.26 tons was achieved in stage-II from an area of 0.36 hectare the average production was 14.61t/ha at Fagu.

Stage- III: A total production of 379.1tons was achieved in stage-III from an area of 17.65 hectares in plains (Table-1). The average production in stage-III was 24.12, 20.87, 19.43 and 16.71t/ha at Modipuram, Jalandhar, Gwalior and Patna respectively. In hills a total production of 12.45tons was achieved in stage-III from an area of 0.86 hectare and the average production was 14.48 t/ha in stage-III at Fagu.

Stage-IV: A total production of 1473.97tons of breeder seed was achieved in stage-IV from an area of 70.30 hectares in plains (Table-1). The average production in stage-IV was 24.45, 19.86, 18.93 and 20.52t/ha at Modipuram, Jalandhar, Gwalior and Patna respectively. In hills, a total production of 35.22 tons of breeder seed was achieved in stage-IV from an area of 2.89 hectares in hills and the average production in stage-IV was 12.19 t/ha at Kufri.

2. Hi-Tech Seed Production System:

Generation-1: A total production of 184.10tons was achieved in generation-1 from an area of 8.64 hectare in plains. The average production in this generation was 22.55, 20.33, 16.20 and 15.77t/ha

Table 1: Station & variety wise area and production in conventional system 2013-14

No	Variety	Area (ha)	Production (q)	Area (ha)	Production (q)	Area (ha)	Production (q)	Area (ha)	Production (q)	Area (ha)	Productio (q)
I. Modipuram											
1	K. Anand	0.05	5.05	0.14	20.15	2.00	450.40	1.45	435.00	3.64	910.60
2	K. Bahar	0.30	32.80	1.05	206.70	0.24	83.70	7.00	1631.50	8.59	1954.70
3	K. Garima	0.08	5.90	0.36	39.85	0.96	161.80			1.4	207.55
4	K. Khyati	0.08	10.30	0.55	71.50	0.80	253.30	2.15	650.00	3.58	985.10
5	K. Pukhraj	0.06	5.95	0.18	27.60	0.35	126.50	2.00	545.00	2.59	705.05
6	K. Sadabahar	0.05	5.25	0.16	18.90	0.35	102.20	2.00	397.50	2.56	523.85
7	K. Surya	0.05	4.45	0.16	19.72	0.45	124.50	1.00	216.50	1.66	365.17
8	K. Chip-1	0.07	5.35	0.20	23.80	0.25	62.00	1.10	241.25	1.62	332.40
9	K. Chip-3	0.05	4.40	0.20	22.55	0.55	79.50	0.50	130.00	1.3	236.45
10	K. Chip-4	0.07	7.20	0.30	34.05	0.25	60.50	0.25	55.00	0.87	156.75
11	K. Frysona	0.08	8.60	0.36	43.10	0.90	208.50	0.50	100.00	1.84	360.20
12	K. Jyoti	-	-	-	-	-	-	1.00	248.00	1	248.00
13	K. Lauvkar	-	-	-	-	-	-	1.00	212.00	1	212.00
14	K. Himsona	-	-	-	-	-	-	0.17	56.75	0.17	56.75
Total		**0.94**	**95.25**	**3.66**	**527.92**	**7.10**	**1712.90**	**20.12**	**4918.50**	**31.82**	**7254.57**
II. Jalandhar											
1	K. CM	0.01	0.80	0.04	3.46	0.20	50.00	1.10	302.00	1.35	356.26
2	K. Jyoti	0.30	21.54	0.60	160.00	3.00	600.00	13.40	2120.47	17.30	2902.01
3	K. Badshah	0.01	1.42	0.09	22.00	0.20	40.00	1.20	328.00	1.50	391.42
4	K. Pukhraj	0.02	1.26	0.05	18.50	0.40	100.00	5.50	1445.00	5.97	1564.76
5	K. Pushkar	0.01	0.20	0.01	0.30	-	-	-	-	0.02	0.50
6	K. Chip-3	0.01	0.20	0.04	0.50	0.01	2.00	0.60	108.30	0.66	111.00
7	K. Khyati	0.02	1.20	0.05	5.24	0.10	25.00	1.40	370.67	1.57	402.11
8	K. Surya	0.01	0.87	0.05	2.40	0.10	20.00	1.00	183.95	1.16	207.22
9	K. Shailja	0.01	1.63	-	-	-	-	0.20	66.25	0.21	67.88
10	K. Himalini	-	-	-	-	-	-	0.10	25.55	0.10	25.55
11	K. Sutlej	-	-	-	-	-	-	0.50	13.85	0.50	13.85
Total		**0.40**	**29.12**	**0.93**	**212.40**	**4.01**	**837.00**	**25.00**	**4964.04**	**30.34**	**6042.56**

III Gwalior											
1	K. Chandramukhi	0.13	9.76	0.22	28.00	0.54	89.50	0.73	135.00	1.62	262.26
2	K. Jyoti	0.24	16.38	0.34	42.80	0.90	207.50	3.32	719.35	4.80	986.03
3	K. Sindhuri	0.11	10.54	0.33	50.95	1.20	229.50	5.00	738.00	6.64	1028.99
4	K. Lauvkar	0.10	4.12	0.32	34.50	0.81	106.50	4.05	604.85	5.28	749.97
5	K. Chip-1	0.11	8.76	0.28	36.45	1.20	277.00	5.51	1252.50	7.10	1574.71
6	K. Chip-3	0.10	9.93	0.33	45.85	0.84	156.50	0.87	238.00	2.14	450.28
Total:		**0.79**	**59.49**	**1.82**	**238.55**	**5.49**	**1066.50**	**19.48**	**3687.70**	**27.58**	**5052.24**
IV.Patna											
1	K. Arun	0.02	1.50	0.10	14.85	0.30	28.75	1.20	148.50	1.62	193.60
2	K. Jyoti	0.03	2.50	0.14	14.0	0.40	100.50	1.95	390.00	2.52	507.00
3	K. Pukhraj	0.02	2.50	0.16	32.00	0.35	46.25	2.55	631.00	3.08	711.75
4	K. Khyati	0.03	4.00	-	-	-	-	-	-	0.03	4.00
5	K. Sindhuri	0.02	1.00	-	-	-	-	-	-	0.02	1.00
Total		**0.12**	**11.50**	**0.40**	**60.85**	**1.05**	**175.50**	**5.70**	**1169.50**	**7.27**	**1417.35**
G. Total Plains (I+II+III+IV)		**2.25**	**195.36**	**6.81**	**1039.72**	**17.65**	**3791.90**	**70.30**	**14739.74**	**97.01**	**19766.72**

at Modipuram, Jalandhar, Gwalior and Patna respectively (Table-2). In hills a total production of 0.71 tons was achieved in generation-1 from an area of 0.10 hectare and the average production in this generation was 7.15 t/ha at Fagu.

Generation-2: A total production of 545.05 tons was achieved in generation-2 from an area of 22.82 hectare in plains. The average production in this generation was 24.98, 26.36, 16.69 and 20.61t/ha at Modipuram, Jalandhar, Gwalior and Patna

Table 2: Station & variety wise area and production in Hi-Tech system 2013-14

Variety	G1		G2		Total	
	Area	Production	Area	Production	Area	Production
I. Modipuram						
K. Bahar	3.13	672.00	3.00	732.50	6.13	1404.5
K. Himalini	0.20	40.00			0.20	40.00
K. Khyati	1.15	286.00	2.10	625.00	3.25	911.00
K. Chipsona-3	0.80	161.00	1.40	366.75	2.20	527.75
K. Chipsona-4	0.45	82.50	1.40	300.75	1.85	383.25
K. Frysona	0.35	124.30	1.75	344.75	2.10	469.05
K. Pukhraj	0.07	26.50	2.50	712.00	2.57	738.50
K. Surya	0.15	51.20	1.00	205.00	1.15	256.20

K. Sadabahar	0.20	22.50	0.15	30.00	0.35	52.50
K. Himsona			0.08	26.00	0.08	26.00
Total	**6.50**	**1466.00**	**13.38**	**3342.75**	**19.88**	**4808.75**
II Jalandhar						
KCM	0.05	15.00	0.20	55.76	0.25	70.76
K. Jyoti	0.30	60.00	0.40	80.00	0.70	140.00
K. Badshah	0.05	10.00	1.45	420.00	1.50	430.00
K. Pukhraj	0.10	25.00	1.00	270.00	1.10	295.00
K. Pushkar	-	-	0.15	34.00	0.15	34.00
K. Chipsona-3	-	-	-	-	-	-
K. Khyati	0.05	13.00	0.20	55.00	0.25	68.00
K. Himalini	0.15	20.00	0.35	90.00	0.50	110.00
K. Surya	-	-	-	-	-	-
K. Shelija	0.05	9.50	-	-	0.05	9.50
K. Sutlej	-	-	0.10	10.00	0.10	10.00
Total	**0.75**	**152.50**	**3.85**	**1014.76**	**4.60**	**1167.26**
III Gwalior						
K. Chandramukhi	0.07	5.75	0.23	37.00	0.30	42.75
K. Sindhuri	0.57	113.50	0.56	115.00	1.13	228.50
K. Lauvkar	0.13	5.50	0.72	100.00	0.85	105.50
Total	**0.77**	**124.75**	**1.51**	**252.00**	**2.28**	**376.75**
IV Patna						
K. Arun	0.04	0.75	0.35	64.00	0.39	64.75
K. Jyoti	0.02	3.50	0.30	60.00	0.32	63.50
K. Ashoka	0.17	26.00	0.93	199.35	1.10	225.35
K. Kanchan	0.10	13.50	0.35	40.20	0.45	53.70
K. Pukhraj	0.15	30.00	1.70	413.50	1.85	443.50
K. Surya	0.05	5.00	0.05	2.50	0.10	7.50
K. Chip-3			0.20	28.25	0.20	28.25
K. Khyati	0.05	13.00	0.20	33.15	0.25	46.15
K. Sindhuri	0.04	6.00			0.04	6.00
Total	**0.62**	**97.75**	**4.08**	**840.95**	**4.70**	**938.70**
Plains Total	**8.64**	**1841.00**	**22.82**	**5450.46**	**31.46**	**7291.46**

respectively (Table-2). In hills total production of 10.03 tons was achieved in generation-2 from an area of 0.67 hectare and the average production in G-2 was 14.93 t/ha at Kufri.

1. Production of microplants, microtubers and minitubers

A total number of 525485 (6.28 tons) minitubers were produced, 329855 (5.57 tons) minitubers from microplants,18632 (0.18 tons) from microtubers and 1,76,998 (0.53 tons) of aeroponic minitubers (Table-3).

2. Production of nucleus and breeder seed during 2013-14

A total production of 2705.818 tons nucleus and breeder seed was achieved in both conventional and hi-tech seed production system from an area of 128.47 hectares in plains. This includes 2019.02 tons breeder seed produced in 93.12 ha area. During this year, 73.05% nucleus and breeder seed was produced from 75.51% area in conventional system and remaining was in hi-tech system. The percentage of breeder seed from conventional system was 73.00% while 27.00% through hi-tech system.

A total production of 65.393 tons of nucleus and breeder seed was achieved in both conventional and hi-tech seed production system from an area of 5 hectares in hills. This provided 45.228 tonsbreeder seed produced in 3.56 ha area. Presently, 83.6% nucleus and breeder seed was produced from 84.60% area in conventional system and 15.40% area in hi-tech system and the percentage of breeder seed from conventional system was 77.88% while 22.12% through hi-tech system for hills.

Table 3: Production of minitubers from microplants, microtubers and aeroponic system

Station	Planting material(Type)	Planted (No.)	Establishment (No.)	No. of minituber produced (wt. in kg
Modipuram	Microplants	61743	61355	200608 (4495)
	Microtubers	2480	1748	11462 (160)
	Microplants (Aeroponic)	2610	2530	71247 (204.59)\
Jalandhar	Microplants	13700	8955	118050 (1020)
	Microtubers	-	-	-
	Microplants (Aeroponic)	720	720	23606 (50.08)
Gwalior	Microplants	-	-	-
	Microtubers	-	-	-
	Microplants (Aeroponic)	-	-	-
Patna	Microplants	3000	2786	10405 (30)
	Microtubers	1600	1550	7170 (20)
	Microplants (Aeroponic)	782	-	23349 (70.53)
Shimla	Microplants (Aeroponic)	6015	5435	58796 (212.43)
Kufri	Microplants	345	290	792 (21.99)
Total Microplants		**78788**	**77466**	**329855 (5566.99)**
Total Microtubers		**4080**	**3298**	**18632 (180)**
Total Aeroponic minitubers		**10127**	**8685**	**176998 (537.63)**

3. Total supply of breeder seed during 2013-14 cropping season

During 2013-14, total 1960.144 tons breeder seed was supplied to various government and private agencies, 1915.42 tons from plains which includes both pre- (1753.02 tons) and post-cold storage (162.406 tons) and 44.718 tons breeder seed has been supplied from hills (Table-4).

B. Seed Production (Hills) during 2014-15

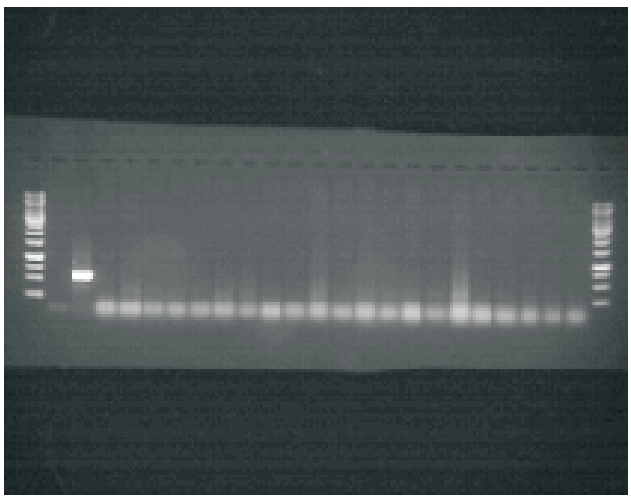
I. Multiplication of basic material maintenance of mother stock

A total no. of 72 individual mother tubers of 18 varieties were separately planted in sterilized soil and its mother plants were tested with ELISA

Table 4: Station and variety wise supply (qts.) 2013-14

S. No.	Variety	Modipuram	Jalandhar	Gwalior	Patna	Kufri	Total
1.	Kufri Jyoti	248.00	2291.14	1011.35	422.00	147.37	4119.86
2.	Kufri Bahar	2430.90	-	-	-	-	2430.90
3.	Kufri Chipsona-1	167.25	-	1252.50	-	-	1419.75
4.	Kufri Khyati	863.50	406.01	-	7.75	-	1277.26
5.	Kufri Lauvkar	212.00	-	703.51	-	-	915.51
6.	Kufri Chipsona-3	395.25	87.98	238.00	28.25	-	749.48
7.	Kufri Badshah	-	719.55	-	-	-	719.55
8.	Kufri Surya	391.40	171.80	-	-	-	563.20
9.	Kufri Sindhuri	-	-	561.00	-	-	561.00
10.	K. Chandarmukhi	-	340.91	172.00	-	-	512.91
11.	Kufri Sadabahar	490.30	-	-	-	-	490.30
12.	Kufri Anand	411.00	-	-	-	-	411.00
13.	Kufri Frysona	350.55	-	-	-	-	350.55
14.	Kufri Himsona	81.25	-	-	-	2.80	84.05
15.	Kufri Chipsona-4	321.75	-	-	-	-	321.75
16.	Kufri Himalini	-	108.96	-	-	126.38	235.34
17.	Kufri Arun	-	-	-	205.00	-	205.00
18.	Kufri Ashoka	-	-	-	184.30	-	184.30
19.	Kufri Shailja	-	65.25	-	-	39.33	104.58
20.	Kufri Girdhari	-	-	-	-	75.50	75.50
21.	Kufri Kanchan	-	-	-	37.50	37.05	74.55
22.	Kufri Garima	23.20	-	-	-	-	23.20
23.	Kufri Pushkar	-	33.50	-	-	-	33.50
24.	Kufri Giriraj	-	-	-	-	18.75	18.75
25.	Kufri Satluj	-	11.50	-	-	-	11.50
	Total	**7675.65**	**5873.45**	**3938.36**	**1666.80**	**447.18**	**19601.44**

against 29 viruses *viz*., PVX (Potato Virus-X), PVS (Potato Virus-S), PVY(Potato Virus-Y), PVA (Potato Virus-A), PVM (Potato Virus-M), PLRV (Potato Leaf Roll Virus), PALCV (Potato Apical Leaf Cure Virus), APLV (Andean Potato Latent Virus), ABV (Arracaccha Virus B), APMV (Andean Potato Mottle Virus), PVT (Potato Virus-T), PYDV (Potato Yellow Dwarf Nucleorhabdovirus), TRSV(Tobacco Ring Spot Virus), TSV(Tobacco Streak Virus), TMV (Tobacco Mosaic Virus), TNV (Tobacco Necrosis Virus), TSWV (Tomato Spotted Wilt Virus), PMTV (Potato Mop Top Virus), CMV (Cucumber Mosaic Virus), TRV (Tobacco Rattle Virus), PVY-n (Potato virus Y-n), PRDV (Potato Rough Dwarf Virus), ACMV(African Cassava Mosaic Virus), PLV (Potato Latent Virus), PVYc (Potato Virus Y^c), TBRV (Tomato Black Ring Virus), TYLCV (Tomato Yellow Leaf Curl Virus)



and SQMV (Squash Mosaic Virus) as well as PCR for PALCV, PSTVd, PVY, PLRV, PVA, PVM, PVS, PVX. The basic plants free from all viruses were maintained in three different lots in net house. Genetic fidelity of above 72 plant samples of 18 varieties was carried out by using STU6 primer for varietal purity. 102 individual tubers (virus-free, true to type, uniform size and genetically pure) of 17 varieties were selected and aseptically maintained at 4ºC as basic material. Total no. of 43 nodal cuttings of 18 virus free varieties (basic material) was taken for micropropagation.

II. Conventional Seed Production System

i) Tuber indexing: During 2014 total no. of 1248 tubers of different commercial potato varieties were indexed at Kufri /Fagu.

ii) Stage-I: A total production of 1.846 tons was achieved in stage-I from an area of 0.10 hectare in hills with the average production was18.46t/ha at Fagu.

iii) Stage-II: A total production of 5.595 tons was achieved in stage-II from an area of 0.35 hectare in hills with the average production was 15.98t/ha at Fagu.

iv) Stage- III: A total production of 17.77 tons was achieved in stage-III from an area of 0.90 hectare in Kufri hills. The average production was19.75t/ha in stage-III at Fagu.

v) Stage-IV: A total production of 35.58 tons of breeder seed was achieved in stage-IV from an area of 3.05 hectares in hills. The average production in stage-IV was 11.51t/ha at Kufri/Fagu (Table-5).

II. Hi-Tech Seed production System

i) Generation-1: A total production of 2.25 tons was achieved from three varieties in generation-1 from an area of 0.30 hectare in hills. The average production in this generation was 7.48t/ha at Fagu and significantly very less than the

Table 5: Variety wise area and production in conventional seed production system at CPRS, Kufri/ Fagu during2014

Variety	Stage-I Area (ha)	Stage-I Production (q)	Stage-II Area (ha)	Stage-II Production (q)	Stage-III Area (ha	Stage-III Production (q)	Stage-IV Area (ha)	Stage-IV Production (q)	Average productivity (Stage-IV) (q/ha)
K. Jyoti	0.056	10.27	0.12	17.9	0.30	50.0	1.25	178.8	143.04
K. Himalini	0.012	2.06	0.07	9.6	0.25	52.0	0.90	79.0	87.77
K. Kanchan	0.008	1.15	0.04	4.9	0.08	18.5	0.25	26.75	107.0
K. Shailja	0.009	1.75	0.06	9.0	0.06	17.5	0.15	10.35	69.0
K. Giriraj	0.002	0.32	0.005	2.25	0.03	5.25	0.04	7.2	180.0
K. Girdhari	0.015	2.62	0.05	10.8	0.17	33.0	0.45	48.5	107.77
K. Himsona	0.002	0.29	0.005	1.5	0.01	1.5	0.05	5.25	105.0
Total	**0.10**	**18.46**	**0.35**	**55.95**	**0.90**	**177.75**	**3.09**	**355.85**	**115.16**

generation-2 in which same agronomic package and practices adopted (Table-6).

iii) Generation-2: A total production of 7.65 tons was achieved from three varieties in generation-2 from an area of 0.30 hectare in hills. The average production in G-2 was 25.5 t/ha at Fagu The highest productivity of 31.87 t/ha was recorded in Kufri Girdhari followed by Kufri Himalini 28.67 t/ha (Table-6).

III. Production and supply of breeder seed from hill

During current year a total of 70.696 tons nucleus and breeder seed was produced from hill station

Table 6: Area and production in high-tech system at CPRS, Fagu farm during 2014

Varieties	Generation-I Area (ha)	Generation-I Producation (q)	Generation-II Area (ha)	Generation-II roducation (q)	Average Productivity (G-2) (q/ha)
Kufri Jyoti	0.03	1.5	0.07	8.0	114.3
Kufri Girdhari	0.12	5.95	0.08	25.5	318.7
Kufri Himalini	0.15	15.0	0.15	43.0	286.66
Total	**0.30**	**22.45**	**0.30**	**76.5**	**255.0**

of Kufri and Fagu from 5.0 hectare land. Out of which 43.235 tons was breeder seed from 3.35 ha area with average productivity of 12.905 t/ha. Total 48.20 tons breeder seed was supplied to different government and private agencies (Table-7).

IV. Production and supply of quality seed

A total quality seed production of 121.53 tons was achieved 9.84 ha area during 2014 at Ooty. Out of which 82.84 tons were supplied to different

Table 7: Variety and agency wise breeder seed supply from Kufri hill stations (quintals) in 2014

Agency	Kufri Jyoti	Kufri Himalini	Kufri Girdhari	Kufri Kanchan	Kufri Shailja	Kufri Giriraj	Kufri Himsona	Total
Himachal Pradesh	65.0	15.0	25.0	-	-	-	-	**105.0**
J&K	-	46.0	16.0	-	-	4.0	-	**66.0**
Arunachal Pradesh	6.0	2.0	-	12.0	-	-	-	**20.0**
Uttaranchal	10.0	15.0	3.0	-	5.0	-	2.0	**40.0**
Meghalaya	15.0	-	-	5.0	-	-	-	**20.0**
Manipur	9.0	-	-	5.0	-	-	-	**14.0**
CPRI	17.7	12.4	15.4	-	5.4	2.0	4.0	**56.9**
Pvt./Farmers	68.5	49.9	24.8	6.75	8.2	1.7	0.25	**160.1**
Total supply	**191.2**	**140.3**	**84.2**	**33.75**	**18.6**	**7.7**	**6.25**	**482.0**

government agencies, local farmers etc. The average productivity five important varieties as mentioned below was maximum 13.35 t/ha in summer season as compared to 11.77 t/ha in spring season (Table-8). The average productivity of three varieties was least in 7.57 t/ha in autumn season which is neither economical nor sustainable and hence should be discontinued. Productivity of Kufri Girdhari was highest 14.73 t/ha in summer but drastically reduced to only 4.7 t/ha in autumn season indicating its best performance in summer season in which it should be only planted. Surprisingly Kufri Jyoti productivity was least 3.85 t/ha and 5.3 t/ha in summer and autumn season respectively which should be stopped for seed production due to its uneconomical and non-sustainability on the location. Like Kufri Jyoti the other variety Kufri Neelima also showed similar performance of low yield in both the season and may be discontinued. Considering the economics and viability of seed production as well as crop rotation/fallowing requirement for the PCN management, only summer crop for quality seed production may be recommended the way it had been going on at other hill locations like Kufri, Fagu and Shillong. The revenue generated from sale of potato seed was Rs 24.01 lakhs.

