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ICAR- Central Potato Research Institute

Shimla - 171 001, Himachal Pradesh

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ICAR-CPRI Annual Report 2019

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Editorial Board

SK Chakrabarti, NK Pandey, Jagesh K. Tiwari, Ravinder Kumar, Salej Sood, Jagdev Sharma, Tanuja Buckseth and Manoj Kumar

Compilation and production

NK Pandey, Jagesh K. Tiwari, Ravinder Kumar, DK Gupta & Rakesh Kanwar

Photographs

DK Gupta

Published by

Dr. Manoj Kumar
Director (Acting)
ICAR-Central Potato Research Institute, Shimla-171001 (Himachal Pradesh)
Email: directorcpri@gmail.com, director.cpri@icar.gov.in
Website: http://cpri.icar.gov.in
Phone: 0177-2625073
Fax: 0177-2624460

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Email : aop144@gmail.com

PREFACE

It is my great pleasure to present the Annual Report 2019 of ICAR-Central Potato Research Institute (CPRI), Shimla. Since inception of the institute in 1949, development of potato varieties and technologies has lead our country as the second largest producer of potato contributing to ~12% of global production. As per the third advance estimate for 2018-19 (NHB), India produced 53.02 million tonnes of potatoes from 2.16 million ha area with an average productivity of 24.54 t/ha. This significant growth became possible only after the development of technologies by the institute. This Annual Report presents an overview of research and development conducted at the institute during the year.

The enrichment of potato germplasm repository of the institute is a continuous process and presently it includes more than 4550 accessions. During the year, a total of 34 accessions were imported from various countries including 15 diploids from the US potato gene bank, 3 from Peru, 15 from Ireland and 1 from Denmark. New potato varieties *viz*., J/92-167, WS/5-146, CP4175 (drought tolerant), Kufri Chipspsona-4 and Kufri Sangam (processing) were recommended for release in the 37th Group Meeting of AICRP (Potato) held during 3-4 September, 2019 at JNKV, Jabalpur, Madhya Pradesh. Advanced hybrids MS/13-391, MS/14-505, MS14-1381 and CP4406 (table purpose) and MP/11-30 MP/12-126 (chips) were introduced in AICRP for multi-location testing. The marker assisted selection revealed that more number of tuberosum accessions had late blight resistant genes, whereas andigena accessions had viruses and PCN resistant genes. In biotechnology, genes and microRNAs involved nitrogen metabolism were identified for improving nitrogen use efficiency in potato plants grown in aeroponic, and identified N use efficient hybrids for further field evaluation. Genome sequence of somatic hybrid and progenies were generated. Somatic hybrids were improved by breeding, and introduced an advanced stage hybrid MSH/14-07 (Kufri Garima x SH mix pollen) in AICRP (Potato) for multi-location trials. Determined site of integration, expression and copy number of the inserted RB gene in the transgenic event SP951 and Kufri Jyoti lines. Under the integrated nutrient and water management, research showed that in soils of Himachal Pradesh boron was found to be the most deficient micronutrient and soils were invariably high in Zn, Fe, Cu and Mn. In Punjab 96% soils were found deficient in available nitrogen and 55% contained low level of organic carbon, and soils invariably had high content of available phosphorus. Documents on 'Indian GAP for production of potato crop' and 'organic potato production technology for hills and plains' were published. The WOFOST crop growth model was used for impact assessment of climate change in West Bengal and Gujarat. The overall average productivity of potato was 34.87 t/ha under baseline scenario in West Bengal. Under the future climate scenarios when the combined effect of temperature and CO_2 fertilization is considered, potato productivity is likely to increase by 1.3% in 2030 and remain unchanged in 2050. In plant protection, late blight appeared in early season during the year across agro-ecologies and expecting 15-20% yield losses. Developed reverse transcriptase loop mediated isothermal amplification (RT-LAMP) assays for detection of GBNV, PVM, PVS; recombinase polymerase amplification assay for ToLCNDV-potato; qPCR for PSTVd and ISEM for potato aucuba mosaic virus. Application of chlorothalonil (0.25%) and famoxadone + cymoxanil @ 0.1% was found effective against late blight. Insect pests were monitored at Gwalior, Jalandhar and Modipuram during the year. The PP row covers (25 GSM) can provide effective protection to potato crops from virus and their vectors. Imidacloprid 17.8 SL @ 0.04 % and Pymetrozine 50 WG @ 0.06% could provide significant control of adult whiteflies and aphids up to 2 weeks. LAMP assay was developed to detect *G. pallida*. Post-harvest losses in potatoes were estimated through an experiment using potato variety, Kufri Chipsona-1 stored in heaps, 10-12°C and 2-4°C. The weight loss was found to be the highest in heaped potatoes, followed by 10-12°C after six months and three months, and it was the least at 2-4°C. Three combinations of volatile oils containing 4, 6 and 9 oils were found effective for sprout suppression up to 300 days of storage at 12°C. A total production of 27770.47 qtls nucleus and breeder seeds were produced from an area of 152.473 ha. The percentage of nucleus and breeder seed from conventional system was 79.29 and 20.71 through hi-tech system respectively. A total 92 virus-free in vitro culture tubes of basic seed material of 18 varieties were supplied to 13 different seed producing organizations in India. A survey conducted in Gujarat, Punjab and Haryana indicated major input was cost of seeds (24 to 33%) followed by hired human labor (9.5 -14 %), rental value of owned land (10 -14 %), interests on value of owned fixed assets (10-13 %) and fertilizers and micronutrients (9-13 %). A study on assessment of seed replacement rate (SRR) in Haryana showed 97.5 % SRR for improved varieties than 28.3 % for certified seeds. During the year, 18 FLDs (3 in UP, 7 in Punjab, 2 in Gwalior, 2 in Ooty and 4 in Shillong) were laid out. The institution also conducted 26 training programmes at the headquarters and its regional stations to 718 participants comprising of officials and farmers. Expert scientists participated in 17 live phone-in programmes on Doordarshan and Aakashwani. Under HRD, 10 Scientists, 9 Technical officers and 9 Administrative officers participated in various training programmes and seminars/ workshops/ conferences etc.

I congratulate entire scientists and other staffs of the institute for carrying out outstanding research and development during the year. I extend my special thanks to the editorial team for making this report brief. I would like to thank the QRT and RAC team for suggestions in refining our research. I am grateful to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR for his support. I express my sincere thanks to DDG (HS), and ADG (HS-I) for providing necessary guidance.

(Manoj Kumar)
Director (Acting)

CONTENTS

ICAR-CPRI: AN INTRODUCTION

ICAR-Central Potato Research Institute was established during August 1949 at Patna (Bihar) on the recommendation of the then Agricultural Advisor to the Government of India, Sir Herbert Steward under the Ministry of Agriculture, Government of India. The institute was later on, shifted to Shimla in 1956 in order to facilitate hybridization work in potato breeding programme 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 headquarters 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 seven regional stations located across the country viz. Modipuram (UP), Kufri (HP), Jalandhar (Punjab), Gwalior (MP), Patna (Bihar), Shillong (Meghlaya) and Ooty (Tamil Nadu) to cater the need for location specific research and extension activities.

The institute has created the state-of-the-art laboratories for conducting basic and strategic research in different areas of potato. The All India Coordinated Research Project on potato (AICRP-Potato) is also located in this 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 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 75 scientists, 135 technical staffs and 69 administrative staff working on potato crop.

THE MISSION

To 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.

THE MANDATE

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

Revised Mandate of ICAR-CPRI, Shimla

Basic strategic and applied research to enhance sustainable productivity, quality and utilization of potato.

- Repository of genetic resources and scientific information on potato.
- Transfer of technology, capacity building and impact assessment of technologies.
- Disease-free nucleus and breeder seed potato production.
- Coordinate research and validation of technologies through AICRP on potato.

Work of the Institute is being carried out by the six Divisions namely; Crop Improvement; Plant Protection; Crop Production, Crop Physiology, Biochemistry & Post Harvest Technology; Seed Technology and Social Sciences under 11 well defined research programmes including potato seed production. In addition to regular research programmes, several externally funded research projects sponsored by different agencies viz. ICAR, DBT, PPV & FRA, CIP, IASRI, NASF, NEC and UPCAR 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