A total quality seed production of 25.988 tons was achieved from 3.92 hectare in generation-3 under conventional and high-tech system at Shillong

Table 8: Quality seed production details of different crop season at Ooty

Sl. No.	Varieties	Summer season			Autumn season			Spring season		
		Area (ha)	Yield (t)	Av. Yield (t/ha)	Area (ha)	Yield (t)	Av. Yield (t/ha)	Area (ha)	Yield (t)	Av. Yield (t/ha)
1.	Kufri Swarna	2.66	33.99	12.77	1.28	10.55	8.24	0.30	4.98	16.60
2.	Kufri Girdhari	4.14	61.00	14.73	0.10	0.35	3.46	0.12	0.56	4.70
3.	Kufri Himalini	0.52	6.49	12.48	-	-	-	0.05	0.72	14.48
4.	Kufri Jyoti	0.32	1.23	3.85	0.16	0.76	4.76	0.10	0.53	5.30
5.	Kufri Neelima	0.06	0.1	1.66	-	-	-	0.03	0.27	9.16
	Total	**7.70**	**102.81**	**13.35**	**1.54**	**11.66**	**7.57**	**0.60**	**7.06**	**11.77**

with average productivity of 6.629 t/ha. A total of 31.439 tons quality seed have been supplied comprising 23.239 tons to Meghalya, 8.0 tons to Arunachal Pradesh and 0.3 ton to West Bengal. The average productivity was only 6.825 t/ha in conventional system while only 6.465 t/ha in high-tech system (Table-8). The average productivity was very less and slightly more than the seed quantity used during planting on average basis of all the varieties. It is very unfortunate that variety wise it was very less than the seed used in Kufri Himsona (0.58 to 1.4 t/ha), Kufri Girdhari (0.44 t/ha) Kufri Kufri Himalini (3.67 t/ha). Extremely low productivity of only 4-6 quintal/ha in high-tech system of seed production above two varieties is unbelievable. Surprisingly the average productivity of Kufri Megha was 49.85 t/ha (Table-9). It is clear based on the available information supplied by the Head of station that quality seed production of only Kufri Megha should be continued and rest all variety should be closed. The revenue generated was Rs. 7,62,687 from the sale of quality seed at Shillong.

Table 9: Quality seed production in Generation-3 under two system at Shillong

Sl. No.	Varieties	Conventional system			High-tech system			Total seed			
		Area (ha)	Yield (t)	Av. Yield	Area (ha)	Yield (t)	Av. Yield	Area (ha)	Yield (t)	Av. Yield	Total Supply (t)
1.	Kufri Jyoti	0.96	9.796	10.20	0.01	0.114	11.4	0.97	9.91	10.21	11.651
2.	Kufri Giriraj	-	-	-	0.87	7.633	8.77	0.87	7.633	8.77	6.675
3.	Kufri Megha	-	-	-	0.07	3.49	49.85	0.07	3.49	49.85	5.552
4.	Kufri Himalini	-	-	-	0.68	2.289	3.366	0.68	2.289	3.366	2.232
5.	Kufri Himsona	0.59	0.826	1.4	0.19	0.11	0.578	0.78	0.936	1.20	2.002
6.	Kufri Girdhari	0.24	1.595	6.64	0.31	0.135	0.435	0.55	1.73	3.145	3.327
	Total	**1.79**	**12.217**	**6.825**	**2.13**	**13.771**	**6.465**	**3.92**	**25.988**	**6.629**	**31.439**

V. Supply of indexed tubers to RPF, Mao, Imphal, Govt. of Manipur

As per the MoU between CPRI, Shimla and Government of Manipur, regarding the breeder seed production at Mao farm, Manipur CPRI has to supply virus free tubers from stage-1 after indexing. Tuber indexing and scoped eye planting was carried out at Fagu farm and the growing plants were tested by ELISA in the division by imported antiserum. A total no. of 1500 indexed tubers comprising 680 of Kufri Jyoti, 260 of Kufri Himalini, 280 of Kufri Kanchan and 280 of Kufri Girdhari were supplied in clonal form for further multiplication in subsequent cycles to augment seed potato production in Manipur and supply chain in NE regions.

V. Supply of microplants to different seed agencies

A total 105 virus-free in-vitro culture tubes of basic seed material comprising 13 different varieties *viz.*, Kufri Jyoti, Kufri Bahar, Kufri Khyati, Kufri Chipsona-1, Kufri Chipsona-3, Kufri Chipsona-4, Kufri Phukhraj, Kufri Frysona, Kufri Chandramukhi, Kufri Lauvkar, Kufri Surya, Kufri Badshah and Kufri Girdhari were supplied to 12 different private seed producing organizations in India (Table 10).

Table 10: Supply of microplants to different seed agencies

S. No.	Name of the firm	Varieties supplied
1.	Sh. Sandeep Jain, Director, Kalindi Agro Biotech Ltd., 40 Udyog Vihar, Phase-I, Gurgaon-122 016 (Haryana)	K. Badshah, K. Surya, K. Lauvkar
2.	Cadila Pharmaceuiticals Ltd., Agro Division, Plot No.735, Prakuriti Farm, Haripur, Tal Dascroi, Ahmadabad (Gujarat)	K. Lauvkar, K. Surya, K. Chipsona-3, K. Badshah
3.	M/s Neva Plantation Pvt. Ltd. Village Gopalpur, Tehsil Palampur, Distt. Kangra-176059 (H.P)	K. Surya
4.	Sagar Biotech, Top Floor, Tip Top Complex, V.P.O Takurdwara, Tehsil Palampur, Distt. Kangra 176 102(HP)	K. Chipsona-1, K. Pukhraj, K. Surya, K. Jyoti, K. Bahar
5.	M/s BMC Biotech VPO, Azwra, Kurushetra, (Haryana)	K. Pukhraj, K. Khyati
6.	GVS Biotech Pvt. Ltd., Aman Plaza, Main Road, SBS Nagar, Banga 144 505, Punjab	K. Girdhari, K. Badshah, K. Khyati, K. Chipsona-3, K. Lauvkar
7.	M/s Pallishree Limited, Arambagh, Hoogly (W.B.)	KCM, K Khyati, K. Pukhraj
8.	Trainer, Horticulture Training Institute, Uchani, Karnal 132 001, (Haryana) State Govt. Organization	K. Khyati
9.	M/s Bhatti Tissue Tech, Vill. Alipur, P.O Mithapur, Distt. Jalandhar-144 002 (Punjab)	KCM, K. Khyati, K. Surya, K. Chip-1, K. Jyoti, K. Badshah, K. Bahar
10.	M/s Merino Industries Ltd. Village Achheja, P.O Hapur-245 11, Ghaziabad (U.P.)	K. Bahar, K. Pukhraj, K. Chipsona-3
11.	M/s Gujarat Narmada Valley Fertilizers Company Ltd., P.O Narmadanagar-392 015, Distt. Bharuch, (Gujarat)	K. Pukhraj, K. Badshah
12.	M/s Dayal Seeds (P) Ltd., Partapur, Meerut-250103	K. Chipsona-1, K. Jyoti, K. Badshah
13.	M/s Shivalik Seeds & Ware Housing Ltd., 68 Mathenia, Kankar Kheda, Meerut (U.P.)	K. Jyoti, K. Bahar
14.	M/s Siddhi Vinayak Agri Processing Pvt. Ltd., Row House 1, Konark Riveria, Yerawada, Pune 411006 (Maharashtra)	K. Chipsona-1, K. Jyoti, K. Khyati, K. Surya

Table: 11 Supply of microplants to different Seed Centres

Sl. No.	Variety	No of culture tubes	Centres/stations
1.	Kufri Jyoti	71	Jalandhar, Patna, Kufri, Shillong, Ooty
2.	Kufri Bahar	741	Modipuram
3.	Kufri Pukhraj	159	Modipuram, Jalandhar, Patna, Shillong
4.	Kufri Khyati	104	Modipuram, Jalandhar, Patna, Shillong
5.	Kufri Badshah	251	Jalandhar, Modipuram
6.	Kufri Chipsona-1	54	Jalandhar, Patna, Gwalior
7.	Kufri Surya	330	Modipuram, Jalandhar, Patna, Gwalior
8.	Kufri Lauvkar	4	Modipuram, Shillong
9.	Kufri Chipsona-3	90	Modipuram, Jalandhar, Gwalior, Shillong
10.	Kufri Chandramukhi	25	Jalandhar, Gwalior
11.	Kufri Girdhari	194	Kufri, Modipuram, Shillong, Ooty
12.	Kufri Chipsona-4	160	Modipuram, Patna
13.	Kufri Himalini	152	Kufri, Jalandhar, Shillong, Ooty
14.	Kufri Ashoka	27	Patna, Jalandhar

Table 12: Variety and agency wise breeder seed supplied from plain stations during 2013-14

S. No.	Variety	BIHAR	CH	J&K	NSC	PB	NABARD	NHRDF	HP	SFCI	UP	WB	MP	HARYANA	Uttrakhand	Jharkhand	Orissa	University	ICAR/FOC	Pvt. /Farmers	Auction	Total
1.	Kufri Frysona	-	-	-	-	-	-	-	-	-	308.50	-	-	-	-	-	-	0.05	1.00	1.20	39.80	**350.55**
2.	Kufri Himsona	-	-	-	-	-	-	23	-	-	-	-	-	-	-	-	-	0.05		53.20	5.00	**81.25**
3.	Kufri Khyati	-	-	-	-	150	-	320	-	-	500	-	-	70	-	-	0.25	1.00	1.15	121.36	113.50	**1277.26**
4.	Kufri Sadabahar	-	-	-	-	-	-	50	-	-	200	-	-	-	-	-	-	-	-	40.00	200.30	**490.30**
5.	Kufri Arun	70.50	-	-	-	38	-	70	-	-	-	18	-	-	-	-	-	3.50	-	5.00	-	**205.00**
6.	Kufri Himalini	-	-	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16.64	38.32	-	**108.96**
7.	Kufri Kanchan	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		7.50	-	**37.50**
8.	Kufri Anand	-	-	-	-	-	-	-	-	-	200	-	100	-	-	-	-	-	10.00	80.00	21.00	**411.00**
9.	Kufri Chipsona-1	-	-	-	-	-	-	-	-	-	1048	-	-	-	-	-	-	0.05	1.00	345.70	25.00	**1419.75**
10.	Kufri Pukhraj	539	60	26	200	200	-	350	-	-	-	117	400	180	-	1.50	0.25	47	87.98	1167.12	332.30	**3708.15**
11.	Kufri Ashoka	41	75	-	-	-	-	38	-	-	-	-	-	-	-	-	-	5.80	11.50	13.00	-	**184.30**
12.	Kufri Shalja	-	-	-	-	45	-	-	-	-	-	-	-	-	-	-	-	-	-	20.25	-	**65.25**
13.	Kufri Satluj	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	1.50	-	**11.5**
14.	Kufri Lauvkar	-	-	-	-	100	-	-	-	-	-	-	60	-	-	-	100.00	-	37.66	600.85	17.00	**915.51**
15.	Kufri Jyoti	1	150	187	135	175	220	150	500	50	-	1020	-	-	28.35	-	-	12.60	42.17	1233.37	68.00	**3972.49**
16.	Kufri Sindhuri	-	-	50	-	100	-	-		-	200	-	-	-	-	-	-	20.00	-	191.00	-	**561**
17.	Kufri Badshah	-	-	100	-	150	-	-		-	190	-	-	-	-	-	-	2.00	10.00	267.55	-	**719.55**
18.	Kufri Bahar	-	10		-	20	-	100		-	1000	-	-	-	-	-	-	-	-	20.00	1280.90	**2430.9**
19.	Kufri Chandarmukhi	-	15	20	-	80	87	-	65	-	40	79	-	-	-	-	-	-	3.15	123.76	-	**512.91**
20.	Kufri Chipsona-3	27.5	163	-	-	70.50	-	20		-	223.50	10.5	-	-	-	-	0.25	0.55	15.00	131.18	87.50	**749.48**
21.	Kufri Chipsona-4	-	-	-	-	-	-	-		-	297	-	-	-	-	-	-	0.05	1.00	3.70	20.00	**321.75**
22.	Kufri Surya	-	40	-	-	-	-	30		-	370	-	-	-	-	-	-		19.38	76.92	26.90	**563.20**
23.	Kufri Pushkar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.50	-	**33.50**
24.	Kufri Garima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23.20	**23.20**
	Total	**707.50**	**513**	**437**	**335**	**1138.5**	**307**	**1151**	**565**	**50**	**4577**	**1244.50**	**560**	**250**	**28.35**	**1.50**	**100.75**	**92.65**	**257.63**	**4575.98**	**2260.40**	**19154.26**

Table 13: Variety and agency wise breeder seed supply from Kufri hill (quintals) during 2013-14

Agency	Kufri Jyoti	Kufri Girdhari	Kufri Giriraj	Kufri Shailja	Kufri Himalini	Kufri Himsona	Kufri Kanchan	Total
Himachal Pradesh	20.0	30.0	6.0	-	35.0	-	-	**91.0**
Jammu & Kashmir	20.0	-	-	-	-	-	-	**20.0**
Arunachal Pradesh	10.0	-	-	-	-	-	10.0	**20.0**
Uttaranchal	-	15.0	5.00	20.0	28.0	-	2.0	**70.0**
Meghalaya	35.0	-	-	-	-	-	-	**35.0**
Manipur	20.0	-	-	10.0	-	-	20.0	**50.0**
CPRI (free of cost)	18.67	5.7	2.00	0.8	38.18	2.5	0.15	**68.0**
Pvt./Farmers	23.7	24.8	5.75	8.53	25.20	0.3	4.9	**93.18**
Total supply	**147.37**	**75.50**	**18.75**	**39.33**	**126.38**	**2.80**	**37.05**	**447.18**

A total 2541 culture tubes (6352 microplants) of 15 varieties were supplied to different seed production stations/centers *viz*., Modipuram, Jalandhar, Gwalior, Patna, Kufri, Shillong and Ooty as detailed below:

VII. Revenue Generation

A total amount of Rs. 8,44,83,250 generated during 2014-15 by the sale of breeder seed under Revolving Fund Scheme (RFS) in which Rs.45004040,17024600, 11563582, 3339435, 1221380 and 6330213 from Modipuram, Jalandhar, Gwalior, Patna, Kufri and Shimla respectively. This includes money received from the sale of post cold stored breeder seed of cropping year 2013-14 and current crop of 2014-15.

Research

Association of *Fusarium* species in seed tubers of Kufri Bahar

Isolation were made from Kufri Bahar round (peel and core part) and elongated (rose-end, distal and core part) tubers from seed farm of Modipuram. Stolen end of elongated tubers yielded 88.89% *Fusarium* while 47.37% in elongated rose-end. The colony was light yellow with pinkish mass, no microconidia, one-two macroconidia, prominent cracking of culture media on reverse side, very high chlamydospore formation, gutulate conidia with 2-3 vacuoles per microscopic field at 10X. The pathogen was identified tentatively as *Fusarium equiseti*. The perfect stage was reported as *Gibberella intricans.* It may be responsible for macerating of stolen end of tuber followed by softening and rotting. The pathogen enters through stolen at early stage of tuberization in tissue culture raised planting material. The tissue cultured based seed planting materials may have less Induced Systemic Resistance (ISR) and Systemic Acquired Resistance (SAR), phenolic compounds and other biochemicals resulted in reduction of inherent resistant mechanism in plant as well as developing juvenile tubers facilitating infection by *Fusarium*. The *Fusarium* inside the tuber may be responsible for growth hormone production particularly gibberellins causing elongation of tubers. Another colony of *Fusarium* mostly found in round tuber was white colony, full of indefinite macroconidia, no microconidia, no chlamydospores, scanty mycelium, no cracking of media from reverse side (Fig.1&2). The pathogen was identified tentatively as *Fusarium roseum*.

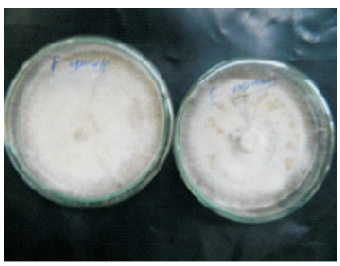


Fig. 1: *Fusarium* spp.

Fig. 2: Reverse side of the plate

Bacterial endophytes of seed potato and its antagonism study with potato pathogen

Antagonistic study was carried out with 55 potato endophytesis isolates by dual culture technique against various pathogens of potato *viz., Rhizoctonia solanii, Ralstonia solanacearum, Phytophthora infestans, Fusarium roseum* and *Fusarium equiseti*. The zone of inhibition of test pathogen revealed that minimum radial growth of *Fusarium equiseti* was 40.67mm with endophyte isolate number 23 while 41.0 mm by isolate no. 45 which was 54.98% and 54.61% inhibition over control respectively (Fig.3). The isolates no. 23 and 29 showed highly antagonistic against *Rhizoctonia solani* with maximum inhibition zone of 60.66 mm and 59.02 mm with 59.02% and 60.66% respectively. The maximum inhibition of *Fusarium roseum* showed by isolate numbers 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 17, 21, 23, 24, 25, 26, 27, 28, 29, 32, 34, 35, 36, 40, 43, 44, 45, 51, 52, 53, 55 ranges between of 50.57-71.64% (Fig.3). The zone of inhibition of *Ralstonia solanacearum* revealed that the seven endophytic isolates *viz.*,10, 17, 43, 45, 50, 53 and 54 were highly antagonistic. Dual culture between endophyets and *Phytophthora infestans* revealed that 1, 2, 3, 4, 6, 8, 13, 17, 18, 23, 25, 31, 34 and 43 isolates showed maximum zone of inhibition. All the 55 isolates were categorized on five grades of rating scale for their percent zone of inhibition. The above mentioned test isolates were rated as very good (++++) antagonists on and may be playing very important role for inherent suppression of these potato pathogens. The above potential bacterial endophytes may also be exploited as potential biocontol agents. All 55 isolates of endophyets were characterized based on colony character on different growth medium and tried to reduce the no. of isolates based on similar cultural characters. Identification was also initiated through Microbial Type Culture Collection, Chandigarh but very high cost, too many isolates and project closure on 31.03.2015 was the limitation hence handed over all available endophytec isolates to Plant Pathology Division for preservation, maintenance and further study.

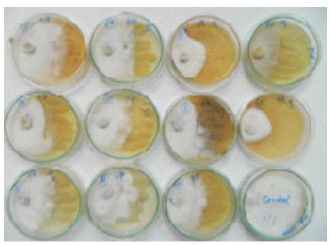


Fig. 3: Endophytes agent *Fusarium*

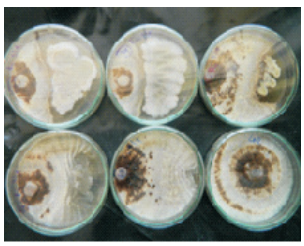


Fig. 4: *Endophytes agent R. solani*

Effect of potato endophytes on various growth parameters of *in vitro* plantlets

An experiment was carried out with three varieties Kufri Khyati, Kufri Chandramukhi and Kufri Lauvkar on growth behavior of microplants during *in vitro* micropropagation under inherent association of dominant and frequently observed pink bacterial endophyte *Methylobacteria* species.

All the growth parameters of microplants such as height, number of roots, number of nodes, fresh weight and dry weight were enhanced in Kufri Chandramukhi under association of *Methylobacteria* (Fig. 5). The growth parameters like height, number of leaves as well as nodes shown positive effect in Kufri Khyati. The culture media pigmented with yellow colored endophytic bacteria also showed the positive effect on different morphological growth parameters except no. of leaves and no. of nodes in Kufri Lauvkar after 42 days. The various growth parameters of microplants in all three varieties under association of these bacterial endophytes were better than absolutely free endophyte culture tube. It was also observed that the culture tubes grown under *Methylobacteria* were not having any deleterious effect on the microplants even after storage of about 50 days. It is clear from present findings that potato endophytes under the studies have positive effect

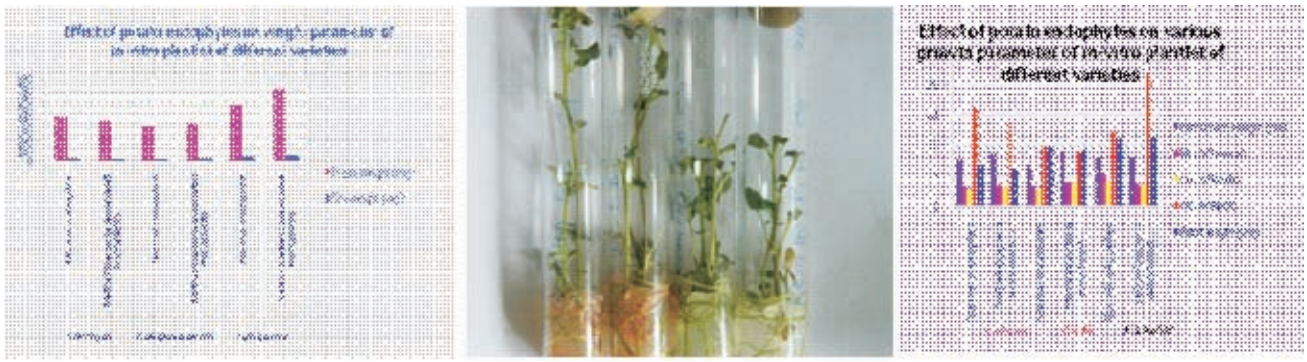


Fig. 5: Microplant growth behaviour in Endophytes

on vigorous growth of the microplants and may be used as PGPR.

Effect of endophytic bacterial association with microtubers on germination, driage, shoot and root length

Microtubers of Kufri Ashoka were harvested from *Methylobacteria* sp. contained flasks as well as healthy flasks in the month of August, packed in perforated polythene bags and stored in culture room for about five months. These microtubers were used for driage, sprouting, germination test, shoot and root. The driage was less and sprouting was more in all these grades in microtubers harvested from the flask having endophytic bacteria (*Methylobacteria* sp.). However, there was no significant effect on final germination in blotter test. The shoot and root length in there all grades of microtuber under influence of endophytes was increased (Fig. 6). It was concluded that the inherent endophytic bacteria of seed potato are important for the better and fast growth of the plants.

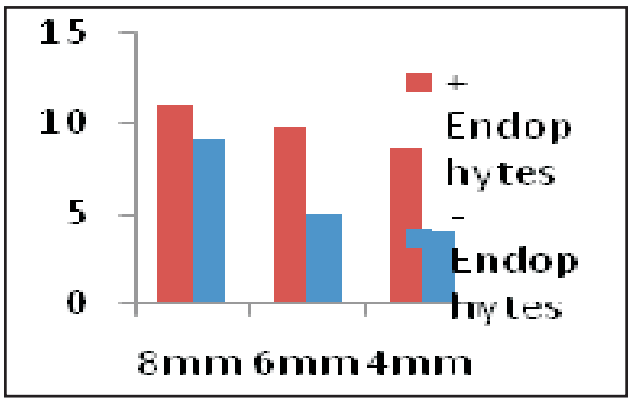


Fig. 6: Microtuber in endophytes

Effect of priming and storage material on post-harvest behaviour of aeroponic minitubers

An experiment was carried out at Shimla conditions using Kufri Girdhari aeroponic minituber in last week of April soon after curing by wet priming of bioagents, fungicides, micronutrients and its integration. The treated minitubers were stored separately in yellow cloth bag, muslin cloth bag, plastic net bag and gunny bag in culture room (non-hermatic) at 22±1°C temperature with 16 hours light and 8 hours darkness. Periodical observations on weight loss upto 306 days of storage and then finally germination, rottage and viability status of minitubers were recorded. Result revealed that weight loss was varied from minimum 40.4% to maximum of 74.0% irrespective of priming material and packing bags on above mentioned storage conditions. Similarly, sprout length varied from 0.8 to 4.6 cm while rottage varied from 0-100%. The overall minimum weight loss at the end of storage was 57.2% in carbendazim primed minituber followed by *P. fluorescence* (59.2%). Among storage bags, cloth bag was supported average minimum (58.6%) weight loss. There was no significant effect of priming and storage bags on weight loss. The maximum viability of sprout

and healthy minituber (75%) were in captan priming followed by *P. fluorescence* (66.6%) and accordingly the rottage was minimum. Priming with *T. viride* & pencycuron and storage in cloth bags was resulted comparatively stout, green, vigorous and healthy aeroponic minitubers. Most of the priming treatments increased the sprout length over control. Maximum sprout vigour in *T. viride*, pencycuron, *P. fluorescence* and integration of *T viride* + *P. fluorescence* + Tricel clearly indicates the growth promoting activities as well as successful integration.