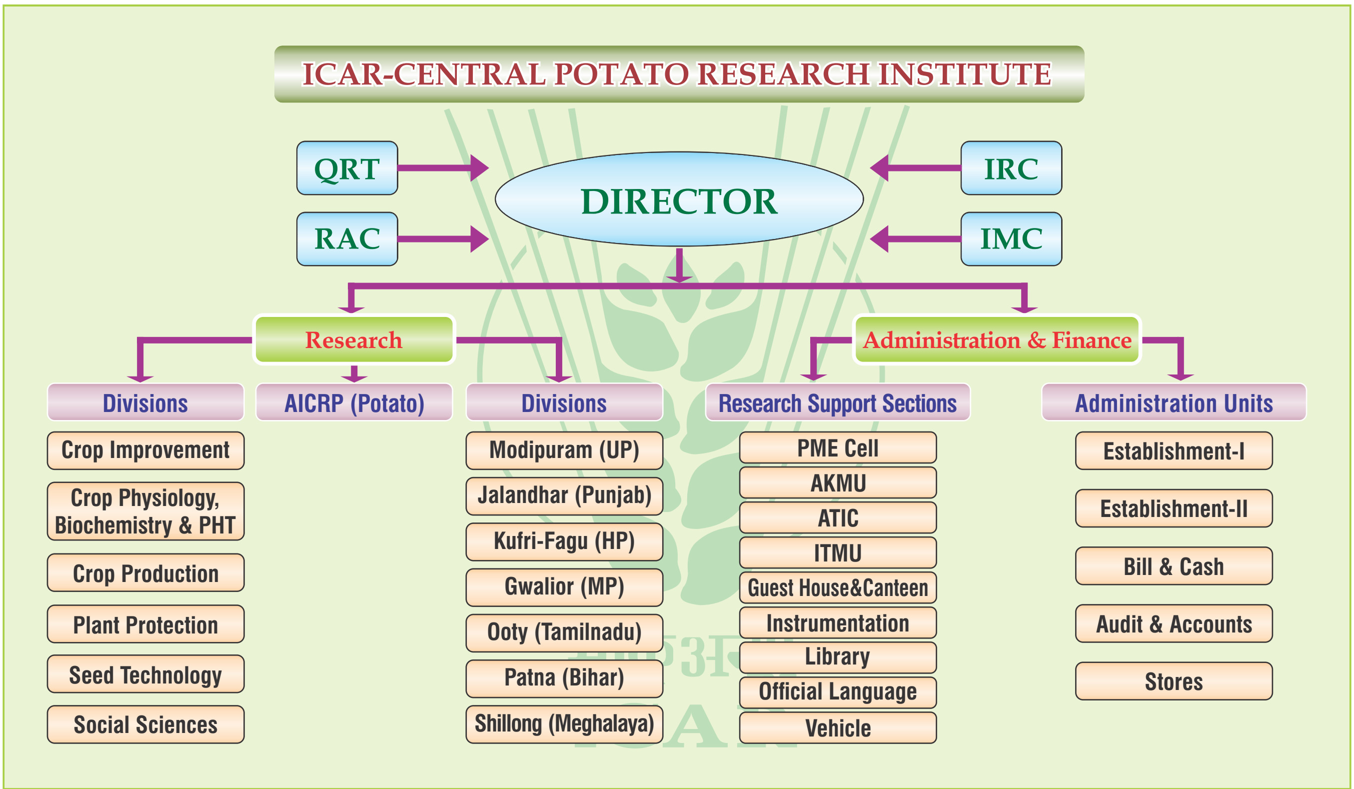
The institute has 597 sanctioned staff strength comprising of 88 scientific, 178 technical, 102 administrative and 207 supporting staff excluding RMP. The staff position as on 31.03.2020 was 371 including 75 scientific, 135 technical, 69 administrative and 92 supporting staff. In 2018-19, total allocation was ₹ 73,61,91,000/- and total expenditure was ₹ 73,43,61,384/-. The institute generated about ₹ 10 crore under Revolving Fund Scheme (RFS) by sale of breeder seed etc. During the year, 2 new scientists joined the institute, 3 scientists were promoted from Scientist to Sr. Scientist and 5 were promoted to Scientist (SS). In technical category, 1 was newly joined, 20 were promoted, 4 were transferred, 7 were retired and 1 died. Under administrative category, 1 was joined, 3 was retired, 4 were transferred, 11 were granted financial up-gradation under MACP Scheme and 4 cleared probation period. In skilled supporting staff, 14 got grant of MACP benefit, 1 cleared probation, 3 retired and 1 died.

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 ICAR-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.

The institute has 521 ha farm lands distributed over 15 units for conducting field experiments and undertaking breeders' seed production. Recently, Aeroponic facility has been created at Shimla, Modipuram, Patna and Shillong for soil-less disease-free seed potato production. A BPD Unit has been established at 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.




ICAR-CPRI, RS, Modipuram


ICAR-CPRI, RS, Patna


ICAR-CPRI, RS, Jalandhar


ICAR-CPRI, RS, Gwalior


ICAR-CPRI, RS, Ooty


ICAR-CPRI, RS, Kufri


ICAR-CPRI, RS, Shillong

EXECUTIVE SUMMARY

DIVISION OF CROP IMPROVEMENT

The management and enhancement of potato germplasm is the basic programme of the institute for collection, conservation, evaluation and documentation of germplasm. During the year, a total of 34 accessions were imported from various countries including 15 diploids from the US potato gene bank, 3 from Peru, 15 from Ireland and 1 from Denmark. Presently 4552 accessions of cultivated and wild species imported from more than 30 countries are conserved at the institute in tuber, in vitro and TPS form. These collections were evaluated for several important biotic and abiotic stresses, keeping quality, processing attributes and adaptability. Promising accessions were identified and documented for breeding uses.

In breeding programme, hybridization programme resulted 13,50,804 true potato seeds from 497 crosses involving superior parents for yield, quality and resistance/tolerance to biotic and abiotic stresses and 21,784 clones were selected. In advanced stage hybrids trials, 156 hybrids were selected from the 331 hybrids assessed in 31 trials for yield, quality and resistance/tolerance to biotic and abiotic stresses. Based on four years trials, nutrient rich clones i.e. MS/15-60, MSP/16-216, MSP/16-272, MSP/16-300, MSP/16-307 and MSP/16-375 were advanced. Based on consistently good performance over the years, 11 advanced stage hybrids namely J/12-10, J/12-54, J/12-146, MS/14-243, PS/14-10, PS/14-21 (table purposes); MP/12-223 (chips), SM/13-150, SM/13-163 (late blight resistance), HT/12-834 (heat stress) and WS/09-609 (drought tolerant) were identified. Advanced hybrids MS/13-391, MS/14-505, MS14-1381 and CP4406 (table purpose) and MP/11-30 MP/12-126 (Chips) were introduced in AICRP for multi-location testing. Among the 71 genotypes assessed for late blight at Modipuram, all showed resistance over susceptible Kufri Bahar. Worked out optimum NPK requirement (kg/ha) of varieties/advanced hybrid namely Kufri Neelkanth (240N, 30P, 120K), MS/9-2196 (240N, 30P, 80K), Kufri Sangam (240N, 40P, 100K), and WS/7-113 (180N, 30P, 80K). Crop geometry of 60x25cm was found optimum for Kufri Neelkanth. The marker assisted selection revealed that more number of tuberosum accessions had late blight resistant genes, whereas andigena accessions had viruses and PCN resistant genes. The ploidy levels of 69 genotypes were identified as diploid and TPS of six crosses were raised to undertake the selfing and berries were formed in four crosses which resulted in 665 TPS. New improved advanced stage hybrids/varieties namely J/92-167, WS/5-146, CP4175 (drought tolerant) Kufri Chipspsona-4 and Kufri Sangam (processing) were recommended for release in the 37th Group Meeting of AICRP (Potato) held during 3-4 September, 2019 at JNKV, Jabalpur, Madhya Pradesh.

In biotechnology programme, transcriptome analysis under contrasting nitrogen regimes (low and high N) revealed differentially expressed genes in potato for further genetic manipulation. A few potential genes were glutaredoxin, Myb-like DNA-binding protein, WRKY transcription factor 16 in shoots; high-affinity nitrate transporter, protein phosphatase-2c, glutaredoxin family proteinin roots; and glucose-6-phosphate/phosphate translocator 2, F-box family protein in stolons. Further, genome-wide identification of microRNAs by small RNA sequencing for low N in potato showed a total of 119 conserved miRNAs belonging to 41 miRNAs families, and 1002 putative novel miRNAs. Genome-wide transcriptome analysis for tuber shape variation in potato cv. Kufri Bahar revealed highly up-regulated genes like glycine-rich protein A3, abscisic acid and environmental stress-inducible protein TAS14; and down-regulated genes like 14 kDa proline-rich protein DC2.15, cytochrome P450 etc. Another transcriptome analysis revealed differentially expressed genes for iron stress in potato. The site of integration, expression and copy number of the inserted RB gene in the event SP951 and KJ lines was determined through molecular analysis. Overexpression of CDF1.2 allele mediates early maturity and tuberisation in Kufri Girdhri was demonstrated. Functional mutants were generated in potato using activation tagging approach. Genome sequence data of interspecific somatic hybrid (P8), wild parent (Solanum pinnatisectum) and progeny (MSH/14-112) were generated using Illumina platform. Allelic variations in wild species and interspecific somatic hybrids of potato were revealed by SSR. Improvement of potato somatic hybrids were done through breeding and introduced an advanced stage somatic hybrids-derived genotype MSH/14-07 (Kufri Garima x SH mix pollen) into AICRP (Potato) for multi-location testing. Besides, we developed NUE efficient potato hybrids (NUE/15-8, NUE/15-14, NUE/15-23 and NUE/15-67) for field evaluation.