Effect of different priming methods and agents on aeroponic minituber sprouting

Aeroponic minitubers of variety Kufri Lauvkar harvested on 19th April, 2014 were wet and dry primed with different bioagents i.e *T. viride*(1%), *P. fluorescence* (1%), carbendazim (0.3%), captan (0.3%), carbendazim±captan (0.3 +0.3%), mancozeb (0.3%) tracel (0.3%) and stored in non-hematic culture room at 16 hours light (irradiance of 60 umol/m^2/s) and 8 hours dark photoperiodism at 22+1°C temperature. Mean sprout length after 112 days revealed that the high dose of priming materials was not deleterious for sprouting as well as minituber viability. The maximum spout length was with priming in tricel, mancozeb, *P. fluorescence* and *T. viride* (6.2 cm). Almost similar trend was observed in dry priming (Fig. 7).

Fig. 7: Primed aeroponic minitubers

Among both the priming methods, wet priming was comparatively better in stout, multiple and vigorous sprouting of aeroponic minitubers.

Effect of different planting date on Aeroponic performance at Shimla hills

Planting of microplants on 3rd February of Kufri Jyoti, Kufri Bahar, Kufri Ashoka and Kufri Chipsona-4 revealed that maximum minituber production per plant was obtained in Kufri Chipsona-4 with average of 1.8 gram weight of each minituber. Remaining three varieties did not performed well and developed long, thick succulent stolon with leaf primodia. The crop was severely infected by powdery mildew. Planting of five varieties i.e Kufri Chipsona-4, Kufri Girdhari, Kufri Chandramukhi, Kufri Jyoti, Kufri Chipsona-3 on 15th March resulted almost negligible fruiting in Kufri Jyoti, Kufri Chipsona-3 and Kufri Girdhari. Long day variety also did not tuberized. Maximum yield per plant was 8.6 by number and 18.6 g by weight in Kufri Chipsona-4. Apical stem detopping and severe root pruning as well as drought socking for nutrient initiated one or two minituber in Kufri Girdhari and KCM. The tall indeterminate vegetative growth and long thick stolon status was same in all varieties except Kufri Chipsona-4. The crop was infected with powdery mildew and Botrytis grey mould. Third planting was done on 25th March 2014 selecting four varieties *viz.*, Kufri Lauvkar, Kufri Surya, Kufri Badshah and Kufri Chipsona-3. The vegetative and root growth of Kufri Surya was very poor may be due to low temperature in the month of March at initial stage. Very long shoot and root growth in remaining three varieties with severe thick, numerous stolon in Kufri Chipsona-3, Kufri Badshah. Kufri Lauvkar initiated tuberization at early stage (April) as well as in late stage (July). Minituber formation stated on onset of rainy season in Kufri

Lauvkar. There was no effect of reducing the light duration by covering green shade net as well as black polythene. Maximum of 6.5 minituber/ plant was harvested in Kufri Surya and Kufri Lauvkar. Very severe infection of Botrytis grey mould in mid June leads to complete rottage of plants otherwise it would have yielded more yield than Kufri Surya in the month of July onwards. The intensity of Botrytis grey mould was 90-95% in Kufri Lauvkar, 5-10% Kufri Badshah, 1-2% in Kufri Chipsona-III and 3-15% in Kufri Chipsona-4 in unit indicating differential degree of resistance for disease.

The wastage of aeroponic minituber due to driage, shrinkage and rottage after curing at ambient condition was maximum by number and weight in Kufri Girdhari followed by KCM and Kufri Ashoka. It was minimum in Kufri Lauvkar (0.6%) and Kufri Surya (1.1%). It indicates that immature, succulent and thin skinned minituber might have produced in early planted (before mid March) as compared to late (end of March). It was concluded based on the above three experimental dates and various varieties that only Kufri Chipsona-4 is most suitable variety for planting in summer season under long day condition for satisfactory yield followed by Kufri Surya. Delay planting in March had adverse effect on Kufri Chipsona-4.

Aeroponic production performance in Bower system of cultivation

Microplants of five varieties i.e. Kufri Bahar, Kufri Lauvkar, Kufri Pukhraj, Kufri Jyoti and Kufri Chandramukhi (KCM) were planted on 11th August, 2014 in aeroponic using Bower system which significantly increased the minituber yield of each harvest. First harvesting started after 60-70 days of planting. Total nine harvesting was carried out and in most of the varieties except Kufri Bahar where 11 harvesting was carried out. Yield (both in number and weight) was gradually increased from 1st harvest to 8th harvest and then decreased in Bower as well as non-Bower system. The yield increases an average was recorded upto the extent of 363.3% by number and 833.2% by weight in 8th harvest. Interestingly, maximum yield in each harvest from 1st to 8th in Bower system was recorded in Kufri Jyoti. Microplants of seven varieties i.e. Kufri Lauvkar, Kufri Himalini, Kufri Khyati, Kufri Jyoti, Kufri Badshah, Kufri Pukhraj and Kufri Chandramukhi (KCM) planted on 1st September, 2014 in aeroponic significantly increased the minituber yield in each harvest under Bower system. First harvesting started after 52 of planting in Kufri Lauvkar and Kufri Himalini while, 66 days after planting in Kufri Khyati, Kufri Jyoti, Kufri Badshah, Kufri Pukhraj and Kufri Chandramukhi. Total nine times economic harvesting was carried and in most of the varieties except Kufri Lauvkar and Kufri Himalini where 10 harvesting was carried out.

Based on experment, it is clear that Bower system of planting & training significantly increased several fold yield by number as well as weight, vegetative growth, biomass of plant and reduced the post harvest loss as driage/rottage of minitubers in both mid August and 1st September planting (Table-1). The increase of yield in no. of leaves per plant, fresh weight was more and comparative post harvest loss was less in mid

Fig. 8: Bower system for hills

Table 1: Status of aeroponicminitubers production on two different panting dates

Parameters	11/08/2014		01/09/2014	
	Bower	Non-Bower	Bower	Non-Bower
Total no. of minitubers	4781	1547	7730	4013
Total wt. of minitubers (g)	12516	3091	22925	9096
% increase in number (over bower)	202.58	-	92.62	-
% increase in weight	304.92	-	152.03	-
% post harvest loss (no.)	78.55	164.5	225.21	179.65
% post harvest loss (wt.)	194.7	244.94	263.52	285.12
No. of leaves/plant	16.05	4.66	8.18	3.14
Plant fresh wt. (gm)	127.67	37.10	117.81	47.36
Plant dry wt. (gm)	20.76	3.40	22.67	6.61

August planting as compared to 1st September. This technique is most effective for all beneficial parameters of aeroponic seed production in hill conditions and should be necessarily adopted.

Effect of Bower system on vegetative growth, biomass and vigour of plants

Vegetative growth in mid August planting as number of leaves of plant was significantly very high in all the test varieties in Bower system (14-19) as compared to non Bower (6-8). The plant biomass as fresh weight of plant was also significantly very high in Bower system (43-256 g) as compared to non-Bower (21-49 g). Dry matter of the plant was significantly high in Bower as compared to non-Bower. Shoot and root weight was also showing same trend. Similarly the vegetative growth in 1st September planting resulted similar trend of increase in number of leaves/plant, biomass and dry matter in Bower system in comparison to non-bower.

Fig. 9: Kufri Jyoti under Bower system

Among the three test varieties, there was significant difference in vegetative growth in both system of crop raising technique in aeroponics. The number of leaves per plant, fresh weight and dry matter of plant was significantly very high in Bower system in comparison to non-Bower during above two crop duration. Kufri Jyoti was more vigorous than remaining two varieties. It is clear that Bower system promoting vigorous, sturdy, hardy and vegetative growth of plants in the test potato varieties.

Post-harvest loss behavior of aeropoinc minitubers in Bower system

Post-harvest behavior of aeroponic minitubers of different varieties in mid August planting revealed that maximum loss was in 3rd harvest (33.6%) in number and weight in Bower system whereas, in non-Bower the maximum was recorded 43.7% in 6th harvest. The loss percentage was less in Bower as compared to non-Bower in all the varieties. Minimum loss of minituber and its weight was in Kufri Jyoti during mid August planting while minimum loss in Kufri Lauvkar during 1st September planting. However, extent of loss was more in September than mid August planting.

Standardization of planting date for seed production in Gwalior region

An experiment was conducted with 5 different dates (10th Oct., 17th Oct., 24th Oct., 31th Oct., and 7th Nov.), three varieties (Kufri Chandramukhi, Kufri Sindhuri and Kufri Chipsona-1). 17th Oct. planted seed crop took significantly lowest time (8.4 days) for emergence over other date of planting. For number of compound leaves, 10th Oct planting (58.3) recorded significantly higher leaves over 24th Oct planting. Kufri Chandramukhi showed significantly delayed days to emergence (10.3) over other two varieties.There was non-significant difference among date of planting for total tuber number and weight but highest was recorded in 7th Oct (560000/ha and 20.99 t/ha respectively) planted seed crop (Fig. 10 and 11). Among the varieties, total tuber yield was significantly higher in Kufri Chipsona-1 (20.96 t/ha) over Kufri Chandramukhi (18.94 t/ha) (Fig. 12 and 13).

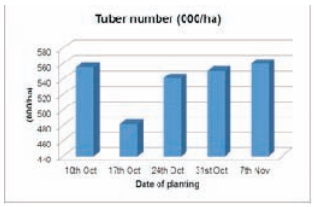


Fig.10: Tuber number by DOP (000/ha)

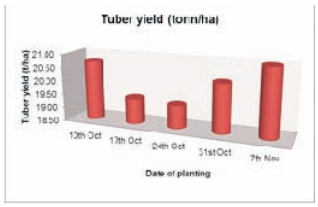


Fig. 11: Tuber weight by DOP (t/ha)

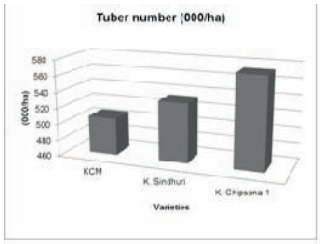


Fig. 12: Variety wise tuber number (000/ha)

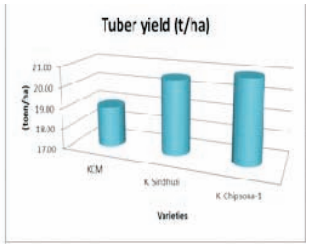
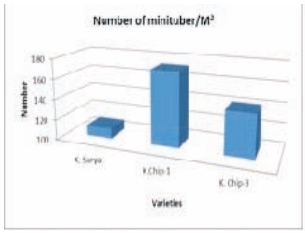


Fig. 13: Variety wise tuber weight (t/ha)

Performance of potato micro-plants under Gwalior conditions

An experiment was conducted to study the Performance of microplants under Gwalior conditions of three varieties Kufri Surya, Kufri Chipsona-1, Kufri Chipsona-3 with 20 microplants/ row at size: 30x10cm distance revealed highest establishment in Kufri Chipsona-1 (51.67%) over Kufri Surya and Kufri Lauvkar. Growth parameters like plant heightand compound leaves were non-significantly higher in Kufri Chipsona-3 (23cm and 47) over other two varieties.Yield parameters like plant tuber number and weight per plant and per m^2 was non-significantly higher in Kufri Chipsona-1 (31per plant and 173/ M^2 by number and 251g per plant and 1845g/ $M^2$by weight respectively (Fig. 14 and 15).



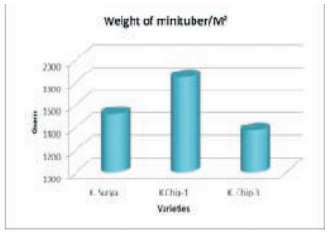
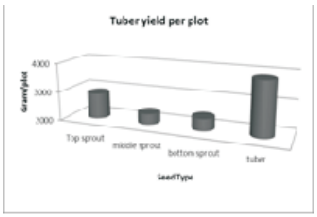


Fig. 14: Variety wise number Fig. 15: Variety wise weight

Performance of sprout cut vis-a-vis minitubers in aeroponic seed potato multiplication

An experiment was conducted by cutting the sprouts (3-4 cm) in top, middle, bottom portion and respective minituber of Kufri Lauvkar from harvest of 2013 were stored at ambient condition of Shimla in gunny bags. Non-significant differences were recorded in germination among seed type but highest was recorded in bottom portion of sprouts (84.50%). Plant height was significantly higher in top portion of sprouts (29 cm) and tuber (36 cm) over middle and bottom portion of sprouts. Non-significant differences were recorded in number of compound leaves among seed type but highest was recorded in tuber (17) followed by top portion of sprouts (14.3). Tuber number and weight was significantly higher in tuber portion (146 and 3857g per plot) but non-significantly higher in top portion of sprout (112 and 2889g per plot) over middle and bottom portion of sprouts (Fig. 16 and 17).



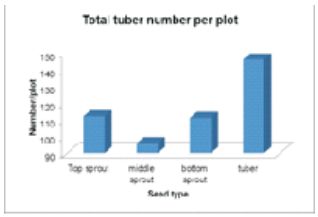
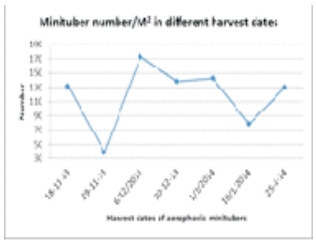


Fig. 16: Tuber number per plot Fig. 17: Tuber weight per plot

Performance of aeroponic minitubers of different harvesting dates at Gwalior

Aeroponic minitubers of variety Kufri Sindhuri produced at Shimla with different harvesting dates were used. Highest germination was recorded on 1st Jan harvest minitubers followed by 10th Jan and least in 6thDec harvest aeroponic minitubers. Growth parameters like plant height and compound leaves were highest in 18th Nov harvest minitubers (33 cm and 35 respectively). Among all the dates of harvest, number and weight of tubers per plant was high in 1st Jan harvest minitubers. But number of minitubers per M^2 was highest in 6th Dec (173) followed by 1st Jan (143) harvest minitubers and yield/M^2 was highest in 18th Nov (2044 g) followed by 20th Dec harvest (1824 g).



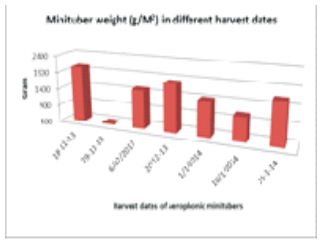


Fig.18: Minituber by number Fig.19: Minituberby weight

Studies on light intensity for promoting photoautotrophic nature of microplants

Commercially available light sources for tissue culture to provide 55L, 60L, 30L and 58 L quantum flux densities of light intensities were applied for 60 days and were observed for microplant number of leaves plant height and biomass production. Significant differences were observed using Turkeys Honest SD test where lumoflor (T2) showed higher number of leaves whereas for plant height and biomass Lumilux Plus 40W osram brand was found superior. The results correlate with higher photosynthetic active radiation available in these lights in tissue culture/photoautotrophic micropropagation systems to promote higher growth.

Effect of coating and storage on survival and germination of minitubers

The experiment was conducted on two varieties Kufri Badshah and Kufri Chipsona-3. The minitubers of less than 3g were divided into less than 1.5 g and 1.5-3 g minitubers. The different coatings of soy oil, paraffin wax and talc were used to coat the minitubers and these were further packaged into polybags, glass bottles and gunny bags in storage. The weight losses of tubers were estimated after 6 months of storage and further germination percent was estimated. Significant differences were observed for packing material (P) and interaction between weight (W) and packing material (P) of microtubers. Polybags showed significantly higher weight loss as compared to bottles and gunny bags. Parafilm showed significantly lower germination as compared to control and talc coating.

Effect of aeroponic practices on production of seed sized tubers

A field experiment was conducted at Gwalior with haulm cutting, nitrogen levels and tuber to tuber spacing. Two Nitrogen levels (120 kg/ha and 150 kg/ha) and two dates of haulm cutting (70 and 80 days after planting) were used. Planting at 15 cm intra row spacing produced higher proportion of seed size tubers. Application of lower dose of nitrogen also contributed in increasing higher proportion of

seed size tubers. Haulm cutting at 80 days after planting helped in increasing proportion of seed size tubers.

Monitoring of aphid population in seed potato crop

Aphid build up in seed potato seed potato crop was monitored during 2014 in three potato varieties *viz*. Kufri Jyoti, Kufri Girdhari and Kufri Himalini under sprayed and unsprayed conditions at Fagu. Aphid count was taken 100 compound leaves per variety. Under sprayed conditions, systemic insecticides *viz*. imidacloprid @ 0.004% (two times) and Rogor @ 1.2 ml/litre water (one time) were sprayed alternatively at fortnightly intervals. Monitoring reveals that during this crop season, aphids appeared by end July under sprayed conditions, whereas in unsprayed conditions, aphids appeared mid June onwards. Under sprayed conditions, the aphid count remained below the critical levels throughout the crop season i.e. up to mid August, whereas under unsprayed conditions aphid count crossed the critical limit from mid July onwards.

Division of Social Sciences

Impact of Potato Production Technologies Developed by the Institute

Seed potato marketing system in India and its impact on farmers' profitability

Seed potato utilization in Assam and Meghalaya states of India

Assam and Meghalaya are the main potato producing states of north-eastern India. However, long distance of these states from the main seed potato producing area of India (Punjab and western UP) make quality seed potato more or less unaffordable for all the growers. Two districts of Assam and one district of Meghalaya were selected as sample districts for this study. In total 135 potato farmers, 15 traders and 3 agricultural/ horticultural officers were interviewed from both the states under this study. 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 in both the states and it was found that in Assam, Kufri Jyoti was the predominant potato variety occupying major area (61%) followed by Kufri Pukhraj (33% potato area) and other potato varieties (6% potato area). However, in Meghalaya, about two third (65%) of the potato area was covered by Kufri Jyoti followed by LS Smith (local variety; 26%), Kufri Giriraj (6%) and Kufri Megha (3%) (Table 1).

Difficulty level for getting quality seed potato

In Assam, other varieties (un-registered; difficulty index=66) and Kufri Pukhraj (difficulty index=56) were the varieties whose seed was difficult to obtain while availability of Kufri Jyoti (difficulty index=38%) was the easiest. Similarly in Meghalaya, LS Smith (difficulty index=71) followed by Kufri Megha (difficulty index=69) and Kufri Giriraj (difficulty index=63) were the varieties whose healthy seed was difficult to obtain while Kufri Jyoti (difficulty index=46) was the variety whose seed was easily available.

Seed potato utilization pattern

In the state of Assam, seed potato purchased from traders constituted highest proportion in Assam for the most population variety Kufri Jyoti.

Table 1: Variety wise source of seed potato (%) in the study area

Seed source	Potato varieties							
		K Jyoti		K	K Giriraj	LS Megha	K Smith	Other Pukhraj
	Assam	Meghalaya	Overall	Meghalaya	Meghalaya	Meghalaya	Assam	Assam
Own farm	19.07	72.90	**36.62**	70.41	76.03	57.89	35.11	32.75
Other farmers	26.17	15.72	**22.76**	12.66	14.86	39.42	18.45	16.37
Traders	54.76	10.46	**40.31**	16.93	9.11	2.69	46.44	50.88
Govt. farms	0.00	0.92	**0.30**	0.00	0.00	0.00	0.00	0.00

However, in Meghalaya about 73% of potato area under Kufri Jyoti was covered using own farm grown seed potato by farmers. Except for Kufri Pukhraj and other varieties in Assam, local grown seed potato of rest of all varieties was used in the highest proportion in the study area.

Effect of seed quality on farmers' profitability

In the study area the cost of cultivation was estimated at Rs. 108510/ ha and 54% of the cost of cultivation was incurred for purchasing seed potato. 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 had higher potato yield, cost of cultivation, net income and benefit-cost ratio compared to the 50% respondents with lower expenditure on seed potato in both the states. In Assam the half of farmers having higher expenditure on seed potato had 33% higher net income, 29% higher gross income and 6% higher B-C ratio (due to higher cost of cultivation). Similarly in the state of Meghalaya half of the higher spenders on seed potato had 45% higher net income, 33% higher gross income and 15% higher B-C ratio. Hence, availability of quality seed potatoes to each and every farmer of the country is in the benefit of farmers as well as the nation.

Constraints in seed potato cultivation

Constraints of potato farmers were studied in terms of their severity and the severity was reflected by the proportion of positive responses. Expensive seed potato was found to be the severest problem for potato farmers in the state of Assam followed by bad quality of seed potato, expensive fertilizers and chemical and unavailability of healthy seed from local government farms. In Meghalaya unavailability of healthy seed potato from local government farms followed by bad quality of available seed, expensive seed potato and expensive fertilizers and chemicals were the severest constraints felt by the potato growers.

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

Adoption of improved potato varieties and technologies in Uttar Pradesh

Major objective of this project was to assess the extent of adoption of potato varieties and technologies in leading potato growing states. This year asurvey of 90 potato growers was carried out in Uttar Pradesh.Two district namely Agra and Kannauj were selected for the because these districts are having highest potato production in the state. Three blocks were selected from each districts and 15 farmers from each block were selected as respondents. Thus, a total sample size of 90 farmers was chosen. Primary data were collected from farmers using an structured interview schedule. Data were analyzed using suitable statistical tools.

Extent of Adoption of different potato varieties

Adoption pattern of different potato variety was assessed in terms of percentage area under a particular variety out of total potato area. It was observed that that Kufri Bahar was the leading potato variety with 90% of total potato area in Agra. Kufri Satluj with 5% area was the second leading variety. Other varieties of potato were grown under the remaining area. On the other hand, in Kannauj district, several varieties of potato were grown, of which Kufri Pukhraj was the most popular variety covering nearly one third of the total area under potato followed by Kufri Bahar (22.2% area). Some local varieties were also popular namely Lal Gullal (16.1%), New Holland (14.8%). Other varieties like Kufri Chpsona-1 and 3, Kufri Frysona etc were also present occupying 15.9% area. Thus, it can be observed that farmers from Kannauj district

adopted many potato varieties while Farmers in Agra were happy with production and quality of Kufri Bahar variety.

Adoption pattern of potato production technologies

Several agronomic and plant protection measures are required for getting higher yield in potato. The results from both the selected districts revealed that the average cultivated land holding of potato in Agra was found to be 6.9 ha which was higher than Kannauj (2.71 ha). The seed rate of potato in Agra and Kannauj were 38.5 q/ha and 37 q/ha. Thus, farmers from both the districts were using higher seed rate. A majority of farmers were using recommended spacing of 60X20 cm in both the districts. Only one weeding was practiced in Agra where pre emergence use of metribuzin @ 400-500 g/ha was most popular. In Kannauj, one weeding using sencore @ 250-300 g/ha at 15-20 days after planting was mostly used practice by farmers. NPK dose in both the districts Agra (210:207:109 Kg/ha) and Kannauj (251:253:99 Kg/ha) were found to be higher than recommended dose especially for phosphate use. In Kannauj, use of N and P was higher as compared to Agra. Late blight was the major disease in both districts followed by black scurf and common scab. A majority of farmers were aware about the alternate use of Diathane M-45 and Ridomil for controlling late blight. No farmers were practicing boric acid treatment for black scurf and common scab. The average yield of potato in Agra was found to be 27t/ha while it was slightly less at 25 t/ha in Kannauj district.

Assessment of improved potato varieties

Overall, 52 demonstrations were laid out in different locations of HP namely Shimla, Kinnaur and Lahaul spiti to assess the performance of potato variety Kufri Himalini at farmers' field.

In Bagna Fagu, Panjala and Talai villages of Shimla district, 10 varietal demonstrations were laid out to show the farmers, the superiority of new potato variety Kufri Himalini over existing Kufri Jyoti. All the recommended package of practices were used in demonstration plots. The average yield of demonstrated variety Kufri Himalini was found to be 16.7 t/ha which was 45.2 per cent higher than the control variety Kufri Jyoti (11.5 t/ha).

In Raksham, Chitkul and Butturi villages of Kinnaur, 20 demonstrations of Kufri Himalini were laid outat farmer's field. The observations were recorded time to time. Analysis of data revealed that the demonstrated variety Kufri Himalini gave 18.4 t/ha yield which was higher than locally cultivated Kufri Jyoti (10.8 t/ha).

Similarly, in Sisu, Sasan, Chilthang, Goparhang and Ropasang villages of Lahaul Spiti, 10 demonstrations of Kufri Himalini were laid out. The yield level were compared with local variety Kufri Jyoti and it was found that Kufri Himalini gave an average yield of 20.5 t/ha while control variety Kufri Jyoti gave only 16.0 t/ha yield. Thus, Kufri Himalini recorded an yield increase of 28.1 per cent over local variety.

Six demonstrations each of red skinned potato varieties Kufri Lalit and Kufri Lalima were conducted in different villages of East Champaran district of Bihar. Results revealed that both the varieties gave significantly higher yield than local red skinned varieties. Kufri Lalit gave 42% higher yield while Kufri Lalima gave 18.8% higher yield as compared to local varieties.

Impact of training programme: A 21-days Summer School sponsored by ICAR was organized on "Current Trends in Quality Potato Production, Processing and Marketing"from July 8-28, 2014. The objective of this training was to enhance the knowledge and skills of trainees regarding current research and development activities going on in potato sector. The training

was attended by 19 participants from 8 states. Several methods of training such as lecture-cum discussion, practical sessions, field visits, video film shows *etc*. were applied during this programme. To assess the impact of training, pre and post training evaluation was conducted. Majority of the trainees were very well satisfied with the training contents and training delivery mechanism. More than 70% of trainees felt that training programme environment and behaviour and style of teacher was excellent during training. Nearly 60% were very well satisfied with lab facilities provided during the training.

The highest gain in knowledge (32.7%) was in the area of "basic knowledge of potato" after training. Gain in knowledge was also found to be higher in Potato Physiology and Post-harvest Technology (27.3%) and Disease and pest management (21.8%). Thus, average increase in knowledge of trainees before and after training was estimated at 21.42% which shows that training was successful in significantly increasing the knowledge of the respondents. A majority (68.4%) of the trainees graded the training programme as excellent while 26.3% felt that it was of very good quality.

Transfer of Technology

Technology transfer activities organized at CPRI, Shimla

During the year 2014-15 a large number of technology transfer activities related to potato were organized by the institute. These activities helped in creating awareness and improving knowledge of farmers as well as other stakeholders *viz*. scientists, teachers, processors, entrepreneurs in the field of potato Research and Development. These technology transfer activities included organization of training programmes, laying out demonstrations on farmers' field, *Kisan Mela*, putting up exhibition stall in various events and organizing live phone in programmes on All India Radio and Doordarshan, Shimla for farmers and other stakeholders. Organization of ICAR sponsored 21 days Summer School, 15 days Short Course at CPRI, Shimla and Eastern Zone Regional Agriculture Fair at CPRS Patna sponsored by Department of Agriculture and Cooperation were the major highlights of Technology Transfer activities during the period under report.

A. Organization of trainings: A large number of training programmes for scientists, farmers, extension functionaries and other stakeholders were organized at CPRI Headquarters, Shimla. Nearly all the aspects of potato cultivation *viz*. seed preparation, planting, fertilizer application, intercultural operations, water management, disease/pest management, harvesting, processing, storage and marketing were covered during these trainings programmes. The trainees were exposed to a series of lectures as well as practical classes on above mentioned topics. In these lectures, audio-visual aids were used by the faculty with extensive use of photographs and other informative tools like live samples, making the process of learning more interactive and informative. Besides this, field visits to CPRS, Kufri-Fagu and other important places like DMR, Solan, UHF, Nauni etc. were also organized for trainees. The details of trainings conducted during 2014-15 are given in the Table 1.

Table 1: Details of training programmes organized at CPRI, Shimla

Sl. No.	Title of training	Date & Duration	Sponsoring Agency	No. of farmers stakeholders
1.	*Adunik Taknik dwara beej aloo utpadan*	6-8 May 2014 (3 days)	CPRI, Shimla	19 Farmers
2.	Competency Development on Potato Cultivation	23-24 may 2014 (2 days)	CPRI, Shimla	21 Extension Functionaries
3.	Competency Development on Potato Cultivation	5-6 June 2014 (2 days)	CPRI, Shimla	30 Extension Functionaries
4.	Potato Cultivation	27th and 29th June, 2014	CPRI, Shimla (under TSP)	160 farmers from Leh (J&K)

5.	Summer School on "Current Trends in Quality Potato Production, Processing and Marketing"	8-28 July 2014 (21 days)	CPRI, Shimla	19 Scientists/ Teachers
6.	*Adunik Taknik dwara beej aloo utpadan,*	2-4 Sept. 2014 (3 days)	CPRI, Shimla	20 Farmers
7.	*Adunik Taknik dwara beej aloo utpadan,*	28-30 Sept. 2014 (3 days)	CPRI, Shimla	21 Farmers
8.	"Cultivation of Seed Potatoes, Wheat and Agro-forestry"	5-7 August 2014 (3 days)	Lahaul-Spiti (HP) Under TSP	44 Farmers
9.	Short Course on "Application of Cellular, Molecular and Genomics Tools in Crop Improvement"	7-16 Oct. 2014 (15 days)	CPRI, Shimla	16 Scientists/ Teachers
10.	*Adunik Taknik dwara beej aloo utpadan,*	7-9 Oct. 2014 (3 days)	CPRI, Shimla	20 Farmers
11.	*Adunik Taknik dwara Bhojya evam beej aloo utpadan*	17-19 March 2014 (3 days)	CPRI, Shimla	18 Farmers

B. Demonstrations: A total of 40 on farm demonstration were laid out in Shimla, Lahaul Spiti and Kinnaur districts of Himachal Pradesh during 2014-15. New potato variety Kufri Himalini was demonstrated to farmers in all these places. The results clearly showed the superiority of Kufri Himalini over existing variety Kufri Jyoti in terms of yield advantage as well as resistance to late blight infestation.

C. Organization of *Kisan Mela* cum Training Programme

Central Potato Research Institute, Shimla in collaboration with Indian Potato Association organized **Eastern Zone Regional Agricultural Fair** at CPRS, Patna during 19-21 Feb., 2015 sponsored by Directorate of Extension, Department of Agriculture and Cooperation, Govt. of India. The theme of this mela was ***"Horticulture for rural livelihood security for Eastern Plains of India".*** More than 10,000 farmers from different districts of Bihar, Jharkhand, Eastern U.P. and Odisha participated in this fair.

Nearly 100 stalls from different public and private sector organizations/NGO were put up during the event. Hon'ble Union Minister of Agriculture, Sh. Radha Mohan Singh Ji

inaugurated the Eastern Zone Regional Agricultural Fair on 20 Feb., 2015.

D. 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/pest management, storage practices *etc.* during *Krishi Darshan*. A list of these programmes is given in Table 2 & 3.

E. Participation in agricultural fair/exhibitions: CPRI, Shimla participated in many exhibitions and agricultural fairs organized in different

Table 2: Live phone in programme on Doordarshan, Shimla during 2014-15

Sl. No	Date	Topic	Name of expert
1.	April, 2014	Seed preparation and planting of potato in higher hills of HP	Dr. Vinod Kumar Dr. Ashwani Kumar
2.	May, 2014	Earthing up, fertilizer application and weed management in high hills of HP	Dr. VK Dua Dr. SS Lal
3.	June, 2014	Disease management in high hills and Harvesting of potato in mid hills of HP	Dr. Sanjeev Sharma Dr. Dhiraj K. Singh
4.	July, 2014	Post-harvest handling in potao in mid hills of HP	Dr. RK Rana Dr. Pinky Raigond
5.	August, 2014	Intercultural practices and disease management in Potato in high hills of HP	Dr. Ravinder Kumar Dr. Dhiraj Kumar Singh
6.	September, 2014	Harvesting and Post harvest operation of seed potato in higher hills of HP	Dr. Vinod Kumar Dr. NK Pandey
7.	October, 2014	Marketing and Storage of Potato in HP	Dr. Brajesh Singh Dr. Dhiraj K. Singh
8.	November, 2014	Planting and Fertilizer application in Lower Hills of HP	Dr. Vinod Kumar Dr. VK Dua
9.	December, 2014	Planting and disease management in Potato in the hills of HP	Dr. Ashwani Sharma Dr. Sanjeev Sharma
10.	January, 2015	Planting and Fertilizer application in mid hills of HP	Dr. Ashwani Sharma Dr. Vinod Kumar
11.	February, 2015	Intercultural operations and harvesting of Potato in HP	Dr. VK Dua Dr. Brajesh Singh
12.	March, 2015	Disease and Pest management in potato in mid hills of HP	Dr. Sanjeev Sharma Dr. Ravinder Kumar

Table 3: Radio talk/ live phone in programme on AIR, Shimla

Sl. No	Date	Topic	Name of Expert
1.	June	Live Phone in Programme on "Disease Management in Potato	Dr. Sanjeev Sharma
2.	June	Radio Talk on " Late blight disease and its management"	Dr. Sanjeev Sharma Dr. NK Pandey

parts of the country and also won many prizes for best stall during these exhibitions. CPRI stall was put up to showcase new potato varieties and production technologies of potato. A large No. of farmers benefitted from these exhibitions. List of these exhibitions is given below.

- National Mushroom Mela at Directorate of Mushroom research, Chambaghat Solan on 10th September, 2014.
- Eastern Zone Regional Agriculture Fair at CPRS Patna during 19-21 Feb., 2015.
- Exhibition organized during National Seminar on "Emerging Problems of Potato" at CPRI, Shimla during 1-2 Nov., 2014.

Activities of Agriculture Technology Information Centre (ATIC)

Sale and distribution of CPRI technical and extension bulletins: A total of 1827 technical and extension bulletins were sold through ATIC. Moreover, nearly 2000 CPRI brochures, Crop Calendar and leaflets related to modern potato technologies were distributed free of cost to the Scientist, Extension workers and Farmers. Six CDs of PPM (Potato Pest Manager) and CAAPS (Computer Aided Advisory System for Potato Crop Scheduling) were also sold through ATIC. Altogether revenue generated through sale of publications and CDs/Expert system was of value Rs. 1, 12,878/-.

Dissemination of knowledge to visitors: An Institute museum as well as a Farmer's Museum has been set up in which the technology developed by CPRI were 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 visitors were benefited by strengthening their knowledge about scientific potato cultivation. A total of 1580 stake holders visited in the institute during the period under report. The visitors included 1059 B.Sc./M.Sc./Ph.D students of various universities of different states, 380 farmers from different states of the country and 140 scientist/extension worker/state level agriculture and horticulture officer.

Extension activities at CPRI Campus Modipuram

- **Training:** One days training programme on Agro-techniques for Production of Processing Potatoes for 20 field staffs of Pepsi Co organized on 16 January, 2015 sponsored by PepsiCo India Holding Pvt. Ltd., Gurgaon.
- **Exhibitions:** CPRIC, Modipuram participated in several exhibitions and showcased the potato technologies developed by the institute. The details are as under:
- Krushi mela on the occasion of Gujrat Krishi Mahotsava- 2014 at Chottaudepur (middle Gujrat) during 3-4 June 2014 and 6-7 June 2014 at Vyara district Tapi (South Gujrat).
- All India Farmers' Fair and Agro-Industrial Exhibition held at SVBP University of Agri. & Technology, Meerut during 16–18 October, 2014. The CPRI stall was awarded third in ICAR group.
- Krishi Gosthi cum Krishi Exhibition held at Rasolpur Jattan village on 13 December 2014 and at Barwala village of Muzafarnagar district on 14 December 2014.
- Pusa Krishi Vigyan Mela held at I.C..A.R. - I.A.R.I. Pusa during 10-12 March, 2015. The institute stall was adjudged by the judging committee for Prasansa Puruskar of the Krishi Vigyan Mela.
- North Zone Regional Krishi Mela – 2015 at I.C.A.R.- IVRI Izatnagar Bareilly U.P. during

17-20 March 2015. The CPRI stall was awarded second best among all stalls.

- KisanVigyan Samagam Organized by Indian Institute Sugarcane Research Lucknow on 23 January 2015 at Indian Institute for Farming System Research Modipuram, Meerut.
- **Visitors and phones attended:** Total 221 farmers from various districts of UP, Haryana, Rajasthan, and MP and 78 agriculture students visited Central Potato Research Institute Campus, Modipuram to know the potato farming activities at the campus. A total number of 50 quarries of potato growers from various districts of U.P. Rajasthan, Punjab and Haryana states answered through phone.

Extension activities at CPRS, Patna

- **Training:** Two 5-days Farmer's training programmes potato cultivation was organized by CPRS, Patna during the period under report. A total of 58 farmers from different districts of Bihar participated and benefitted from these trainings. In addition, 8 more training of one day duration were conducted at CPRS Patna for the benefit of 243 farmers from Bihar.
- **Demonstrations:** A total of 30 Front Line Demonstrations were laid out in different villages of East Champaran district for seed production and improved package of practices.
- **Exhibitions:** CPRS, Patna participated in following exhibitions and showcased the potato technologies developed by the institute.
- Kisan Mela at IIVR, Varanasi during 30-31 Jan, 2015.
- Regional Agricultural fair at CPRS, Patna during 19-21 Feb., 2015.
- Kisan Mela at BAU, Sabour during 1-2 March, 2015. The CPRI stall was awarded second best among the stalls.
- **"Mann Ki Baat" Radio Programme:** A group meeting of 40 farmers were organized to listen to Honourable Prime Minister' live address "Mann Ki Baat" on 22nd March, 2015.

Extension activities at CPRS, Gwalior

- **Training:** The centre organized three day training programme on 'Potato production technology and agricultural management' sponsored by ATMA Bhind M.P. during 2-4th March, 2015 in which 30 farmers participated and benefitted.
- **Exhibitions:** CPRS, Gwalior participated in following exhibitions and showcased the potato technologies developed by the institute.
- CPRS, Gwalior installed exhibition stall and scientists gave lecture on "potato production technology'at krishi fair at Etawah on 19/11/2015 rganized by Horticulture department Etawah, UP.
- ICAR-CPRS, Gwalior participated in a three day KRISHI VIJAY Agricultural Mega fair organized by RVSKVV Gwalior (M.P.) from 27-30 September, 2014. ICAR-CPRS, Gwalior was adjudged the best and bagged first prize in stall exhibition.
- **Visitors attended:** Total 1272 farmers from various districts of Madhya Pradesh and other states of India visited the station and apprised about potato technologies by experts from CPRS Gwalior during the period under report.

Extension activities at CPRS, Jalandhar

- Training programme on Seed Production of Potato was conducted at ICAR-CPRS Jalandhar during 10-11 February, 2015 for a

group of 9 persons (3 official + 6 progressive farmers) of Idukki, Kerala.

- Three authorized representatives from the Beejo Sheetal company were trained for 2 days for the period from 11.11.2014 to 12.11.2014 covering all aspects of fabrication of Aeroponics System Technology.
- A group of 100 farmers visited on 21.08.2014 at CPRS Jalandhar from NHRDF, Karnal. A training/ Orientation Programme was organized on Breeder Seed Production.
- A total of 55 farmers were shown demonstration on Drip irrigation/Fertigation during 2014-15 at CPRS, Jalandhar.

Extension activities at CPRS, Shillong

- A total of 22 on farm demonstrations were conducted in six different villages of East khasi hills district of Meghalaya. Kufri Himalini used for the demonstration recorded an average yield of 19.83 t/ha while the local variety used by the farmers recorded only 7.75 t/ha. Almost three fold yield increase was realized from improved potato variety Kufri Himalini.

Extension activities at CPRS, Ooty

- Front Line Demonstrations were laid out for popularization of potato cultivars in Hassan District of Karnataka at 10 selected locations during Kharif season. Nearly 500 farmers were benefitted from these demonstrations.
- Experts from CPRS, Ooty participated in Four TV programmes on DD Pothigai on different aspects of potato cultivation *viz*. "Management of potato cyst nematode in Nilgiris (Tamil)", "Quality seed production in potato (Tamil)", "Potato cultivation technologies (Tamil)" and "Management of late blight in potato (Tamil)". Thousands of farmers benefitted from these programmes.

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 67 thousands documents and has attained the position of most sought-after library on potato R & D in India. Since its inception this library has acted as repository and clearinghouse of potato literature and information. It continually provided scientific and technical information supports and services towards attainment of research mission of the institute. Efforts were made for strengthening and developing the information resources and services through undertaking various activities given here below:

Resource Development

At the headquarter (Shimla), a total of 446 documents were purchased, procured and added to library resources. The total collection at Shimla stand at 38503 documents comprised of 15758 books, 15164 back volume of journals, 2616 serials, 2228 annual reports, 582 theses, 251 standards, 51 maps/atlases, 1663 reprints and 190 CD's. The libraries at six regional stations and one campus at Modipuram are having their own library collection of 29212 books; journals back volumes and other documents *i.e.* AR/Reprints and Bulletins etc as per the details below (Table-1).

Periodicals and Serials Management

Forty serials title *i.e.* advances, annual reviews, reference annuals, yearbooks and statistical data publications etc. were purchased. A total of 178 current journals comprising of 30 foreign and 148 Indian have been subscribed at Shimla. Out of which 18 foreign and 137 Indian journals were subscribed on payment basis and rest on exchange or gratis. In all 1108 issues of such journals were received, marked and kept in library for use. Besides, 66 titles of different journals were subscribed at CPRS libraries. 330 330 books were classified, catalogued, labeled, pasted and transcribed and entered in Library Automation Software 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+

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	4572	5716	2807	13095	23
2 CPRS, Jalandhar	3173	1401	1228	5802	18
3 CPRS, Patna	2060	1280	-	3340	11
4 CPRS, Gwalior*	1013	4	69	1086	-
5 CPRS, Ooty	1623	1888	546	4057	10
6 CPRS, Shillong	1521	-	167	1688	4
7 CPRS, Kufri	144	-	-	144	
TOTAL	14106	10289	4817	29212	66

Note: Figure shown for CPRS Gwalior is for the year 2013-14

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 3114 documents were circulated (borrowed and returned) for home studies and 8192 readers consulted 9705 documents within the library. Besides, 17 outside scientists and research scholars of various research organizations consulted the library resources. 11 new members were enrolled and 14 old members withdrew their library membership due to their transfer or retirement. At present 147 readers are active members of library including RAs/SRAs. Library received 12288 reference queries from the users of the library and responded to them satisfactorily. Besides, 780 job requests were received for 2,16,825 copies of photocopying and printing work of different scientific and administrative documents.

Documentation and Information Services

1108 issues of journals (806 issues of national and 302 issues of international journals) were scanned for potato literature and 89 potato articles were found and recorded. Approximately, 35,330 records of library resources have been successfully migrated from 'Liberty' to 'Koha' an open source library management software and integrated with World CAT of OCLC through AgriCat OPAC of NARS libraries. This has provided international visibility of CPRI library resources. 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. 3,44,032.00 which includes the amount charged on account of rendering CDROM searching & photocopying (Rs. 6,622.00), IGNOU computer practical (Rs. 24,275.00) and library discount (Rs.3,13,135.00) in addition to normal 10% GOC discount saved on purchase of library books and journals through CPRI Book store. A total of Rs. 46,52,228.00 was spent (under Plan Rs. 44,94,035.00 and Non-Plan Rs. 1,58,193.00) on purchase of library resources like books (Rs.21,46,452.00), and subscription of journals (Rs.21,38,991.00) at HQ library Shimla and Rs 3,66,785.00 on CPRS libraries.

CDS/ISIS Practical Training

As per MOU between CPRI and IGNOU, New Delhi, 17 days computer, IT, and database creation and operation practical session was organized during 26th Aug – 12th Sep, 2013 for 9 MLIS and 18 BLIS students of IGNOU Study Center, Shimla.

Infrastructure Development

Six executive chairs and 15 visitor (reader chairs) were purchased under plan to enrich the library reading facilities.

Institute Research Council Meeting

The Institute Research Committee Meeting (IRC), 2014 was held at ICAR-CPRI, Shimla during 23rd-25 August, 2014 which was attended by 53 scientists from the Headquarters and the regional station. The basic objective of this meeting was to review the achievements of 2013-14, finalize the work plan for 2014-15 and to discuss and finalize the new programmes starting w.e.f 1st April, 2015. The major decision taken during the Meeting are given below:

1. Germplasm screening for frost resistance will be undertaken at ICAR-CPRI, Shimla and the seed material for the same will be provided by CPRS, Jalandhar.
2. Estimation of glycemic index should be removed from new program.
3. Morphological characterization should be specified for elite germplasm in the new program.
4. Pre-breeding should be a part of management and enhancement of germplasm programme and the traits for pre-breeding should be identified and prioritized.
5. DUS characterization of elite germplasm lines shall be done.
6. In C5 or C6 stage, advanced hybrids may be tested through ELISA to maintain the health of advanced hybrids.
7. The parameters of Desiree for keeping quality should be kept as baseline in breeding program.
8. Four Table purpose advanced hybrids J/6-182, MS/8-1148, MS/8-1565 and MS/9-723 and one early processing advanced hybrid were recommended for introduction into AICRP.
9. The elite early maturing hybrid is to be registered and its name should not be disclosed until the hybrid is registered. Necessary precautions like compulsory coding, not publishing about it and not sending the extra harvested material to the market etc. should be followed.
10. Root studies and soil water deficit should be considered for breeding for water stress. Kufri Pukhraj, Kufri Sindhuri and Kufri Arun should be taken as controls.
11. Breeding for biotic stress, abiotic stress, nutrient use efficiency and breeding for Kharif will become part of breeding programme. The resistant starch component should go into health and nutrition programme. The scientists responsible for different components of breeding programmes may also be identified.
12. Overall programme leader of breeding programme will be Dr SK Luthra, Principal Scientist, ICAR-CPRIC, Modipuram.
13. Role of vacuolarinvertase and sucrose synthesis in potato tuber to be reviewed and a note should be made and sent to Dr. Uday Kumar, RAC member.
14. Major works like gene cloning, construct development and all the transgenics works would be reflected under biotech program and all other small works would be reflected in their respective divisions.
15. Methodology for nutrient use efficiency particularly for gene expression study of ammonium transporter gene would be defined.
16. Work on metagenomics would be carried out atleast for 2-3 years and should include soil scientist, agronomist and biotechnologist.