DIVISION OF CROP PRODUCTION

Under the integrated nutrient and water management programme experiments with different sources, methods and doses of fertilizers were conducted. In soils containing high available phosphorus 30% of the recommended phosphorus dose was found sufficient at Shillong. Experiments at Ooty and Shillong revealed that phosphate in combination with PSB is a suitable source of P in acid soils. PSB in combination with rock phosphate could save 25% of the recommended P dose at Shillong and at Ooty application of 5 ton lime and 20 kg PSB per hectare could save 50 % of P dose. Soil fertility and irrigation water quality was studied in different potato growing districts of Punjab and Himachal Pradesh. Electrical conductivity of irrigation water was within safe limits for growing potatoes in Punjab. Irrigation water contained significant amount of nitrates to affect the crop growth. In Punjab 96% soils were found deficient in available nitrogen and 55% contained low level of organic carbon. Soils invariably had high content of available phosphorus. In soils of Himachal Pradesh, boron was found to be the most deficient micronutrient and soils were invariably high in Zn, Fe, Cu and Mn. Studies revealed that variable yield in Punjab were associated with inappropriate fertilizer usage. Growers invariably applied less of N and K and excess P.

Under resource optimization programme, documents on 'Indian GAP for production of potato crop' and 'organic potato production technology for hills and plains' were published. In long term experiment, recommended nutrient doses along with crop residue incorporation is a promising option in potato-based cropping systems. Highest incidence of bakane disease was observed in inorganic and crop residue treatment in rice crop in rice-potato-wheat sequence. Similar was the case for banded sheath blight in maize in maize-potato-onion system. In groundnut crop of groundnut-potato- green gram rotation, maximum disease severity of leaf spot and dry root was recorded in organic nutrition and crop residue incorporation. Whitefly incidence in potato did not show significant differences due to source of nutrition and cropping systems. Doses of P and K were optimized for Kufri Surya and Kufri Himalini in kharif season of Karnataka. Three prototypes of solar drying units were developed for drying potato products. A soilless seed potato production unit has been developed rapid seed multiplication. A potato treatment and grading line with capacity of 10 ton/h was developed for cleaning, sorting, treatment, drying, grading and packaging of seed potatoes. A transparent aeroponics system has been developed and tested successfully for experimental and display purpose. Patents were granted for 'CPRI spade' and 'CPRI L-type hoe' in mechanical technologies activity.

In climate change programme, WOFOST crop growth model was used for impact assessment of climate change in West Bengal and Gujarat. The overall average productivity of potato was 34.87 t/ha under baseline scenario in West Bengal. Under the future climate scenarios when the combined effect of temperature and CO_2 fertilization is considered, potato productivity is likely to increase by 1.3% in 2030 and remain unchanged in 2050 whereas 3% decrease in 2080 is expected under RCP 4.5 while the corresponding figures under RCP 6.0 are likely to be +4.2, +4.6 and +1.1%. Potato productivity varied under RCP 4.5 and 6.0 for the future climatic scenarios in Gujarat, where it is likely to decline by 16.4% in 2080 under RCP 4.5 and increase by 2.1% under RCP 6.0 during same time. Potential impact of climate change on potato late blight outbreak in West Bengal using Indo-Blightcast model was studied and the findings revealed that in general, late blight favourable period is likely to be reduced in all the studied districts except Kolkata, Malda, Parganas North and Puralia where it is likely to remain as a threat in the future climate (2030 & 2050) scenario. Climate analogues are significant to study the appearance of late blight and it may appear either at same time or at different times in similar climate analogues. In this context, observations on appearance of late blight in different climate analogues were recorded. Along with these, periodic generation of data was recorded on arrival and buildup of aphids and whiteflies population.

DIVISION OF PLANT PROTECTION

During the year, late blight (*Phytophthora infestans*) appeared early in the season across agro-ecologies and expecting 15-20% yield losses. Developed reverse transcriptase loop mediated isothermal amplification (RT-LAMP) assays for detection of GBNV, PVM, PVS; recombinase polymerase amplification assay for ToLCNDV-potato; qPCR for PSTVd and ISEM for potato aucuba mosaic virus. Agro-advisories for the management of late blight across agro-ecologies were issued based on Indo-Blightcast model. Application of chlorothalonil (0.25%) and famoxadone + cymoxanil @ 0.1% was found effective against late blight. Scheduling fungicide application for management of late blight using Indo-Blightcast resulted in reduction of fungicide use by 22.2%, 28.5% and 44.4% during 2017, 2018 and 2019 crop seasons, respectively over calendar based fungicide scheduling; thereby saved money and environment. The highly resistant RNAi PAP2 transformed line yielded only avirulent colonies of *Ralstonia solanacearum*, whereas moderately resistant lines yielded virulent colonies. Among the 34 agro-chemicals evaluated against *Streptomyces scabies*, 09 chemicals namely, mancozeb 72WP, Curzate 72 WP (cymoxanil 8% + mancozeb 64%), benalaxyl + mancozeb, Sectin 60WP (fenamidon10%+ mancozeb 50%), copper oxychloride 50WP, copper hydroxide 53.8 W/W, Zineb 75WP (all at 1500 ppm), streptomycin (at 100ppm) and $ZnSO_4$ (at 1000 ppm), were found effective in inhibiting the growth of *S. scabies* under *in-vitro* but none was found effective under field conditions. However, one endophytic bacterial strain (E-23) resulted in significant reduction in common scab (9.59%) and black scurf (0.35%) severity compared to 19.65% common scab and 6.40% black scurf severity in control. Attempts were made to develop alternative approaches namely dsRNA against ToLCNDV-potato, genome editing for late blight, identification of host susceptibility genes against ToLCNDV-potato for management of potato pathogens.

Insect pests were monitored at Gwalior, Jalandhar and Modipuram in 2019. *Myzus persicae* first appeared on potato in the 1st and 4th week of November at Jalandhar and Gwalior, respectively. The population of whitefly remained above economic threshold till the 2nd and 4th week of November at Jalandhar and Gwalior, respectively. The PP row covers (25 GSM) can provide effective protection to potato crops from virus and their vectors. Imidacloprid 17.8 SL @ 0.04 % and Pymetrozine 50 WG @ 0.06% could provide significant control of adult whiteflies and aphids up to 2 weeks. Data revealed that soil incorporated insecticides e.g. Cartap Hydrochloride 4G at (20 kg/ha) was effective against whitefly and leafhopper and was at par with Phorate 10 G (15kg/ha). Nanma @10ml/l was found effective against whitefly, aphids, leafhoppers and thrips but lost their effectiveness within 2-3 days. Putative functional virulence genes were identified in the glass house potato aphid *(Aulacorthum solani)*. In studies on phyto-semiochemicals, total of 27 plant volatile organic compounds were identified from the GC-MS analysis of potato volatiles. LAMP assay was developed to detect *G. pallida* directly from soil by developing the mitochondrial cytochrome c oxidase I (COI) gene specific primer. The bleaching powder (20-200 gm/m^2) reduced the PCN population without affecting the germination under field condition. The *Paecilomyces lilacinus* @20 kg/ha was effective against cyst nematodes with lowest Rf value. Mustard @12.5 t/ha was effective as biofumigant against cyst nematodes.