17. Biotechnologists should concentrate and work on emerging fields in potato like converting C3 potato into C4, development of hybrid potatoes, development of day neutral potatoes, genome editing, proteomics and metabolomics on priority basis
18. The technologies developed by institute for micro irrigation should be popularized.
19. The potato digger should be improved for minimizing the damage to skin during harvesting.
20. For developing experimental purpose grader the breeders / end users should be consulted.
21. Attempts should be made to develop starch extraction instrument for lab purpose.
22. For purification, check the concentration of ToLCNDV-potato in middle/lower leaves. Till then emphasis should be given on PCR based diagnostics.
23. Studies on effect of soil moisture levels in development of common scab be studied based on virulence of strains with or without genes for thaxtomin production.
24. Scale developed for mite infestation may be revised with quality photographs using same background and taking into consideration most characteristic symptoms.
25. Identification of pre-storage markers for assessment of keeping quality during storage may be included in the new project proposal.
26. Assessment of rots (soft and dry) and their management during post-harvest storage should be carried out in storage systems.
27. Efforts need to be made to increase the area under hi-tech seed production in a phased manner.
28. The existing tissue culture facilities at different station should be in operation round the year.
29. All the station should develop facilities for PCR based testing in order to screen the available tissue culture materials at their level for further multiplication.
30. The technology of Bower system in aeroponic should be perfected for hills.
31. Every station has to develop their own strategy for getting better seed crops in aeroponics.
32. The research activity on photo-autotropism conducted at CPRS, Jalandhar should be concluded and commercialized.
33. A survey should be conducted in early growing regions of Punjab for finding out reasons for non adoption of Kufri Surya.
34. Based on 2-3 year demonstration data, strong recommendation should be given to concerned state govt. for adoption of new varieties.
35. Cost of cultivation of potato for all the major potato growing states (Punjab, Bihar, UP and West Bengal) should be worked out.

Publications

A. Research Papers

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E. Miscellaneous Publications

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Institute Activities

Important meetings and Visitors

Institute Management committee (IMC) meeting held at CPRI Shimla

Institute Management Committee (IMC) meeting was held at CPRI Shimla on 24th June 2014 in the chairmanship of Dr. B.P. Singh, Director, CPRI Shimla. Other members Dr. S.K. Kaushik, Joint Director, CPRIC, Modipuram, Dr. Neelima Garg, Head (PHT), CISH, Lucknow, Sh Ram Kandege (Advocate & Ex MLA), Pune, Maharashtra, Shri Kanwar Pratap Singh Chaudhary from Delhi and Sh A.K. Singh, Member Secretary (IMC) also participated in the meeting. Important decisions were taken by the committee.

CPRI celebrated its 65th Foundation Day

The 65th Foundation Day of CPRI was celebrated on 22nd August, 2014. ASRB Chairman, Dr. Gurbachan Singh graced the occasion as the Chief Guest of the function and Member of Parliament, Shimla, Sh Virender Kashyap presided over the

function. Director, Directorate of Mushroom Research, Solan Dr. Manjit Singh, Director, CTCRI, Trivandrum Dr. SK Chakrabarti, Director, Directorate of Onion and Garlic Research, Dr. Jai Gopal and Former Vice Chancellor, UHF, Nauni

Dr. KR Dhiman were also present on this occasion. Dr. BP Singh, Director, CPRI welcomed all the dignitaries and briefed them about the functions and achievements of CPRI. Dr. Gurbachan singh delivered the Foundation Day lecture and talked about the achievements of this institute and future challenges. Sh Virender Kashyap, in his remarks talked on Lab to Land programme and emphasized on necessity of reaching of varieties and technologies to farmers. On this occasion, On line Examination Hall under ASRB was inaugurated by Dr. Gurbachan Singh. Prestigious Dr. Ramanujam Award of CPRI was conferred upon Dr. SK Chakrabarti for his outstanding achievement in the field of potato research and development. Scientists and other technical and suppoting staff of CPRI were awarded by CPRI Best Worker Award.

IRC Meeting

The Institute Research Committee meeting was held on August 23-25, 2014 at CPRI, Shimla. The meeting was attended by 52 scientists from Shimla and Regional Stations 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 2013-14 under 18 research programmes of the Institute. The new research project proposals were also presented and deliberated.

RAC Meeting

The 21st meeting of the Research Advisory Committee (RAC) was held at the ICAR-Central Potato Research Institute, Shimla during 18-19 August, 2014 under the Chairmanship of Dr. GL Kaul, Ex-Vice Chancellor, Assam Agricultural University, Jorhat. Dr. BP Singh, Director, CPRI

welcomed the Chairman and the members of RAC. The Chairman, Dr. GL Kaul congratulated the institute for Best Annual Report Award and for development of Indo-Blight cast model. The RAC reviewed the progress of 18 Institute's Research Programmes and gave their recommendations.

MoU for breeder seed production signed between CPRI, Shimla and PAU, Ludhiana

A Memorandum of Understanding was signed between CPRI, Shimla and Punjab Agricultural University (PAU), Ludhiana on August 28, 2014 in Chandigarh for breeder seed production of potato by the University. On this occasion, Dr. NK Krishna Kumar DDG (Horticultural Science) ICAR, New Delhi and Shri Suresh Kumar Financial Commissioner (Development), Government of Punjab were also present. The

MoU was signed by Dr. Bir Pal Singh, Director CPRI Shimla and Dr. BS Dhillon, Vice Chancellor, PAU Ludhiana. The main objective of this MoU is to augment the production of breeder seed of important varieties of CPRI by PAU Ludhiana on their seed farm under the technical guidance of CPRI Shimla.

Hindi Chetna Maas

The institute celebrated the Hindi Pakhwada from 14 September to 13 October, 2014. Several competitions related to essay writing, Hindi word knowledge, Hindi typing, quiz etc were held in which many staff of CPRI participated. Hindi Divas was also celebrated at CPRI Stations *viz*. Modipuram, Jalandhar, Patna, Gwalior, Ooty and Shillong. The winners of these competitions were awarded with prizes by Dr BP Singh, Director, CPRI. He also emphasized on the more use of Hindi in the day to day work of the Institute.

Visit of Dr. VN Sharda, Member ASRB to CPRI, Shimla

Dr. VN Sharda, Member, ASRB, New Delhi visited CPRI, Shimla during 23rd to 25th September, 2015 to inspect the holding of examination at newly built ASRB Online Examination centre at the Institute. During his visited, Dr. Sharda visited

CPRI laboratories and processing unit at CPRS, Kufri. He appreciated the activities being performed in the Institute and gave guidance to various scientists during his visit.

National Seminar on Emerging problems of Potato at CPRI, Shimla

A National Seminar on Emerging Problems of Potato was organized jointly by Indian Potato Association and Central Potato Research Institute at Shimla during1-2 November, 2014. Her Excellency, The Governor of Himachal Pradesh Smt. Urmila Singh graced the occasion as the

Chief Guest of the inaugural function and Dr NK Krishna Kumar, DDG (Horticultural Science) presided over the function. Dr SK Malhotra, Horticulture Commissioner, Ministry of Agriculture and Dr Julian Parr, Regional Director, International Potato Centre (CIP), New Delhi were present as Guest of Honour along with other dignitaries. Chief Guest, Her Excellency, the Governor of HP lauded the efforts made by CPRI Scientists for enhancing the potato production in the country through development of suitable potato varieties and production technologies. Various Technical sessions were organized on Crop Improvement, Plant Protection, Post-harvest technology, Biotechnology, Nanotechnology etc. During this Seminar, several challenges confronted by potato R&D sector in the country *viz*. climate change, virus vector dynamics, processing sector, higher yield gap etc were discussed in length and breadth by 250 researchers from India and abroad. During this

Function, Prestigious IPA Kaushalya Sikka Award was conferred to Dr Jeevalatha, Scientist, CPRI Shimla and her teammates namely Dr Baswaraj R., Dr Ravinder Kumar, Dr SK Chakrabarty and Dr BP Singh for their outstanding contribution in the field of potato disease diagnostics. Another Chandraprabha Singh Young Scientist Award was conferred upon Dr Jagesh Tiwari, Scientist, CPRI, Shimla. Four publications were also released on this occasion by the Governor.

Eastern Zone Regional Agriculture Fair organized at CPRS, Patna

Eastern Zone Regional Agricultural Fair at Central Potato Research Station, Patna, was organized during 19-21 Feb., 2015 by ICAR-Central Potato Research Institute, Shimla, Indian Potato Association and DAC, Ministry of Agriculture. The fair was inaugurated by Union Agriculture Minister Sh. Radha Mohan Singh. Agriculture Minister in his inaugural address, he emphasised the need of Soil Health Card and Lab to Land Programme. The innovative farmers from state of Bihar, Jharkhand, Odisha and West Bengal were felicitated by Union Minister of Agriculture on the occasion. A special issue of 'Kheti' on potato and other publications were also released by Union Minister of Agriculture.

More than 12,000 farmers from Bihar and neighbouring states, Jharkhand, Odisha and West Bengal visited and benefitted from this fair. They also participated in *Kisan Goshthis* on various topics during the Fair. A large number of ICAR Institutes, SAUs, government organisations, private NGOs participated and setup about 100 exhibition stalls for benefit of farmers. Shri Ramkripal Yadav, Union Minister of State for Drinking Water & Sanitation was the chief guest in concluding ceremony. He appreciated the efforts of agricultural scientists for organising the regional fair at Patna.

IJSC Meeting

Three Institute Joint Staff Council meetings were organized during June, October and February during the year 2014-15 at CPRS, Ooty, CPRS, Patna and CPRI, Shimla respectively. The meeting was chaired by Director CPRI, Dr BP Singh. Agenda items related to different issues of staffs of CPRI, Shimla and other regional stations were discussed and several important decisions were taken during these meetings.

Foreign Visits by CPRI Scientists

Sl. No.	Name of the scientist place & duration
1.	Dr. Bir Pal, Singh, Director, CPRI, Shimla attended the meeting of Board of Trustees of CIP held at Beijing, China during 14-18 April, 2014 .
2.	Dr. Bir Pal, Singh, Director, CPRI, Shimla attended the "Regulatory Strategy Meeting"of ABSP-II LBR Potato Project held at Dhaka Bangladesh during 12-14th May, 2014.
3.	Dr. Vinay Bhardwaj, Sr. Scientist, CPRI, Shimla attended the "Regulatory Strategy Meeting" of ABSP-II LBR Potato Project held at Dhaka Bangladesh during 12-14th May, 2014.
4	Dr. Sanjeev Sharma, Sr. Scientist, CPRI, Shimla attended the "Regulatory Strategy Meeting" of ABSP-II LBR Potato Project held at Dhaka Bangladesh during 12-14th May, 2014.
5.	Dr. Surendresha, Scientist, CPRI, Shimla attended the "Regulatory Strategy Meeting" of ABSP-II LBR Potato Project held at Dhaka Bangladesh during 12-14th May, 2014.
6.	Dr. Sanjeev Sharma, Sr. Scientist, CPRI, Shimla for attending the workshop on "Potato Late Blight" held at Kathmandu, Nepal during 06-09 November, 2014.
7.	Dr. Bir Pal, Singh, Director, CPRI, Shimla attended the "CIP Board of Trustees Meeting" held at Lima Peru during 20-25 November, 2014.
8.	Dr. Sanjay Rawal, Pr. Scientist, CPRIC, Modipuram attended the training on "Abiotic stress and breeding activities" held at CIP, Lima Peru during 07-18 December, 2014.
9.	Dr. VK Gupta, Sr. Scientist, CPRIC, Modipuram attended the training on "Abiotic stress and breeding activities" held at CIP, Lima Peru during 07-18 December, 2014.

Education, Training, Awards and Honours

Conference/Seminar/Symposium/Workshop w.e.f. 01.04.2014 to 31.03.2015

Sl. No.	Name & Designation	Training Programme	Date & Venue
1.	Dr. KK Pandey, PS, Dr. MS Gurjar, Sci., Dr. Jeevalatha, Sci., Dr. RP Pant, Sr. Sci.	National Symposium on **"Plant Pathology in genomic Era"**	May 26-28, 2014 at IGKV, Raipur
2.	SK Yadav, Scientist	National Seminar on **"Organic Agriculture Challenges & Prospects"**	May 28-29, 2014 at CSKHPKV, Palampur
3.	Dr. VK Dua, PS, Dr. Sanjeev Sharma, Sr. Sci., Dr. Devendra Kumar, PS, Dr. Baswaraj, Sci., Dr. Pinky, Sci., Dr. Mehi Lal, Sr. Sci., Dr. Sridhar, Sci., Dr. Dhruv Kumar, PS, Dr. SP Singh, PS, Dr. Manoj Kumar, PS, Dr. Anuj Bhatnagar, PS.	Global conference on **"Technological challenges and Smart Horticulture"**	May 28-31, 2014 at Navsari, Gujarat.
4.	Rajesh Kumar Rana, Principal Scientist	Workshop on Possibility of Spreading Out the Insurance Coverage to Horticultural Crops	July 7, 2014, Krishi Bhawan, New Delhi
4.	Dr. Mehi Lal, Sci.	National conference on **"Pro- Post harvest losses… in Vegetables"**	July 12-13, IIVR, Varanasi
5.	Dr. Dhruv Kumar, PS	MDP on **"Technology management for Researchers"**	August 19 – 23, 2014 at NAARM, Hyderabad
6.	Dr. NK Pandey, PS, Dr. VK Dua, PS, Dr. SK Kaushik, JD, Dr. Kamlesh Malik, PS, Dr. VK Gupta, Sr. Sci., Dr. Sanjay Rawal, PS, Dr. TK Bag, Head, Dr. JS Minhas, Head, Dr. Raj Kumar, PS, Dr. Manoj Kumar, Head, Dr. SK Singh, PS, Dr. EP Venkatasalam, Head, Dr. R Sudha, Dr. SK Yadav, Sci., Dr. Shambhu Kumar, Pr. Sci., Dr. MS Gurjar, Sci.	National Seminar on **"Post Harvest Management and Processing of Potato for Increasing food Security in India"**	September 22, 2014 at UAS, Dharwad, Karnataka

7.	Dr. Bir Pal Singh, Director, Dr. Brajesh Singh, PS, Dr. Rajinder Singh Sr. Sci., Dr. Prasant G. Kanwar, Sr. Sci., Dr. VU Patil, Sci., Dr. Jagesh K. Tiwari, Sci., Dr. Jeevalatha, Sci., Dr. Baswaraj, Sci., Dr. Pinky, Sci., Dr. Alka Joshi, Sci., Dr. Som Dutt, Sr. Sci., Dr. Devendra Kumar, PS, Dr. Sanjay Rawal, PS, Dr. Anuj Bhatnagar, PS, Dr. Name Singh, PS, Dr. Vinay Singh, PS, Dr. MA Khan, PS, Dr. Aarti Bairwa, Sci., Dr. R Sudha, Sci., Dr. Raj Kumar, PS, Dr. SK Singh, PS, Dr. Shambhu Kumar, Sr. Sci., Dr. Ashwani Kumar, Sr. Sci., Dr. KK Pandey, Head, Dr. VK Dua, Head, Dr. Jagdev Sharma, PS, Dr. Ravinder Kumar, Sci., Dr. Dhiraj K. Singh, Sci., Dr. Sundaresha, Sci., Dr. Sridhar, Sci., Dr. Venkateswarlu, Sci., Dr. Tanuja Buckseth, Sci., Dr. S Roy, Head, Dr. Murlidhar J Sadawarti, Sci., Dr. JS Minhas, Head, Dr. Sukhwinder Singh, Sci., Dr. Prince Kumar, Sci., Dr. Dhruv Kumar, PS, Dr. Mehi Lal, Sci., Dr. RP Pant, Sr. Sci., Dr. Bandana, Sci., Sh. Pynbianglang, Sci., Ms. Rinki, Sci., Ms. Pooja Chaukhande, Sci., Ms. Clarissa Challam, Sci., Sh. Hemant Balasaheb Kardile, Sci., Dr. Sanjeev Sharma, Sr. Sci., Dr. NK Pandey, Head, Dr. Rajesh Kumar Rana, PS, Dr. Vinay Bhardwaj, Sr. Sci., Dr. Vinay Sagar, Sr. Sci., Dr. Shashi Rawat, Sr. Sci., Dr. Dalamu, Sci., Dr. Vinod Kumar, Head, Dr. VK Gupta, Sr. Sci., Dr. SK Luthra, PS, Dr. SK Yadav, Sci., Dr. Manoj Kumar, Head, Dr. Sunil Gulati, Sci. (SG), Dr. TK Bag. Head, Dr. R Sudha, Sci., Dr. AK Srivastava, Sci., Sh. Kapil Kumar Sharma, Sh. Islam Ahmed, Sr. Tech. Officer, Sh. Sushil Kumar, Sr. Tech. Officer, Dr. Sumita Sharma, TO, Mrs. Shruti Gupta, TO, Ms. Anupama Guleria, SRF, Ms. Reena Sharma, SRF, Ms. Reetu Singh, SRF, Ms. Anupama Singh, RA, Ms. Youvika Singh, RA, Sh. Sanjay Kumar, SRF, Ms. Shivani Roach, SRF, Ms. Nilofer, JRF, Ms. Sapna, JRF, Mrs. Poonam, SRF, Sh. Anil Kumar, SRF, Sh. Touseef Hussain, SRF, Ms. Anubha Gupta, SRF, Ms. Anshu Mala, SRF, Ms. Astha Saraswati, SRF, Ms. Mamta Thakur, SRF, Ms. Sadhana Sharma, RA, Smt. Vandana Thakur, SRF, Sh. Krishan Gopal, RA, Sh. Rahul Sharma, RA.	National Seminar on **"Emerging Problems of Potato"**	November 01-02, 2014 at CPRI, Shimla
8.	Dr. SP Singh, PS	National Symposium on "Agriculture diversification ….Security"	November 18-20, 2014 at PAU, Ludhiana

9.	Dr. Anuj Bhatnagar, PS	International Conference on " Climate Change…… Management	November 27-29, 2014 at AMPUAT, Udaipur
10.	Dr. Som Dutt, Sr. Scientist and Dr. Sundresha, Sci.	Symposium "Strategic Approaches for Horticulture Research Education and Development – way forwards"	December 26 – 27, 2014 at NAAS Complex, New Delhi
11.	Dr. SP Singh, PS and Dr. Murlidhar J. Sadawarti, Sci.	XII Agricultural Science Congress, 2015 on "Diversifying Cropping ……Central India"	February 03 – 06, 2015 at NDRI, Karnal
12.	Dr. SK Yadav, Sci.	International Conference on "Natural Resource Management for Food Security and Rural Livelihoods"	February 10 – 13, 2015 at New Delhi
13.	Dr Sanjeev Sharma, Sr. Sci., Dr. Jeevalatha, Sci. and Dr. Sundaresha S., Sci.	National Symposium on "Understanding host-pathogen interaction through science of omics"	March 16 – 17, 2015 at IISR, Calicut
14.	Dr. Rakesh Mani Sharma, Sr. Librarian and Sh. Rajdeep Bux, TO	10th International Conference on "Convention on Automation of Libraries in Education and Research Institutions"	March 12 – 14, 2015 at IIAS, Shimla
15.	Dr. Jagdev Sharma, PS	National Symposium on "Modern Agro-technologies for Nutritional Security and Health (MANUSH)"	March 23, 2015 at Dr. YSP University, Solan

National Training w.e.f. 01.04.2014 to 31.03.2015

Sl. No.	Name & Designation	Training Programme	Date & Venue
1.	Ashish Dhangar, AF&AO	Workshop on "Pension & other retirement benefits"	June 09-12, 2014 at ISTM, New Delhi
2.	Dr. Sanjeev Sharma, Sr. Scientist	Training course on "International training on Pest risk Analysis"	September 01-05, 2014 at NIPHM, Hyderabad
3.	Sh. Murari Lal, Sr. Technical Officer	Training programme on "Application of ……..in agriculture"	Nov. 12 - Dec. 02, 2014 at SVPUAT, Meerut
4.	Dr. TK Bag, Head and Dr. KK Pandey, Head	Training programme on "Management Development……Leadership"	December 01-12, 2014 at NAARM, Hyderabad
5.	Dr. VU Patil, Sci.	Training programme on "Advance in omics data analysis" learning by example"	December 03-23, 2014 at IASRI, New Delhi

6.	Sh. Ramesh Chand, Sr. T.O. and Sh. Sanat Kumar	Training on "Manage of frost and prologet foggy weather"	December 17 – 23, 2014 at CSSRI, Karnal
7.	Dr. Prashant G. Kanwar, Sr. Sci.	Training programme on "Recent trends in ……in Agriculture"	January 02 – 13, 2015 at NAARM, Hyderabad
8.	Dr. Rajender Singh, Sr. Sci.	Training programme on "Recent Advances in Statistical Genetics"	February 03 – 23, 2015 at IASRI, New Delhi
9.	Dr. NK Pandey, Head	Training workshop on HRD Nodal Officers	February 26, 2015 at NAARM, Hyderabad
10.	Dr. Sushil Kumar, Sr. T.O., Sh. Dinesh Singh, Sr. T.O., Sh. Yogesh Kumar Gupta, Sr. T.O.	Training programme on "Office Automation using Oracle ERP"	March 09 – 13, 2015 & March 16 – 20, 2015 at IASRI, New Delhi

Awards and Honours

CPRI best worker award for year 2014

S.No.	Name of the Person	Category	Award	Year
1.	Dr. VK Dua & Dr. Brajesh Singh, CPRI, Shimla	Scientific	CPRI Best Worker Award	2014
2.	Sh. Kapil Kumar Sharma, CPRS, Jalandhar, Sh. Sushil Kumar, Sh. Naresh Kumar Sharma, CPRI, Shimla	Technical	CPRI Best Worker Award	2014
3.	Sh. Sachin Kanwar, Sh. Hans Raj, CPRI, Shimla	Administrative	CPRI Best Worker Award	2014
4.	Sh. Kanhaya Prasad , Sh. Babu Ram & Sh. Sanjeevan Kumar, CPRI, Shimla	Supporting	CPRI Best Worker Award	2014

- IPA-KaushalyaSikka Memorial Award of Indian Potato Association, Shimla for the block year 2009-2013 - Drs A. Jeevalatha, Baswaraj Raigond, Ravinder Kumar, S.K. Chakrabarti and B.P. Singh.
- Dr Sanjeev Sharma is honoured with Best Paper Award published in International Journal of Innovative Horticulture, 2013.
- Young scientist associate award (2014) conferred to MS Gurjar by Hi Tech Horticultural Society in International Conference on "Technological Interventions in Agricultural Sciences for enhanced Productivity, Nutritional Quality and Value Addition (17-19 Feb., 2015) at Central Institute of Horticulture, DAC. Ministry of Agriculture, Dimapur, Nagaland.
- IInd Best oral presentation award conferred to MS Gurjar on Phenotyping of Exotic Potato Genotypes for Late Blight (*Phytophthora infestans*) Resistance under Epiphytotic Conditions in International Conference on Technological Interventions in Agricultural Sciences for enhanced Productivity, Nutritional Quality and Value Addition (17-19 Feb., 2015) at Central Institute of Horticulture, DAC. Ministry of Agriculture, Dimapur, Nagaland.
- IInd Best poster presentation award to MS Gurjar, TK Bag, K Suraj Singh and Sanchita Roy (2014) on conference presentation on"Production, Post-harvest losses and Storage of Potato in Meghalaya: A current status (2014)". In: National Seminar on Post

Harvest Management and Processing of Potato for Increasing Food Security in India at UAS, Dharwad on 22nd Sept., 2014.

- Anuj Bhatnagar was awarded Second best oral presentation in International conference Changing Scenario of pest problems in Agri-Horti Ecosystem and their management organized by Entomological Research Association, Department of Entomology on 27-29 November, 2014 MPUAT, Udaipur.
- Vallepu Venkateswarlu received Best Oral presentation award at theInternational conference: Changing Scenario of pest problems in Agri-Horti Ecosystem and their management organized by ERA, MPUAT, Udaipur on 27-29 November, 2014 at MPUAT, Udaipur.
- Sridhar Jandrajupalii received Best poster presentation award at National seminar on emerging problems of potato", organised by CPRI, Shimla and IPA, Shimla on 1-2 November, 2014.

Best poster awards

- A. Jeevalatha, Priyanka Kaundal, Anupama Guleria, S Sundaresha, R.P. Pant and B P Singh. 2014. SYBR green based duplex qRT-PCR detection of *Tomato leaf curl New Delhi virus-potato* with *Potato virus X* and *Potato leaf roll virus.* In: Abstracts, National symposium on plant pathology in Genomic era" , 26-28th May, IGKV, Raipur, India p.
- A. Jeevalatha, S. Sundaresha, Ashwani Kumar, Anupama Guleria, Sanjeev Sharma, AshwaniVerma and B.P. Singh. Differential expression of genes during ToLCNDV-potato infection in resistant and susceptible potato cultivars. In: Abstracts, National Seminar on Emerging problems of Potato during 1-2nd November, 2014 at CPRI Shimla, P.167.
- Bagged 'Best Paper Presentation Award' for the presentation entitled 'Antioxidative potential of Indian Potato Cultivars differing in keeping quality' by Pinky *et al.* presented at Global Conference on Technological Challenges and Human Resources for Climate Smart Horticulture - Issues and Strategies 2014, NAU, Navsari, Gujarat.
- Bagged 'Best Poster Award' for the presentation entitled 'Glycaemic index in Indian potatoes: evaluation through resistant starch, α-glucosidase inhibitors and α-amylase inhibitors' by Pinky *et al.* presented at National Seminar on Emerging Problems of Potato, held on 1-2 November 2014 at CPRI, Shimla.
- Bagged 'Second Best Poster Award' for the presentation entitled 'Fortification in potato chips by vacuum impregnantion' by Alka Joshi et al. presented at National Seminar on Emerging Problems of Potato, held on 1-2 November 2014 at CPRI, Shimla.
- Devendra Kumar *et al.* bagged 'Best Poster Award' for the presentation "Enhancement of seed tubers in potato crop grown in net house: exploitation of PGR" in National Seminar on Emerging Problems of Potato, by Indian Potato Association, November 1-2, 2014 at CPRI, Shimla.
- JS Minhas *et al.* bagged 'Second Best Poster Award' for the presentation "Use of insect proof net and plastic mulch enhances number, weight and quality of seed tubers and saves water in stage-I in National Seminar on "Emerging Problems of Potato"; by Indian Potato Association 1-2 November 2014).
- Sadawarti, M.J., Pandey, K.K., Singh, Y.P., Singh, S.P. and Roy, S. (2015) received Best Poster Award for poster titled 'Microplant based Hi-tech seed potato production system of popular varieties in Central India' in XII Agricultural Science congress on "Sustainable livelihood security for small

holder farmers" at ICAR-NDRI, Karnal on 3-6th March, 2015.

- Manjit Singh, Sukhwinder Singh, Parveen Kumar, Dhruv Kumar, BP Singh and SK Pandey. Best paper award by IPA on Nov 2, 2014 at CPRI Shimla for paper entitled "Development and testing of a wide row ridger, inter row cultivator and digger for nucleus seed potato production" published in Potato J (2011) 38 (2): 155-161. Authors.
- Name Singh, Second Best Poster Paper 2014 Indian Potato Association CPRI, Shimla (HP).
- Baswaraj Raigond *et al.,* on "Serological and molecular based detection of Potato virus Y (PVY) strains infecting potato in India" during Global Conference on "Technological Challenges and human resources for Climate Smart Horticulture" 28-31 May 2014, NAU, Navsari, Gujarat.

Promotions/Retirements/Transfers/Deaths

Scientific Staff

Appointment/ New Joining

1. Dr. (Mrs.) Alka Joshi, Scientist (Food Tech.) from 7.4.2014
2. Dr.(Mrs.) TanujaBuckseth, Scietist (Veg. Science) from 4.4.2014
3. Sh. Prince Kumar, Scientist (Veg. Science) from 3.4.2014.
4. Dr. Raja Shankar, Sr. Scientist (Veg. Science) from 26-05-2014.
5. Dr. Som Dutt, Sr. Scientist (Plant Bio-chemistry) from 31-5-2014.
6. Dr. Prashant G Kawar, Sr. Scientist (Genetics and Plant Breeding from 02-06-2014.
7. Dr. Rajendra Singh, Sr. Scientist (Genetics and Plant Breeding) from 15-4-2014.
8. Dr. Jagdev Sharma, Principal Scientist, Soil Science from 25-6-2014.
9. Sh. Hemant Balasahib Kardile, Scientist (Agril. Biotechnology) from 13.10.2014.
10. Ms. Clarissa Challam, Scientist (Agril. Biotechnology) from 13.10.2014.
11. Sh. Pynbianglong Kharumunid, Scientist (Agril. Extension) from 13.10.2014
12. Ms. Rinki, Scientist (Plant Physiology) from 13.10.2014
13. Ms. Chaukhande Pooja Baldeo, Scientist (Vegetable Science) frp, 13.10.2014
14. Dr. VK Dua, Head, Division of Crop Production from 10.10.2014.
15. Dr. Brajesh Singh, Head, Crop Physiology, Bio-chemistry and Post Harvest Technology, CPRI, Shimla.
16. Dr. NK Pandey, Head, Division of Social Sciences from 20.10.2014.
17. Dr. M. Nagesh, Head, Division of Plant Protection from 12.11.2014.

Retirements/Transfer/Promotions

1. Dr. M.C. Sood, Principal Scientist, CPRI, Shimla retired on 30.4.2014.
2. Dr. RK Arora, Principal Scientist,CPRS, Jalandhar retired on 30-4-2014.
3. Dr. SS Lal, Head, Division of Crop Production, CPRI, Shimla retired on 31-7-2014.
4. Dr.(Mrs.) Uma Maheshwari, Scientist (Nematology), CPRS, Ootytransferred to Indian Institute of Horticultural Research, Banglore from 29.5.2014.
5. Dr. R. Muthuraj, Sr. Scientist (Seed Technology) transferred to CTCRI, Trivandrum from 12.5.2014.
6. Dr. AK Srivastava, Scientist (Pl. Breeding) transferred to IIPR, Kanpur from 1.12.2014.
7. Dr. Shiv Pratap Singh, Sr. Scientist promoted for the next higher grade Principal Scientist from 20.02.2012.

Technical Staff

Promotions

1. Sh. Mahesh Kumar, Asstt. Chief Technical Officer, w.e.f.19.02.2011, CPRIC, Modipuram.
2. Sh. Munna Lal, Asstt. Chief Technical Officer, w.e.f. 22.4.2013, CPRS, Jalandhar.
3. Dr. T.K. Sinha, Chief Technical Officer, w.e.f. 03.02.2012, CPRI, Shimla.
4. Dr. Sushil Kumar, Asstt. Chief Technical Officer, w.e.f. 01.01.2013, CPRI, Shimla.

5. Sh. Sushil Singh, Sr. Tech. Assistant (T-4), w.e.f. 19.06.2014, CPRI, Shimla.
6. Sh. Ashok Kumar, Technical Assistant(T-3), w.e.f. 01.03.2013, CPRI, Shimla.
7. Sh. Roop Lal, Technical Assistant (T-3), w.e.f. 17.11.2013, CPRI, Shimla.
8. Sh. Kehar Singh, Sr. Tech. Assistant (T-4), w.e.f. 30.6.2014, CPRIC, Modipuram.
9. Sh. Vipin Kumar, Sr. Technician (T-2), w.e.f. 31.03.2012, CPRIC, Modipuram.
10. Sh. Ram Nath Vishwakarma, Sr. Technical Assistant (T-4), w.e.f. 01.01.2012, CPRS, Patna (Retired on 31.1.2013)
11. Shri Nihal Singh,Technical Assistant (T-I-3 under old TSR), w.e.f. 27.5.2012, CPRS, Gwalior.
12. Shri Ram Dass Rai, Tech. Assistant (T-I-3 under old TSR) w.e.f. 10.6.2012, CPRS, Shillong.
13. Sh. Yogesh Kumar Gupta, Sr. Tech. Officer, CPRS, Jalandhar w.e.f. 10.4.2011.
14. Sh. Pushpendra Kumar, Tech. Officer, CPRIC, Modipuram w.e.f. 11.2.2014.
15. Dr. Shiv Bir Singh Parihar, CPRIC, Modipuram (Retd. On 30.6.2013). w.e.f 01.1.2005
16. Sh. Akhilesh Kumar Singh, Tech. Officer, CPRS Jalandhar w.e.f. 24.7.2014.
17. Sh. Avinash Chaudhary, Tech. Officer, CPRIC, Modipuram w.e.f. 30.6.2014.
18. Sh. Arjun Kumar Sharma, Sr. Tech. Officer, CPRS, Patna w.e.f. 08.6.2014.
19. Dr. Sanjay Kumar Sharma, Tech. Officer, CPRS, Gwalior w.e.f. 14.5.2014.
20. Sh. Parkash Chand, Tech. Asstt, CPRI, Shimla w.e.f. 06.5.2014.
21. Sh. Alekh Narain, Tech. Asstt, CPRS, Patna w.e.f.11.6.2014.
22. Sh. Narinder Mayer, Tech. Asstt., CPRS, Jalandhar w.e.f. 24.09.2014.
23. Sh. Pradeep Kumar Upadhaya, Sr. Technician, CPRS, Jalandhar w.e.f. 02.8.2014.
24. Sh. Ajit Singh, Sr. Technician, CPRS, Kufri w.e.f. 26.7.2014.
25. Sh. Rakesh Singh Hada, Sr. Technician, CPRS, Gwalior w.e.f. 13.8.2014.
26. Sh. Rakesh Kumar, Tech. Assitt., CPRI Shimla w.e.f.10.06.2014.
27. Sh. Deep Ram, Sr. Technician, CPRI Shimla w.e.f. 23.7.2014.
28. Sh. Rambir Singh, Technician, CPRIC, Modipuram w.e.f. 15.6.2014.
29. Sh. Neem Chand, Technician, CPRI, Shimla w.e.f. 15.4.2014.
30. Sh. Kamal Singh, Technician, CPRIC Modipuram w.e.f. 12.5.2014.
31. Dr. Y.P. Singh, Tech. Offricer, CPRS, Gwalior w.e.f. 18.6.2014.
32. Dr. Vinit Sharma, Tech. Officer, CPRIC, Modipuram w.e.f. 30.7.2014.
33. Sh. Dinesh Singh, Tech. Officer, CPRIC, Modipuram w.e.f. 17.2.2013.

Transfers

1. Smt. Ruma Charkaborty (Transferred) 21.6.14 Shimla to IARI, New Delhi.
2. Dr. Sanat Kumar, Sr. Tech. Officer, CPRS, Jalandhar to CPRIC, Modipuram (joined on 31.1.2015 at CPRIC, Modipuram.)

Retirement

1.	Sh. Surinder Paul, Tech. Officer	30.04.14	Shimla
2.	Sh. Brij Mohan lal, Tech. Officer	30.04.14	Kufri
3.	Sh. Ajayvir Singh. Tech. Asstt.	30.04.14	Modipuram

4.	Sh. Harbans Lal, Sr. Tech. Officer	30.04.14	Jalandhar
5.	Sh. Mool Chand, Tech. Officer	31.08.14	Modipuram
6.	Sh. Ravindra Sharma, Tech. Officer	30.11.14	Patna
7.	Shri Devi Chand Sharma, Tech. Officer	31.12.14	Kufri
8.	Sh. R.K. Chauhan, Chief Tech. Officer	28.2.2015	Shimla
9.	Sh. Kharaiti Lal, Sr. Tech. Asstt.	28.2.2015	Shimla
10.	Sh. Ram Het, Technicianet	31.3.2015	Gwalior

Administrative Staff

Promotions

1. Sh. Dhani Ram, Asstt. CPRI, Shimla Promoted as Asstt. Admn. Officer at CPRI, Shimla w.e.f. 20.06.2014
2. Sh. Gurjeet Singh, PA, CPRI, Shimla promoted as PS at CPRI, Shimla w.e.f 15.07.2014 (FN).
3. Smt. Urmila Verma, UDC, CPRI, Shimla promoted as Asstt., at CPRI, Shimla w.e.f 21.07.2014 (FN).
4. Smt. Sunita Thakur, UDC, CPRI, Shimla promoted as Asstt., at CPRI, Shimla w.e.f 21.07.2014 (FN).
5. Smt. M Rani, UDC, CPRS Muthorai promoted as Asstt. at CPRS, Muthorai w.e.f 21.07.2014 (AN).
6. Sh. Suresh Verma, Steno Gr.-III, CPRS, Jalandhar promoted as PA w.e.f. 21.07.2014 (FN).
7. Sh. Hans Raj, LDC, CPRI, Shimla promoted as UDC, at CPRI, Shimla w.e.f 26.07.2014 (AN).
8. Sh. Pradhuman Kumar Sarswat, LDC, CPRS, Gwalior promoted as UDC at CPRS, Gwalior w.e.f 26.07.2014 (AN).
9. Smt. Bimla Salhotra, LDC, CPRS Jalandhar promoted as UDC at CPRS, Jalandhar w.e.f 28.07.2014 (FN).
10. Sh. Roshan Lal, Asstt., CPRI, Shimla promoted as AAO at CPRI, Shimla w.e.f 26.08.2014 (FN).
11. Sh. Krishan Lal, UDC, CPRI, Shimla promoted as Asstt. at CPRS, Patna w.e.f 01.09.2014 (FN).
12. Sh. Sachin Kanwar, LDC, CPRI, Shimla promoted as UDC at CPRI, Shimla w.e.f 25.09.2014.
13. Sh. Jagdish Chand, UDC, CPRI, Shimla promoted to the post of Asstt. w.e.f. 03.03.2015.
14. Sh. Kamal Chand Verma, LDC, CPRS, Gwalior promoted to the post of UDC w.e.f. 26.03.2015.

Retirements

Sl. No.	Name, Designation & Place of Posting	Date of Retirement
1.	Sh. Amar Singh, Asstt., CPRI, Shimla	30.04.2014
2.	Smt. Roseline, AAO, CPRI, Shimla	30.04.2014
3.	Sh. Hari KrishanVerma, PS, CPRI, Shimla	31.05.2014
4.	Smt. Teirina Nongkhlaw, Asstt, CPRS, Shillong	01.06.2014
5.	Sh. DD Kashyap, Asstt., CPRI, Shimla	30.06.2014
6.	Sh. Jeet Ram, AAO (Store), CPRI, Shimla	31.07.2014
7.	Sh. Sikandra Ishwari, Asstt, CPRS, Shillong	31.07.2014
8.	Sh. Shatrughan Prasad, LDC, CPRS, Patna	30.11.2014
9.	Sh. Devender Kumar, Asstt.CPRS, Kufri	31.12.2014
10.	Smt. M. Lathika, Personal Asstt., CPRS, Muthorai	31.01.2015
11.	Sh. Amar Singh Negi, AO, CPRI, Shimla	28.02.2015

Transfers

1. Sh. Anil Kumar Singh, Chief Admn. Officer, CPRI, Shimla to Central Soil & Water Conservation Research and Training Institute, Dehradun w.e.f 25.09.2014.

Probations & Confirmation

Sl. No.	Name & Designation	Date from which probation cleared
1.	Sh. Sandeep, Asstt., CPRS, Patna	22.10.2014
2.	Ms. Prawartika Das, CPRI, Shimla	16.07.2014

Skilled Supporting Staff

Promotions

1. Smt. Tara Devi, Skilled Support Staff, CPRS Patna promoted to SS Gr. III w.e.f. 19.01.2005.

Skilled Support Staff Promoted to under 33.33% Departmental Promotion Quota

1. Shri Vinod Kumar, Skilled Support Staff, CPRI, Shimla, promoted as T-1 (Field Farm Technician) at CPRI, Shimla, w.e.f. 26.3.2015.
2. Shri Mansha Ram Skilled Support Staff, CPRI, Shimla, promoted as T-1 (Field Farm Technician) at CPRI, Shimla, w.e.f. 26.3.2015.
3. Shri Arjun Dass, Skilled Support Staff, CPRI, Shimla, promoted as T-1 (Field Farm Technician) at CPRI, Shimla, w.e.f. 26.3.2015.

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.	Smt. Tara Devi, SSS, CPRS, Patna	Rs. 5200-20200 +1900	2nd MACPS w.e.f. 1.9.2008	Rs.5200-20200+Rs.2000
		Rs. 5200-20200 + 2000	3rd MACPS w.e.f. 14.03.2012	Rs.5200-20200+Rs.2400
2.	Sh. Charan Dass, SSS, CPRI, Shimla	Rs. 5200-20200 +2000	3rd MACPS w.e.f. 7.2.2014	Rs.5200-20200+Rs.2400
3.	Sh. Narinder Kumar, Cook, CPRI, Shimla	Rs. 5200-20200 +2400	3rd MACPS w.e.f. 4.7.2014	Rs.5200-20200+Rs.2800
4.	Sh. Nand Lal, Wash Boy, CPRI, Shimla	Rs. 5200-20200 +2000	3rd MACPS w.e.f. 4.7.2014	Rs.5200-20200+Rs.2400

Retirements

1. Sh. Rattan Chand, CPRS, Jalandhar retired on 31.7.2014.
2. Sh. Kashi Chaudhary, SSS, CPRS, Patna retired on 31.10.2014.
3. Sh. Ram Babu Rai, SSS, CPRS, Patna retired on 31.10.2014.
4. Sh. Anant Ram, Tea cum Coffee maker, CPRI, Shimla retired on 31.1.2015.
5. Sh. Rishipal CPRIC, Modipuram retired on 19.2.2015.

Untimely Demise

1. Sh. Dhominik Mawkhlieng, SSS, CPRS Shillong died on 11.5.2014.
2. Sh. Ajmer Singh, SSS, CPRS, Gwalior died on 2.6.2014.

Station-wise Staff Sanctioned

List of Scientific staff at CPRI, Shimla & its Regional Stations as on 31-3-2015

Dr. BP Singh Director:

AICPIP Unit

1. Dr. PM Govindakrishnan, Project Coordinator
2. Dr. Raja Shankar, Sr. Scientist

Division of Crop Improvement

3. Dr. Vinay Bhardwaj, Sr. Scientist & Acting Head
4. Dr. Rajendra Singh, Sr. Scientist
5. Dr. Prashant Govindrao Kawar, Sr. Scientist
6. Dr. Jagesh Kumar, Scientist
7. Sh. Virupakshagauda U Patil, Scientist
8. Dr. (Ms.) Dalamu, Scientist
9. Dr. (Mrs.) G Vanishree, Scientist
10. Sh. Hemant Babasaheb Kardile, Scientist

Division of Seed Technology

11. Dr. KK Pandey, PS & Head
12. Dr. Tanuja Buckseth, Scientist

Division of Crop Production

13. Dr. VK Dua, Principal Scientist & Head
14. Dr. Jagdev Sharma, Principal Scientist
15. Dr. (Ms.) Chaukhande Pooja Baldeo, Scientist

Division of Social Sciences

16. Dr. NK Pandey, PS & Head
17. Dr. Rajesh Kumar Rana, Principal Scientist
18. Dr. Dhiraj Kumar Singh, Scientist

Division of Plant Protection

19. Dr. M. Nagesh, Principal Scientist & Head
20. Dr. Sanjeev Sharma, Sr. Scientist
21. Dr. Vinay Sagar, Sr. Scientist
22. Dr. (Ms.) Jeevalatha A, Scientist
23. Dr. Baswaraj R., Scientist
24. Dr. Sundersha S, Scientist
25. Dr. Ravinder Kumar, Scientist
26. Dr. Vallepu Venkateswarlu, Scientist
27. Dr. Shridhar Jandrajupalli, Scientist

Division of Crop Physiology, Biochemistry & Post-harvest Technology

28. Dr. Brajesh Singh, Principal Scientist & Head
29. Dr. Som Dutt, Sr. Scientist
30. Dr. (Mrs.) Pinky Raigond, Scientist
31. Dr. (Mrs.) Alka Joshi, Scientist
32. Ms. Rinki, Scientist

ARIS Cell

33. Dr. Shashi Rawat, Sr. Scientist

CPRI Campus, Modipuram

34. Dr. SK Kaushik, Joint Director
35. Dr. Devendra Kumar, PS
36. Dr. (Mrs.) Kamlesh Malik, PS
37. Dr. SK Luthra, Principal Scientist
38. Dr. Name Singh, Principal Scientist
39. Dr. Vinay Singh, Principal Scientist
40. Dr. Anuj Bhatnagar, Principal Scientist

41. Dr. MA Khan, Principal Scientist
42. Dr. Rajender Prasad Pant, Sr. Scientist
43. Dr. Sanjay Rawal, Principal Scientist
44. Dr. Dhruv Kumar, Principal Scientist
45. Dr. Vijai Kishore Gupta, Sr. Scientist
46. Dr. Mehi Lal, Scientist
47. Dr. (Mrs.) Bandna, Scientist

CPRS, Jalandhar

48. Dr. JS Minhas, Head
49. Dr. (Mrs.) Ashiv Mehta, Principal Scientist
50. Er. Manjit Singh, Principal Scientist
51. Dr. Raj Kumar, Principal Scientist
52. Er. Sukhwinder Singh, Scientist SG
53. Er. Sunil Gulati, Scientist (SG)
54. Dr. (Mrs.) Ratna Preeti Kaur, Scientist
55. Sh. Prince Kumar, Scientist

CPRS, Gwalior

56. Dr. S Roy, Principal Scientist & Head
57. Dr. Shiv Pratap Singh, Principal Scientist
58. Dr. Murlidhar J. Sadawarti, Scientist

CPRS, Shillong

59. Dr. TK Bag, Principal Scientist & Head
60. Dr. Sanjay Kumar Yadav, Scientist
61. Dr. Malkhan Singh Gurjar, Scientist
62. Ms. Clarissa Challam, Scientist

CPRS, Muthorai

63. Dr. EP Venkatsalam, Sr. Scientist & Incharge
64. Dr. (Mrs.) R. Sudha, Scientist
65. Dr. (Ms.) Aarti Bairwa, Scientist

CPRS, Kufri

66. Dr. Vinod Kumar, Principal Scientist & Incharge
67. Dr. Ashwani Kumar Sharma, Sr. Scientist

CPRS, Patna

68. Dr. Manoj Kumar, Principal Scientist & Head
69. Dr. Shambhu Kumar, Principal Scientist
70. Dr. SK Singh, Principal Scientist
71. Dr. Raj Kumar, Sr. Scientist
72. Sh. Rahul R Bakade, Scientist
73. Sh. Pynbianglang Kharumunid, Scientist

List of Technical staff at CPRI, Shimla & its Regional Stations as on 31-3-2015

CPRI, Shimla

Sl. No.	Name	Designation
1.	Sh. BS Latwal	Chief Tech. Officer
2.	Dr. Rakesh Mani Sharma	Asstt. Chief Tech. Officer
3.	Dr. TK Sinha	Chief Tech. Officer
4.	Sh. Kameshwar Sen	Sr. Tech. Officer
5.	Sh. Avnish Kumar Atray	Sr. Tech. Officer
6.	Sh. Krishan Singh Negi	Tech. Officer
7.	Dr. Sushil Kumar	Asstt. Chief Tech. Officer
8.	Smt. Shelly Chopra	Sr. Tech. Officer
9.	Sh. Pravesh Jassal	Sr. Tech. Officer
10.	Sh. Yogesh	Sr. Tech. Officer
11.	Smt. Tarvinder Kochhar	Sr. Tech. Officer
12.	Sh. Dharminder Verma	Sr. Tech. Officer
13.	Sh. Kana Singh Chauhan	Tech. Officer
14.	Sh. Harvinder Singh	Tech. Officer
15.	Sh. Tilak Raj	Tech. Officer
16.	Sh. Prithi Raj	Sr. Technician
17.	Sh. CM Bist	Tech. Officer