DIVISION OF CROP PHYSIOLOGY, BIOCHEMISTRY AND POST-HARVEST TECHNOLOGY

Post-harvest losses in potatoes were estimated through an experiment using potato variety, Kufri Chipsona-1 stored in heaps, 10-12°C and 2-4°C. The weight loss was found to be the highest in heaped potatoes, followed by 10-12°C after six months and three months, and it was the least at 2-4°C. Three combinations of volatile oils containing 4, 6 and 9 oils were found effective for sprout suppression up to 300 days of storage at 12°C. The method for ABA analysis was developed for its quantification through LC-MS. Quantification technique was developed for estimation of Insulin like antigens and sprouted potatoes were observed to have higher contents of these antigens as confirmed with ELISA. *In-vivo* anti-hyper-glycemic activity of potatoes was estimated using mice model of CDRI and Kufri Surya was found to have the highest activity amongst the tested varieties. Purification procedures of phenols using HPLC was developed and chlorogenic acid was estimated in potatoes. Bioaccessibility studies were done using *in-vitro* gastrointestinal models for carbohydrate fractions, phenols and ascorbic acid. Glycemic index as affected by maturity and texture of potatoes was evaluated and floury texture varieties were found to have higher GI. Retrogradation effects on GI and resistant starch was estimated in few potato varieties and it was found that retrogradation changes starch structure leading to low GI in potatoes at low temperatures. Production process of glucose syrup from potatoes was developed, which resulted in conversion of up to 96% starch into glucose. A process of Bio-ethanol production from waste potatoes was developed using *Saccharomyces cerevisiae* strains obtained from IMTECH and with best strain, productivity of bio-ethanol up to 82.4g/l was obtained. Two novel potato products viz. Potato Preserve and Potato

Muffins were developed and the technology documents have been submitted to ITMU for their commercialization. A preliminary patent on "Composition exhibiting sprout inhibitory effect in potatoes" was filed in May 2019 and final patent shall be filed within a year after supplementing the required information.

DIVISION OF SEED TECHNOLOGY

A total production of 27770.47 qtls nucleus and breeder seeds were produced from an area of 152.473 ha. Out of which, 22019.74 qtls production from 124.121 ha was through conventional and 5750.73 qtls from 28.352 ha through hi-tech seed production systems respectively. The percentage of nucleus and breeder seed from conventional system was 79.29 and 20.71 through hi-tech systems respectively. Total 23080.85 qtls breeder seed was supplied to various government and private agencies from plains. A total 92 virus-free in vitro culture tubes of basic seed material of 18 varieties were supplied to 13 different seed producing organizations in India and a revenue of Rs. 4,60,000/- has been generated. As per the MoU for breeder seed production, the healthy aeroponic minitubers of varities *viz.*, Kufri Jyoti (1100 no.), Kufri Khyati (2500 no.) and Kufri Chandramukhi (1300 no.) were supplied to West Bengal for further multiplication and a revenue of Rs. 42,000 was generated. Apical Rooted Cutting technology for the production of quality seed potato material was standardized. The results were remarkable which suggests that the technology can be used for production of quality planting material at low cost in seed deficit areas. Comparative performance of aeroponic tubers of three potato cultivars of hills under late planting conditions in polyhouse suggests that aeroponic tubers of all the potato cultivars of hills can be successfully multiplied under late planting conditions which will be helpful in reducing the crop duration from 150 to 90 days and thus saving in cost of production. An analysis demonstrated that microplants developed without the growth regulators proved to have equivalent potential of increasing the multiplication rate of *in vitro* potato varieties. The seed crop haulming study suggests that tuber number and yield (25-75 g) was significantly influenced by age of crop at the time of haulm killing, cultivar and its interactions. Canopy management studies in aeroponic suggests that maximum number of minitubers per plant was obtained in earliest nipping (26 DAP) as compared to control. Optimizations of inter and intra row spacing to get higher number of seed size tubers were carried out across seed centres.

DIVISION OF SOCIAL SCIENCES

Survey were conducted in Gujarat, Punjab and Haryana for assessing the cost and income of potato production and found that seed cost was highest (24 to 33%). Other major cost components were hired human labor (9.5 -14 %), rental value of owned land (10 -14 %), interests on value of owned fixed assets (10-13 %) and fertilizers and micronutrients (9-13 %). The study for assessment of seed replacement rate (SRR) was conducted in Haryana. On an average, the SRR for improved varieties was 97.5 % than 28.3 % for certified seeds. Survey on the adoption patterns of potato varieties showed that Kufri Jyoti covered maximum area (38 %) followed by Kufri Pukhraj (29 %) in Punjab, whereas Kufri Pukhraj (92.4 %) was predominant in Haryana. In Bihar, the predominant varieties were Kufri Pukhraj (38 %) followed by Kufri Sindhuri (33 %), Kufri Arun (10%) and Boora Aloo (8%). A survey in Nalanda, Buxar, Saran and Muzaffarpur districts of Bihar observed that technologies like use of optimum seed rate, improved varieties, pre-sprouting of seed tubers, use of whole seed tubers, seed retention period, maintenance of spacing, weeding and late blight management were followed by majority of the farmers. However, there is very poor adoption of technologies like use of certified quality potato seeds, FYM application, recommended dose of NPK fertilizers, irrigation interval and pre-sowing irrigation. For popularization of technologies developed by the institute, 18 FLDs (3 in UP, 7 in Punjab, 2 in Gwalior, 2 in Ooty and 4 in Shillong) were laid out. The institution also conducted 26 training programmes at the headquarters and its regional stations to 718 participants comprising of officials and farmers. Many exhibitions, fairs, celebration of important days, chat shows, kisan goshthees were also organized. Expert scientists from different disciplines of ICAR-CPRI, Shimla and its regional stations participated in 17 live phone-in programmes on doordarshan and aakashwani. Under HRD Cell, 10 Scientists, 9 Technical officers and 9 Administrative officers were sent to participate in various training programmes and several attend seminars/ symposia/ workshops/ conferences etc.