18.	Sh. Laiq Ram	Technician
19.	Smt. Shruti Gupta	Tech. Officer
20.	Dr. (Smt.) Sumita Sharma	Tech. Officer
21.	Sh. Sita Ram	Technician
22.	Sh. Rajdeep Bux	Tech. Officer
23.	Sh. Surinder Pal	Technician
24.	Sh. Rakesh Kumar Patyal	Tech. Asstt.
25.	Sh. Yash Pal Sharma	Sr. Tech. Asstt.
26.	Sh. Rajinder Kumar	Tech. Asstt.
27.	Sh. Sheesh Ram	Sr. Tech. Asstt.
28.	Sh. Vinod Kumar	Tech. Officer
29.	Sh. Prakash Chand	Tech. Asstt.
30.	Sh. Naresh Kumar Sharma	Sr. Tech. Asstt.
31.	Smt. Manjit Syal	Tech. Asstt.
32.	Sh. Hari Kishore	Tech. Asstt.
33.	Sh. DP Gautam	Sr. Tech. Asstt.
34.	Smt. Asha Thakur	Tech. Asstt.
35.	Sh. Ranjesh Bhardwaj	Tech. Asstt.
36.	Sh. Rakesh Kumar	Sr. Technician
37.	Sh. Naresh Chand Sharma	Tech. Asstt.
38.	Sh. Deep Ram	Sr. Technician
39.	Smt. Jitender Kaur Arora	Sr. Technician
40.	Sh. Ram Singh	Tech. Asstt.
41.	Smt. Madhu Bala	Tech. Asstt.
42.	Sh. Dharminder Kr. Gupta	Tech. Asstt.
43.	Sh. Jagdish Chand	Sr. Technician
44.	Sh. Naresh Kumar Thakur	Tech. Asstt.
45.	Sh. PermeshDutt	Technician
46.	Sh. Ravinder Kumar	Sr. Technician
47.	Sh. Onkar Singh	Tech. Asstt.
48.	Sh. Sushil Singh	Sr. Tech. Asstt.
49.	Sh. Jagdish Chand	Sr. Technician
50.	Sh. Ashok Kumar	Tech. Asstt.
51.	Sh. RoopLal	Tech. Asstt.
52.	Sh. Vijay Kumar	Tech. Asstt.
53.	Sh. Ram Dayal	Sr. Technician
54.	Sh. Anil Kumar Dubey	Sr. Technician
55.	Sh. Neem Chand	Technician
56.	Sh. Dev Raj	Sr. Technician

CPRS, Kufri

1.	Sh. Kedar Singh	Tech. Asstt.
2.	Sh. Mohan Lal	Sr. Technician
3.	Sh. Ram Jivan Singh	Sr. Technician
4.	Sh. Ajit Singh	Sr. Technician

CPRIC, Modipuram

1.	Sh. Islam Ahmad	Chief Technical Officer
2	Sh. Ram Kumar Verma	Asstt. Chief Technical Officer
3	Sh. Balak Ram	Asstt. Chief Technical Officer
4	Sh. Mahesh Kumar	Sr. Technical Officer
5	Sh. Mahipal Singh	Asstt. Chief Technical Officer
6	Sh. Ramesh Chand	Asstt. Chief Technical Officer
7	Sh. Harvir Singh	Asstt. Chief Technical Officer
8	Sh. Ashok Kumar	Asstt. Chief Technical Officer
9	Sh. Krishan Pal Singh	Asstt. Chief Technical Officer
10	Sh. Satendra Kumar	Sr. Technical Officer
11	Sh. NK Sood	Technical Officer
12	Sh. Ompal Singh	Sr. Technical Officer
13	Smt. Kusum Singh	Sr. Technical Officer
14	Sh. RK Sharma	Technical Officer
15	Sh. Harvir Singh	Technical Officer
16	Sh. Santosh Kumar	Technical Officer
17	Sh. Ombir Singh	Technical Officer
18	Sh. Murai Lal	Sr. Technical Officer
19	Sh. Vijay Kumar Yadav	Technical Officer
20	Sh. Subhash Chand	Technical Officer
21	Smt. Vineet Shamra	Sr. Technical Officer
22	Sh. Avinash Chaudhary	Technical Officer
23	Sh. Jasvir Singh	Technical Officer
24	Sh. Dinesh Singh	Sr. Technical Officer
25	Sh. Ved Singh	Technical Officer
26	Sh. Pushpender Singh	Technical Officer
27	Sh. Kundan Singh	Technical Officer
28	Sh. Udaivir Singh	Technical Officer

29	Sh. Krishanpal Singh	Technical Assistant
30	Sh. Vipin Kumar	Sr. Technician
31	Sh. Satpal Singh	Technician
32	Sh. Rambir Singh	Technician
33	Sh. Mahesh Pal Singh	Technical Assistant
34	Sh. Kehar Singh	Technical Assistant
35	Sh. Pawan Kumar Malik	Technical Assistant
36	Sh. Madan Pal	Technician
37	Sh. Narayan Singh	Technical Assistant
38	Sh. Kamal Singh	Technician

Jalandhar

Sl. No.	Name	Designation
1	Sh. Ashwani Kumar Sharma	Asstt. Chief Tech. Officer
2	Sh. Jaswinder Singh	Sr. Tech. Officer
3	Sh. Yogesh Kumar Gupta	Sr. Tech. Officer
4	Sh. Kapil Kumar Sharma	Sr. Tech. Officer
5	Sh. Pawan Kumar	Technician
6	Sh. Akhilesh Kumar Singh	Technical Officer
7	Dr. Sanat Kumar	Sr. Tech. Officer
8	Sh. Gurudev Singh	Technical Officer
9	Sh. Jagdish Chand	Technical Officer
10	Sh. Anil Kumar Chandel	Sr. Technicain
11	Sh. SomDutt	Sr. Tech. Asstt.
12	Sh. Narinder Mayer	Technical Asstt.
13	Sh. Pradeep Kumar Upadhya	Sr. Technician
14	Sh. Nirmal Singh	Tech. Asstt.
15	Sh. Bhag Singh	Tech. Asstt.
16	Sh. Kulwinder Singh	Tech. Assitt.
17	Sh. Vijay Kumar Rai	Sr. Technician
18	Sh. Munna Lal	Asstt. Chief Tech. Officer

Gwalior

Sl. No.	Name	Designation
1	Sh. Surinder Singh	Sr. Tech. Asstt.
2	Sh. Chet Ram	Technician
3	Sh. RK Samadhiya	Tech. Officer
4	Dr. Yogender Pal	Technical Officer
5	Dr. Sanjay Kumar Sharma	Technical Officer
6	Sh. Shyam Kumar Gupta	Technical Officer
7	Sh. Praveen Kumar	Technical Asstt.
8	Sh. Rakesh Singh Hada	Sr.Technician
9	Sh. Radha Krishan	Sr. Technician
10	Sh. Nihal Singh	Tech. Asstt.
11	Sh. Prakash Ram	Technician
12	Sh. Bijendra Singh	Technician
13	Sh. Tara Chand	Technician

Muthorai

Sl. No.	Name	Designation
1	Sh. B. Chandran	Technical Officer
2	Sh. V. Rajendran	Technical Officer
3	Sh. R. Lakashaman	Technical Asstt.
4	Sh. B Suresh	Technician

Patna

Sl. No.	Name	Designation
1.	Sh. Arun Kumar Singh	Asstt. Chief Tech. Officer
2.	Sh. Arjun Kumar Sharma	Sr. Technical Officer
3.	Sh. Rakesh Srivastva	Sr. Tech. Asstt.
4.	Sh. Anil Kumar	Sr. Tech. Asstt.
5.	Sh. Agre Nand Singh	Sr. Tech. Asstt.
6.	Sh. Alekh Narain	Tech. Asstt.
7.	Sh. Bhuneshwar Prasad	Tech. Asstt.
8.	Sh. SDA Rizvi	Sr. Technician
9.	Sh. Narinder Kumar	Sr. Technician
10.	Sh. Lal Babu Dass	Tech. Asstt.
11.	Sh. Sunil Kumar Singh	Technician
12.	Sh. Pravesh Kumar	Technician

Shillong

Sl. No.	Name	Designation
1	Sh. Emeralstone Syiemlieh	Technical Officer
2	Sh. Bosterwell Langestieh	Sr. Tech. Asstt.
3	Sh. Hesting Jyrwa	Sr. Tech. Asstt.
4	Sh. P. Roy Khanghuh	Tech. Asstt.
5	Sh. U. P. Paudel	Tech. Asstt.
6	Sh. Ram Dass Rai	Sr. Technician
7	Sh. S. Nongrum	Sr. Technician

List of Administrative Staff as on 31.03.2015

Sl No. Name & Designation

1. Sh. K.P. Sharma, AO

Establishment I Section

2. Sh. Joginder Singh Thakur, AAO
3. Smt. Shashi Bala Thakur, PA to CAO
4. Smt. Poonam Sood, Asstt.
5. Smt. Meena Verma, Asstt.
6. Smt. Sunita Thakur, Asstt.
7. Sh. Om Parkash, UDC
8. Sh. Padam Chand, LDC

Bill & Cash Section

9. Sh. Hira Nand Sharma, AAO
10. Sh. Amar Chand, Asstt.
11. Ms ReetaWalia,Asstt.
12. Sh. Ashwani Gupta,LDC Cum Cashier
13. Sh. Tej Singh, LDC
14. Sh. Raghubir Singh, LDC

Audit Section

15. Sh. Tej Singh Bhati,FAO
16. Sh. Chander Prakash, AF&AO
17. Dr. Ashish Dhangar, AF&AO
18. Sh. Roshan Lal, AAO
19. Sh. CR Nahata, PS
20. Sh. PC Sharma, Asstt.
21. Sh. Jai Ram Thakur, Asstt.
22. Sh. Jagdish Chand, Asstt.
23. Miss Prawartika Das, Asstt.
24. Smt. Shyam Lata Beakta, UDC
25. Sh. Jagdish Chand, Asstt.
26. Sh. Sandeep Verma, UDC
27. Smt. Geeta Devi, LDC

Estt. II Section

28. Sh. AD Sharma, AAO
29. Sh. Laiq Ram, Asstt.
30. Smt. Kanta Rani, Asstt.
31. Smt. Urmila Verma, Asstt.
32. Sh. Narender Paul, LDC
33. Smt. Punam Jyoti, LDC

Store Section

34. Sh. Dhani Ram, AAO
35. Sh. KC Chopra, Asstt.
36. Sh. Chanda Ram, Asstt.
37. Sh. Hans Raj, UDC
38. Smt. Sonia Chauhan, LDC
39. Sh. Mohinder Singh, LDC
40. Sh. Gokal Ram, LDC

PME Cell

41. Sh. Deep Ram, UDC
42. Sh. Sachin Kanwar, UDC
43. Sh. Rakesh Negi, LDC

Vigilance Section

44. Sh. Pawan Kumar, UDC

AICPIP Unit

45. Smt. Nirmala Chauhan, LDC

Seed Technology

46. Smt. Babli Bhawani

Director Cell

47. Sh. Ram Chand, PA

Social Science

48. Sh. Roshan Lal Verma, PS

Plant Protection

49. Sh. Gurjeet Singh, PS

Hindi Section

50. Sh. Suresh Kumar, PA

Crop Production

51. Sh. Girish Thakur, Steno Gr.-III

Engineering Section

52. Sh. Kundan Lal, LDC

List of Skilled Support Staff, CPRI Shimla and its Regional Stations as on 31.03.2015

CPRS, Kufri

1. Smt. Chandni Bhagta, UDC

CPRIC, Modipuram

2. Sh. Miraj-Ul-Haq, AAO
3. Sh. Baldev Raj, AAO
4. Sh. Jagbir Singh, Asstt.
5. Sh. Surender Singh, Asstt.
6. Sh. Mahendra Singh, Asstt.
7. Sh. Santosh Kumar, UDC
8. Smt. Sneh Lata, LDC
9. Smt. SeemaVerma, LDC
10. Sh. Atar Singh, LDC
11. Sh. Ashok Kumar, LDC
12. Sh. Rajesh Kumar, PA

Jalandhar

13. Sh. Jeevan Kumar, AAO
14. Sh. NK Sharma, Asstt.
15. Sh. Sukhpal Sharma, Asstt.
16. Sh. Suresh Kumar Verma, PA
17. Smt. Sandhya Kapila, UDC
18. Sh. Rakesh, UDC
19. Smt. Bimla Salhotra, UDC
20. Smt. Daishey Tuli, LDC
21. Sh. Naresh Kumar, LDC
22. Sh. Daljeet Singh, LDC

Gwalior

23. Sh. Krishan Lal, AAO
24. Sh. Pradhuman Kumar Sarswat, UDC
25. Sh. Kamal Chand Verma, LDC
26. Sh. Ashish Kalyan, LDC
27. Sh. Shri Krishan, LDC

Muthorai

28. Smt. IC Dharmapaul, Asstt.
29. Smt. M. Rani, Asstt.

Patna

30. Sh. HK Sen, Pvt. Secy.
31. Sh. Sandeep, Asstt.
32. Sh. Krishan Lal, Asstt.
33. Sh. Ramesh Kumar Gupta, UDC
34. Sh. Akhilesh Singh, LDC

Shillong

35. Smt. Pomilian W. Syiem, Asstt.

CPRI, Shimla

Sl. No. Name & Degination.

1. Sh. Narain Dass, SSS (SS Gr. IV)
2. Sh. Maharaj Singh, SSS (SS Gr. III)
3. Sh. Khem Chand, SSS (SS Gr. III)
4. Sh. Charan Dass, SSS (SS Gr. III)
5. Sh. Roshan Lal, SSS (SS Gr. III)
6. Sh. Kanhiya Prasad, SSS(SS Gr. III)
7. Sh. Bir Bhadur, SSS(SS Gr. III)
8. Sh. Piar Chand, SSS (SS Gr. III)
9. Sh. Subhash Chand, SSS (SS Gr. III)
10. Sh. Mansa Ram, SSS (SS Gr. III)
11. Sh. BabuRam, SSS (SS Gr. III)
12. Sh. Ramesh Kumar, SSS (SS Gr. III)
13. Sh. Rajinder Kumar, SSS (SS Gr. II)
14. Sh. Kulwant Singh, SSS (SS Gr. II)
15. Sh. Sanjeevan Kumar, SSS (SS Gr. II)
16. Smt. Kamla Devi, SSS (SS Gr. II)
17. Sh. Ashok Kumar, SSS (SS Gr. I)
18. Sh. Narender Kumar, SSS (SS Gr. I)
19. Smt. Kajal, SSS (SS Gr. I)
20. Sh. Padam Dev, SSS (SS Gr. I)
21. Sh. Roshan Lal, SSS (SS Gr. I)
22. Smt. Manjit, SSS (SS Gr. I)
23. Sh. Amar Nath, SSS (SS Gr. I)
24. Sh. Hira Singh, SSS (SS Gr. I)

CPRI Cantten Staff

1. Sh. Narinder Sood, Cook
2. Sh. NandLal, Wash Boy

CPRS Kufri

1. Sh. Hira Singh , SSS (SS Gr. III)

2. Sh. Saran, SSS (SS Gr. III)
3. Smt. Muni Devi, SSS (SS Gr. II)
4. Smt. Indira Devi, SSS (SS Gr. II)
5. Sh. Madan Lal, SSS (SS Gr. I)
6. Sh. Sita Ram, SSS (SS Gr. I)
7. Sh. Roop Singh, SSS (SS Gr. I)
8. Sh. JiaLal, SSS (SS Gr. I)

CPRIC Modipuram

1. Sh. Suraj Singh, SSS (SS Gr. III)
2. Sh. Mangtey, SSS (SS Gr. III)
3. Sh. Satya Pal Singh, SSS (SS Gr. II)
4. Sh. Amiruddin, SSS (SS Gr. II)
5. Sh. Jagtey, SSS (SS Gr. II)
6. Sh. Som Pal, SSS (SS Gr. II)
7. Sh. Krishan Pal, SSS (SS Gr. I)
8. Sh. Mani Ram, SSS (SS Gr. I)
9. Sh. Rajpal, SSS (SS Gr. I)
10. Sh. Rajvir Singh, SSS (SS Gr. I)
11. Sh.Raj Kumar, SSS (SS Gr. I)
12. Sh. Sudesh Pal, SSS (SS Gr. I)
13. Sh. Tej Bir Singh, SSS (SS Gr. I)
14. Sh. Gyanendra Kumar, SSS (SS Gr. I)
15. Sh. Sohan Pal, SSS (SS Gr. I)
16. Sh. Ramphal, SSS (SS Gr. I)
17. Sh. Mukesh, SSS (SS Gr. I)
18. Sh. Murari, SSS (SS Gr. I)
19. Sh. Rajpal Singh, SSS (SS Gr. I)

CPRS Jalandhar

1. Sh. Komal, SSS (SS Gr. III)
2. Ms. Niranjan Kaur, SSS (SS Gr. II)
3. Sh. Gian Singh, SSS (SS Gr. II)
4. Sh. Karnail Singh, SSS (SS Gr. II)
5. Sh. Satnam Singh, SSS (SS Gr. II)
6. Mrs. Passo, SSS (SS Gr. II)
7. Smt. Rashpal Devi, SSS (SS Gr. II)
8. Sh. Ram Lubhaya, SSS (SS Gr. II)
9. Sh. Ram Prakash, SSS (SS Gr. II)
10. Sh. Sukhwinder, SSS (SS Gr. II)
11. Sh. Subhash, SSS (SS Gr. II)
12. Sh. Hans Raj, SSS (SS Gr. II)
13. Sh. Jagai Ram, SSS (SS Gr. II)
14. Sh. Paramjit Singh, SSS (SS Gr. II)
15. Sh. Manjinder Singh, SSS (SS Gr. I)
16. Sh. Ram Sarup, SSS (SS Gr. I)
17. Sh. Joginder Pal, SSS (SS Gr. I)
18. Sh. Ram Nath, SSS (SS Gr. I)
19. Sh. Jagan Nath, SSS (SS Gr. I)
20. Sh. Niril, SSS (SS Gr. I)

CPRS Patna

1. Sh. Sheo Nath Singh, SSS (SS Gr. III)
2. Smt. Tara Devi, SSS (SS Gr. III)
3. Sh. Tapan Burman, SSS (SS Gr. III)
4. Sh. Ram Kisun Ram, SSS (SS Gr. II)
5. Sh. Teka Rai, SSS (SS Gr. II)
6. Sh. Jagat Kumar, SSS (SS Gr. II)
7. Sh. Ram Balak Rai, SSS (SS Gr. II)
8. Sh. Bishun Rai, SSS (SS Gr. I)

CPRS, Gwalior

1. Sh. Ram Babu, SSS (SS Gr. II)
2. Sh. Mohan Lal, SSS (SS Gr. II)
3. Sh. Ramji Lal, SSS (SS Gr. II)
4. Sh. Shiv Singh, SSS (SS Gr. II)
5. Sh. Niranjan Singh, SSS (SS Gr. II)
6. Sh. Kailash, SSS
7. Sh. Ram Singh, SSS
8. Sh. Jagdish, SSS (SS Gr. II)
9. Sh. Ram Rattan, SSS (SS Gr. II)
10. Sh. Shyam Singh, SSS (SS Gr. II)
11. Sh. ParkashTomar, SSS (SS Gr. II)
12. Sh. Virendra Singh, SSS (SS Gr. II)
13. Sh. Ranbir Singh, SSS (SS Gr. II)
14. Sh. Kallu, SSS (SS Gr. II)
15. Sh. Ashok Kumar, SSS (SS Gr. II)
16. Smt. Vimla Devi, SSS (SS Gr. I)
17. Sh. Jaswant Singh, SSS (SS Gr. I)
18. Sh. Kedar, SSS (SS Gr. I)
19. Sh. Sonpal, SSS (SS Gr. I)
20. Sh. Parasu Ram, SSS (SS Gr. I)
21. Sh. Punjab Singh, SSS (SS Gr. I)
22. Sh. Ram Parkash, SSS (SS Gr. I)

23. Sh. Bharat Singh, SSS (SS Gr. I)
24. Sh. Munnu Singh, SSS (SS Gr. I)

CPRS Shillong

1. Sh. Bat Bok Kharir, SSS (SS Gr. IV)
2. Sh. Ashok Kumar Dev, SSS (SS Gr. III)
3. Sh. Ram Ekbal Rai, SSS (SS Gr. III)
4. Smt.Theibet Thawmuit, SSS (SS Gr. III)
5. Mrs. Tellinora, SSS (SS Gr. III)
6. Km. Thapa, SSS (SS Gr. III)

CPRS Muthorai

1. Smt. Rajamma, SSS (SS Gr. I)
2. Sh. K. Ramasamy, SSS (SS Gr. I)
3. Sh. J. Bhojan, SSS (SS Gr. I)
4. Smt. S Pankajam, SSS (SS Gr. I)

Scientific strength station wise sanction/filled /vacant position as on 31.3.2015

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	6	(-1)	10	7	3	29	20	10	44	33*	14
2.	Kufri	-	-	-	1	-	1	2	2	-	3	2	1
3.	Jalandhar	1	1	-	2	-	2	10	7	3	13	8	5
	Modipuram	1	1	-	4	3	1	16	10	6	21	14	7
5.	Gwalior	1	1	-	1	-	1	3	2	1	5	3	2
6.	Patna	1	1	-	1	1	-	9	4	6	11	6	6
7.	Ooty	1	-	1	-	-	-	3	3	-	4	3	1
8.	Shillong	1	1	-	-	-	-	5	3	2	6	4	2
	Total	**11**	**11**	**-**	**19**	**11**	**8****	**77**	**51**	**32**	**107**	**73**	**34**

*Excluding RMP, S-Cadre Strength, F-In position, V-Vacancy

Discipline-wise Sanction/Filled /Vacant position of the Scientists after adjustment of Sr. Scientist (to be filled at entry level) as on 31.03.2015

Sl. No.	Discipline	Scientist (including Sr. Sci. & PS promoted Through CAS)			Senior Scientist (DR)			Principal Scientist (DR)			Total		
		S	F	V	S	F	V	S	F	V	S	F	V
1.	AGRICULTURAL BIOTECHNOLOGY	3	3	-	1	-	1	-	-	-	4	3	1
2.	AGRONOMY	4	6	(-)2	-	-	-	1	2	(-)1	5	8	(-)3
3.	AG. ENTOMOLOGY	6	3	3	1	1	-	-	-	-	7	4	3
4.	AG. ECONOMICS	3	-	3	-	1	(-)1	-	1	(-)1	3	2	1
5.	AG METROLOGY	1	-	1	-	-	-	-	-	-	1	-	1
6.	AGRICULTURAL MICROBIOLOGY	3	-	3	-	-	-	-	-	-	3	-	3

7. AG. STATISTICS	1	-	1	-	-	-	-	-	-	1	-	1
8. COM. APPLN.	1	1	-	-	-	-	-	-	-	1	1	-
9. AG. EXTENSION	2	2	-	1	-	1	1	-	1	4	2	2
10. AGRI. PROCESS ENGINEERING	1	-	1	-	-	-	-	-	-	1	-	1
11 AG. ENGG.(FM&P)	3	3	-	-	-	-	-	-	-	3	3	—
12 AG. ENGG (ASPEE)	-	-	-	-	-	-	-	-	-	-	-	
13 AG. CHEMISTRY	-	1	(-)1	-	-	-	-	-	-	-	1	(-)1
14 PL.BIOCHEMISTRY	2	1	1	1	1	-	-	-	-	3	2	1
15 FOOD TECHNOLOGY	2	1	1	-	-	-	-	-	-	2	1	1
16 GEN. & CYTOGEN	-	2	(-)2	-	-	-	-	-	-	-	2	(-)2
17 VEG. SCIENCE	14	9	5	2	1	1	4	-	4	20	10	10
18 NEMATOLOGY	2	1	1	-	-	-	1	1	-	3	2	1
19 GENETICS AND PLANT BREEDING	10	3	7	3	3	-	1	-	1	14	6	8
20 PL. PATHOLOGY	10	7	3	2	3	(-)1	1	3	(-)2	13	13	-
21 PL. PHYSIOLOGY	5	4	1	-	-	-	-	2	(-)2	5	6	(-)1
22 SOIL SCIENCE, SOIL CHEM/ FERT. MICRO	5	1	4	-	-	-	-	1	(-)1	5	2	3
23 SOIL PHY. & SOIL WATER CONSERV.	-	-	-	-	-	-	-	-	-	-	-	-
24 SEED SCIENCE AND TECHNOLOGY	5	3	2	-	1	(-)1	1	-	1	6	4	2
25 FLEXI DISCIPLINES	-	-	-	2	-	2	-	-	-	2	-	2
26 JOINT DIRECTOR	-	-	-	-	-	-	1	1	-	1	1	-
TOTAL	**83**	**51**	**32**	**13**	**11**	**2**	**11**	**11**	**-**	**107**	**73**	**34**

S-Cadre Strength, F-In position, V-Vacancy

List of admn. Staff (Sanctioned & Filled as on 31.03.2015

Cadre	Shimla		Jalandhar		Mod.		Gwlr.		Shillong		Kufri		Patna		Ooty		TOTAL		
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	V
Chief Admn. Officer	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	01	-	1
FAO (in lieu of Sr. Fin. & A/Cs Officer)	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	01	01	-
Admn. Officer	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	02	01	1
Asstt. Admn. Officer	5	5	1	1	2	2	1	1	-	-	-	-	1	1	-	-	10	10	-
Asst. Fin. & A/Cs Officer	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	02	02	-
Asstt. Director (OL)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	01	-	1

Private Secretary	3	3	-	-	1	-	-	-	-	-	-	-	-	1	-	-	04	**04**	**-**
Personal Assistant	7	3	1	1	-	1	1	-	-	-	-	-	1	-	-	-	10	**05**	**5**
Stenographer Grade-III	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**01**	**+1**
Assistant	20	16	1	2	3	3	1	-	2	1	1	-	1	2	1	2	30	**26**	**4**
UDC	05	07	3	3	3	1	2	1	1	-	1	1	2	1	1	-	17	**15**	**2**
LDC	14	13	2	3	3	4	2	3	1	-	-	-	2	1	1	-	24	**23**	**1**
Total	**61**	**52**	**08**	**10**	**12**	**11**	**5**	**5**	**4**	**1**	**2**	**1**	**7**	**6**	**3**	**2**	**102**	**87**	**16**

S-Cadre Strength, F- In position, V-Vacancy

1. One posts of Asstt. (LDCE) three for DR.
2. One post of UDC by downgrading as LDC advertised for CPRS, Shillong. Other one for (LDCE) and one for promotion
3. Case referred to ICAR for permission for filling up as the three Stenographer Grade-III in lieu of PA
4. One post of AAO (LDCE) advertised.

Overall Administrative staff strength at CPRI

Category	Sanction	Filled	SC	ST	OBC	Women
Administrative	**102**	**87**	**23**	**02**	**05**	**24**

Sanctioned strength of skilled supporting staff as on 31.03.2015

Grade	Sanctioned	Filled	Vacant
SS Grade-I	82*	45	**37**
S Grade-II	65	42	23
SS Grade-III	39	24	15
SS Grade-IV	18	02	16
Sub Total	**204**	**113**	**91**
Canteen Staff			
Cook	1	1	0
Tea Maker	1	**0**	**1**
Wash Boy	1	1	0
Grand Total	**207**	**115**	**92**

Station-wise/Grade-wise list of the Skilled Supporting Staff 31.03.2015

Station	Sanctioned Strength	Grade-IV	Grade-III	Grade-II	Grade-I	Total
Shimla	75	01	11	04	08	24+2* Canteen staff
Kufri	12	—	02	02	04	08
Modipuram	42	—	02	04	13	19
Jalandhar	26	—	01	13	06	20
Patna	20	—	03	04	01	08
Gwalior	12	-	-	15	09	24
Shillong	12	01	05	-	-	06
Muthorai	08	-	-	-	04	04
Total	207	02	24	42	45	113+2=115

*2 Posts of Canteen Staff

*3 posts of Skilled Support Staff redeployed to Ranchi Regional Centre of the ICAR research Complex for Eastern Region vide Council letter No.33-12/2007-Estt.I (Pt.) dated 23rd September, 2010 and reverted back to CPRI, Shimla as and when these posts will be vacated on account of superannuation etc. of the incumbent against these posts.

Classified Abstract of Expenditure of Plan, Non-plan and Reciept

Detail of Institute Non Plan Expenditure

(Amount in Rupees)

S. No.	Head	Allocation Govt. Grant	Allocation Internal Resource + Additional amount provided by HQ out of Council's share	TOTAL ALLOCATION	Expenditure (Govt. Grant)	Expenditure (Govt. Generation)	TOTAL Expenditure
1	2	3	4	5 (3+4)	6	7	8 (6+7)
Grants in Aid - Capital							
	Works						
A.1	Land	0.00	0.00	0.00	0.00	0.00	0.00
B.1	Office buildings	0.00	0.00	0.00	0.00	0.00	0.00
B.2	Residential buildings	0.00	0.00	0.00	0.00	0.00	0.00
B.3	Other works	0.00	0.00	0.00	0.00	0.00	0.00
	Total Works	0.00	0.00	0.00	0.00	0.00	0.00
Other Capital Expenditure							
C.	Equipment	700000.00	500000.00	1200000.00	700000.00	499473.00	1199473.00
D.	Information Technology	0.00	0.00	0.00	0.00	0.00	0.00
E.	Library books and journals	200000.00	0.00	200000.00	174942.00	0.00	174942.00
F.	Vehicles and Vessels	0.00	0.00	0.00	0.00	0.00	0.00
G.	Livestock	0.00	0.00	0.00	0.00	0.00	0.00
H.	Furniture & Fixtures	400000.00	0.00	400000.00	395836.00	0.00	395836.00
I.	Others	0.00	0.00	0.00	0.00	0.00	0.00
	Total : Other Capital Expenditure	1300000.00	500000.00	1800000.00	1270778.0	499473.00	1770251.00
	Total Grants-in-Aid Capital	**1300000.00**	**500000.00**	**1800000.00**	**1270778.00**	**499473.00**	**1770251.00**
Grants-in-Aid - Salaries							
	Establishment Expenses						
A.1	Establishment charges	274814000.00	5000000.00	279814000.00	274814000.00	896445.00	275710445.00
A.2	Wages	4822000.00	0.00	4822000.00	4821092.00	0.00	4821092.00
A.3	Overtime Allowance	0.00	0.00	0.00	0.00	0.00	0.00
	Total : Establishment Expenses	279636000.00	5000000.00	284636000.00	279635092.00	896445.00	280531537.00
	Total : Grants in Aid - Salaries	**279636000.00**	**5000000.00**	**284636000.00**	**279635092.00**	**896445.00**	**280531537.00**
Grants in Aid – General							
	Pension & Retirement Benefits						
A.	Pension & Other Retirement benefits	125000000.00	0.00	125000000.00	124994971.00	0.00	124994971.00
	Total : Pension & Retirement Benefits	125000000.00	0.00	125000000.00	124994971.00	0.00	124994971.00
Travelling Allowances							
A.	Domestic TA/Transfer TA	1800000.00	0.00	1800000.00	1772988.00	0.00	1772988.00
B.	Foreign TA	0.00	0.00	0.00	0.00	0.00	0.00
	Total Travelling Allowance	1800000.00	0.00	1800000.00	1772988.00	0.00	1772988.00

S. No.	Head	Allocation Govt. Grant	Allocation Internal Resource + Additional amount provided by HQ out of Council's share	TOTAL ALLOCATION	Expenditure (Govt. Grant)	Expenditure (Govt. Generation)	TOTAL Expenditure
1	2	3	4	5 (3+4)	6	7	8 (6+7)
Research & Operational Expenses							
A.	Research Expenses	8000000.00	5000000.00	13000000.00	8000000.00	6959419.0	14959419.00
B.	Operational Expenses	4000000.00	3000000.00	7000000.00	4000000.00	1040001.0	5040001.00
	Total : Research & Operational Expenses	12000000.00	8000000.00	20000000.00	12000000.00	7999420.0	19999420.00
Administrative Expenses							
A.	Infrastructure	8000000.00	3000000.00	11000000.00	8000000.00	2997362.0	10997362.00
B.	Communication	700000.00	0.00	700000.00	635970.00	0.00	635970.00
C.1	Repairs/Maintenance-Equipments Vehicles & others	3300000.00	500000.00	3800000.00	'3300000.00	142856.00	3442856.00
C.2	Repairs/Maintenance – Office building	1600000.00	400000.00	2000000.00	1600000.00	397916.00	1997916.00
C.3	Repairs/Maintenance-Residential Buildg.	1500000.00	0.00	1500000.00	1499497.00	0.00	1499497.00
C.4	Repairs/Maintenance Minor Works	500000.00	0.00	500000.00	499845.00	0.00	499845.00
D.	Others (excluding TA)	6000000.00	1000000.00	7000000.00	6000000.00	940675.00	6940675.00
	Total : Administrative Expenses	21600000.00	4900000.00	26500000.00	21535312.00	4478809.0	26014121.00
Miscellaneous Expenses							
A.	HRD	222000.00	0.00	222000.00	219503.00	0.00	219503.00
B.	Other Items (Fellowships, Scholarships etc.)	0.00	0.00	0.00	0.00	0.00	0.00
C.	Publicity & Exhibition	100000.00	0.00	100000.00	89143.00	0.00	89143.00
D.	Guest House – Maintenance	50000.00	0.00	50000.00	49740.00	0.00	49740.00
E.	Other Misc.	228000.00	72000.00	300000.00	228000.00	71267.00	299267.00
	Total : Miscellaneous Expenses	600000.00	72000.00	672000.00	586386.00	71267.00	657653.00
Total Grant in Aid - General		161000000.00	12972000.00	173972000.00	160889657.00	12549496.0	173439153.00
GRAND TOTAL : Capital + Revenue (Salaries) + Revenue (General)		**441936000.00**	**18472000.00**	**460408000.00**	**441795527.00**	**13945414.00**	**455740941.00**
Loan & Advances			1200000.00	1200000.00		1087470.00	1087470.00

Detail of Institute Plan Expenditure

S. No.	Head	RE Allocation	Expenditure (Rs.)
Grants in Aid – Capital Works			
A.1	Land	0.00	0.00
B.1	Office Buildings	13260000.00	12185940.00
B.2	Residential Buildings	0.00	1074060.00
B.3	Other works	0.00	0.00
	Total Works	13260000.00	13260000.00
Other Capital Expenditure			
C.	Equipments	15140000.00	14953262.00
D.	Information Technology	2350000.00	2352797.00
E.	Library Books and Journals	4500000.00	4499447.00
F.	Vehicles and Vessels	0.00	0.00
G.	Livestock	0.00	0.00
H.	Furniture & fixtures	1150000.00	1148591.00
I.	Others	0.00	0.00
	Total : Other Capital Expenditure	23140000.00	22954097.00
	Total Grant-in-Aid-Capital	36400000.00	36214097.00
Grant-in-Aid - Salaries			
	Establishment Expenses	0.00	0.00
A.1	Establishment charges	0.00	0.00
A.2	Wages	0.00	0.00
A.3	Overtime Allowance	0.00	0.00
	Total : Establishment Expenses	0.00	0.00
	Total Grant –in-Aid Salaries	0.00	0.00
Grant-in-Aid - General			
	Pension and Retirement Benefits		
A.	Pension & other retirement benefits	0.00	0.0o
	Total : Pension & Retirement Benefits	0.00	0.00
A.	Domestic TA/Transfer TA	4900000.00	4897486.00
B.	Foreign TA	0.00	0.00
	Total Travelling Allowances	4900000.00	4897486.00
Research and Operational Expenses			
A.	Research Expenses	56300000.00	39308870.00
B.	Operational Expenses	0.00	9733136.00
	Total Research & Operational Expenses	56300000.00	49042006.00

S. No.	Head	RE Allocation	Expenditure (Rs.)
Administrative Expenses			
A.	Infrastructure	0.00	2318315.00
B.	Communication	0.00	207285.00
C.1	Repairs/Maintenance – Equipment, Vehicles & Others	0.00	416582.00
C.2	Repairs/Maintenance – office building	0.00	73291.00
C.3	Repairs/Maintenance – Residential Building	0.00	2762584.00
C.4	Repairs/Maintenance- Minor Works	0.00	6500.00
D	Others (excluding TA)	0.00	1454292.00
	Total Administrative Expenses	0.00	7238849.00
Miscellaneous Expenses			
A.	HRD	800000.00	788703.00
B.	Other Items (Fellowships, Scholarships etc.)	0.00	0.00
C.	Publicity & Exhibitions	0.00	0.00
D.	Guest House – Maintenance	0.00	0.00
E.	Other Miscellaneous	0.00	0.00
	Total : Miscellaneous Expenses	800000.00	788703.00
	Total Grants in Aid – General	62000000.00	61967044.00
	Grand Total : Capital + Revenue (Salaries) + Revenue (General)	**98400000.00**	**98181141.00**

Revenue Receipts

S. No.	Particulars	Amount (Rs.)
1.	Sale of Farms Produce	15102154.00
2.	Sale of fish and poultry	0.00
3	Sale of land	0.00
4	Sale of building	0.00
5	Sale of vehicle, other machine tools	90000.00
6	Sale of livestock's	0.00
7	Income from Royalty, sale of publications & Advertisement	47486.00
8	License fee	1401667.00
9	Interest earned on loans and advances	911218.00
10	Leave salary and pension contribution	0.00
11	Receipt from schemes	0.00
12	Analytical and testing fee	109397.00
13	Pre-shipment fee	0.00
14	Application fee from candidates	120700.00
15	Diploma charges	0.00
16	Receipts from services rendered	3940.00
17	Unspent balance of grants	0.00
18	Interest earned on short term deposits	5097760.00
19	Income generated from internal resource generation	1823348.00
20	Net profit in revolving funds	28638455.00
21	Recoveries of loans and advances	1942602.00
22	Miscellaneous receipts	1623237.00
	GRAND TOTAL	**56911964.41**
Break up		
	Revenue Receipts	54879362.41
	Loan recoveries	1942602.00
	Sale of Assets	90000.00
		56911964.41

Results Framework Document for ICAR-Central Potato Research Institute (2013 – 2014)

Section 1: Vision, Mission, Objectives and Functions

Vision

Potato for food & nutritional security and sustainable inclusive growth.

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.

Objectives

1. Management and utilization of genetic resources for improved quality and production.
2. Production management and value addition.
3. Dissemination of knowledge.

Functions

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

Section 2: Inter se priorities among key objectives, success indicators and targets

Sl. No.	Objectives	Weight	Action	Success Indicators	Unit	Weight	Target / Criteria Value				
							Excellent 100%	Very Good 90%	Good (80%)	Fair (70%)	Poor (60%)
1	Management and utilization of genetic resources for improved quality and production	40	Evaluation of genetic resources	Germplasm evaluated	Number	18	240	220	200	190	170
			Development of improved hybrids, varieties and elite germplasm	Breeding lines developed/ varieties released/ elite material registered	Number	22	5	4	3	2	1
2	Production management and value addition	35	Production of potato nucleus and breeder seed	Nucleus and breeder's seed breeder's seed	Tonne	15	3100	3050	3000	2900	2850
			Development of production, protection, post-harvest technologies, farm implements, softwares, protocols & gene constructs	Technologies developed	Number	20	6	5	4	3	2

3	Dissemination of knowledge Consultancies	14	Organizing/ providing training, demonstrations, Kisan Melas, Awareness camps, Exhibitions and	Trainings & demonstrations organised	Number	8	15	13	12	11	10
				Kisan Melas, Awareness camps and Exhibitions organised and Consultancies provided	Number	6	5	4	3	2	1
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15 May, 2013	16 May, 2013	17 May, 2013	20 May, 2013	21May 2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	1 May, 2013	2 May, 2013	5 May, 2013	6 May, 2013	7May 2013
*	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80
			Prepare an action plan for Innovation	On-time submission	Date	2	30 July, 2013	10 Aug, 2013	20 Aug, 2013	30 Aug, 2013	10 Sep 2013
*	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

Section 3: Trend values of the success indicators

Sl. No.	Objectives	Actions	Success Indicators	Unit	Actual Value for FY 11/12	Actual Value for FY 12/13	Target Value for FY 13/14	Projected Value for FY 14/15	Projected Value for FY 15/16
1	Management and utilizationof genetic resources for improved quality and production	(1.1) Evaluation of genetic resources	(1.1.1) Germplasm evaluated.	Number		200	220	230	235
		(1.2) Development of improved hybrids, varieties and elite germplasm.	(1.2.2) Breeding lines developed/ Varieties released/ Elite material registered	Number		3	4	4	4
2	Production management and value addition	(2.1) Production of potato nucleus and breeder seed.	(2.1.1) Nucleus and Breeder's seed produced.	Tonnes	3025	3025	3050	3050	3050

		(2.2) Development of production, protection, post-harvest technologies, farm implements, softwares, protocols & gene constructs.	(2.1.2) Technologies developed	Number		4	5	5	6
3	Dissemination of knowledge and Consultancies.	(3.1) Organizing/ providing training, demonstrations, Kisan Melas, Awareness camps, Exhibitions Kisan Melas, Awareness camps, and Exhibitions	(3.1.1) Trainings & Demonstrations organised	Number		12	13	13	14
			(3.1.2) Kisan Melas, Awareness camps and Exhibitions organised Consultancies provided.	Number		3	4	4	5
*	Efficient Functioning of the RFD System	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	-	-	16 May 2013	-	-
		Timely submission of Results for RFD (2012-13)	On-time submission	Date	-	-	2 May, 2013	-	-
*	Administrative reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%	-	-	95	-	-
		Prepare an action plan for Innovation	On-time submission	Date	-	-	10 Aug, 2013	-	-
*	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	-	-	95	-	-
			Independent Audit of implementation of public grievance redressal system	%	-	-	95	-	-

· Mandatory (Objective(s)

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

Sl No.	Success indicator	Description	Definition	Measurement	General Comments
1	Germplasm evaluated	Evaluation of germplasm is the basic requirement to breed new improved varieties	Basic information about genetic resource for crop improvement	Number of germplasm samples	Utilization of the evaluated germplasm in breeding pogrammes.
2	Breeding lines developed/ Varieties released/ Elite material registered	Breeding lines/elite germplasm tested and identified for registration / introduction for multi-location trial for release as improved variety	Best performing germplasm for registration/ entry identified for trials/ release	Number of germplasm/ variety	Targets for elite material/ varieties identified given in Section 2 and their respective trend values in Section 3 may vary as the identification of the varieties depend upon the availability of superior material with respect to yield, biotic and abiotic resistance/ tolerance over the existing variety/ germplasm.
3	Nucleus and Breeder's seed produced.	Nucleus and breeder seed is the starting point in seed chain of producing quality seeds for farmers	Breeder seed is the starting point in seed chain which is multiplied/ converted into foundation/ certified seed	Quantity produced (Tonnes)	Production of nucleus and breeder seed may depend upon the climatic conditions over the seasons and the given targets may vary as per these conditions.
4	Technologies developed	Identification of technologies for potato production, protection and post-harvest management	Development of technologies, farm implements, software's, protocols and gene constructs	Number of technologies	Technologies shall be identified for efficient use of inputs, diagnostic tools for different pathogens and better post-harvest management.
5	Trainings & Demonstrations organised	The knowledge and skills of primary and secondary stakeholders shall be enhanced by conducting training and on-farm trials/emonstrations	Exposure to advanced techniques inunderstanding and managing production constraints.	Number of trainings/ demonstrations stakeholders.	Skill enhancement of primary and secondary
6	Kisan Melas, Awareness camps and Exhibitions organised and Consultancies provided.	Capacity building activities for knowledge and skill improvement for the farmers, rural youth and extension personnel and providing consultancies to the stakeholders	Transfer of technologies through these methods is aimed to benefit potato growers, researchers and private enterprenuers in potato production and processing	Number	Transfer of knowledge to the stakeholders.

Section 5: Specific performance requirements from other Departments

Location Type	State	Organisation Type	Organisation Name	Relevant Sucess Indicator	What is your requirement from this organisation	Justification for this requirement	Please Quantify your requirment from this Organisation	What happens if your requirment is not met

No dependency on the other departments.

Section 6: Outcome / Impact of activities of organisation ministry

Outcome / Impact	Jointly responsible for influencing this outcome / impact with the following organisation (s) / departments/ministry(ies)	Success Indicator (s)	Unit	FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16
1 Development of improved potato varieties and technologies for increased production and transfer of technology	Nil	Increase in production of potato	%	0.5	0.5	0.5	0.75	1.0
		Increase in area covered under new varieties developed during the last ten years	%	1.0	1.0	1.5	1.5	1.5
		Increase in Farmers' knowledge and technology adoption	%	0.5	0.5	0.7	0.7	0.8

Performance Evaluation Report

S.N.	Objective(s)	Wt.	Actions	Success Indicators (s)	Unit	Wt.	Target/Criteria Value					Achv. Performance		
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weighted Score
1.	Management and utilization of genetic resources for improved quality and production	40	Evaluation of genetic resources.	Germplasm evaluated.	Number	18	240	220	200	190	170	232	96	17.28
			Development of improved hybrids, varieties and elite germplasm.	Breeding lines developed/ Varieties released/ Elite material registered	Number	22	5	4	3	2	1	5	100	22.0
2.	Production management and value addition.	35	Production of potato nucleus and breeder seed.	Nucleus and Breeder's seed produced.	Quantity (Tonnes)	15	3100	3050	3000	2900	2850	3088	97.6	14.64
			Development of production, protection, post-harvest technologies, farm implements, softwares, protocols & gene constructs.	Technologies developed	Numbers	20	6	5	4	3	2	6	100	20.0
3.	Dissemination of knowledge	14	Organizing/ providing training, demonstrations, Kisan Melas,	Trainings & Demonstrations organised	Number	8	15	13	12	11	10	15	100	8.0
			Awareness camps, Exhibitions and Consultancies.	Kisan Melas, Awareness camps and Exhibitions organised and Consultancies provided.	Number	6	5	4	3	2	1	5	100	6.0
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15 May	16 May 2013	17 May 2013	20 May 2013	21 May 2013	14th May 2013	100	2.0
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	1 May 2013	2 May 20163	5 May 2013	6 May 2013	7 May 2013	30th Apr 2013	100	1.0
*	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80	100	100	2.0
			Prepare an action plan for Innovation	On-time submission	Date	2	30 July 2013	10 Aug 2013	20 Aug 2013	30 Aug 2013	10 Sept 2013	24th July 2013	100	2.0
*	Improving Internal Efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80	100	100	2.0
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	95	90	1.80

*Mandatory Objective(s)

Total Composite Score: 98.72