RESEARCH PROGRAMMES

Sr. No.	Research Programmes & Institute Code No.	Programme Leader and Associates
1.	Management and enhancement of potato germplasm HORTCPRICIL201500100129	**PI: Dr. Vinod Kumar, Associates:** Drs. Vinay Bhardwaj, Ashwani Kumar Sharma, JK Tiwari, Dalamu, G Vanishree, Tanuja Buckseth, Raj Kumar, Ratna Preeti Kaur, SK Luthra, Shambhu Kumar, Name Singh, Bandana, Kamlesh Malik, Sanjeev Sharma, Baswaraj R, Ravinder Kumar, Aarti Bairwa, Jagdev Sharma, Som Dutt, EP Venkatasalem, Divya K Lekshmanan, Arvind Kumar Jaiswal, Priyank Mhatre, Clarissa Challam, Anil Gupta, KR Naik, Kiran Kumar, Shruti Gupta, Kameshwar Sen, Vineet Kumar, Salej Sood, Nishant chourasia, Gaurav Verma & Mr. Munna Singh
2.	Breeding to evolve trait specific varieties for productivity, quality and resistance to biotic and abiotic stresses HORTCPRICIL201500200130	**PI: Dr. SK Luthra, Associates:** Drs. VK Gupta, Raj Kumar, Ashwani Kumar Sharma, RP Kaur, Shambhu Kumar, Mehi Lal, Sanjay Rawal, Vinay Bhardwarj, Bandana, Dalamu, G Vanishree, Sanjeev Sharma, S Sundaresha, Baswaraj Raigond, Aarti Bairwa, Gaurav Vermsa, Brajesh Singh, Devendra Kumar, Name Singh, Som Dutt,, Vinod Kumar, EP Venkatasalam, Sarla Yadav, Babita Chaudhary, Divya K Lekshmanan, Kailash Chander Naga, Sushil Sudhakar Changan, VK Dua, Jagdev Sharma, Manoj Kumar, Prince Kumar, Salej Sood, Raj Kumar Rana, Priyank Mhatre, Clarissa Challam, Ravinder Kumar, Subhash Katare, Kamlesh Malik, Pinky Raigond, Jagesh K Tiwari, Nishant Chourasia, Arvink Kumar Jaiswal, Sugani Devi, Hemant Kardile, Murlidhar Sadawarti, Nishan Chourasia & VU Patil
3.	Genetic enhancement of potato through molecular and genomic tools. HORTCPRICIL201500300131	**PI: Dr. Jagesh Kumar Tiwari, Associates:** Drs. VK Dua, Som Dutt, VU Patil, S Sundaresha, Vinay Bhardwaj, Hemant Kardile, Brajesh Singh, Shashi Rawat, Raj Kumar, SK Luthra, Dalamu, Pinky Raigond, Baswaraj Raigond, Sanjeev Sharma, Clarissa Challam, Vinay Sagar, Aarti Bairwa, EP Venkatasalem, Priyank Mhatre, RP Kaur, Devender Kumar, Tanuja Buckseth, RK Singh, Vinod Kumar, Salej Sood, Manoj Kumar, Ashwini K Sharma, Name Singh, Sushil Sudhakar Changan, Nishant Chourasia, G Vanishree, Dharmendra Kumar, Preeti Singh & Milan Kumar Lal
4.	Impact, adaptation and management strategies for climate resilient potato production HORTCPRICIL201600100139	**PI: Dr. VK Dua, Associates:** Drs. Devendra Kumar, Jagdev Sharma, Shashi Rawat, Sanjay Rawal, SP Singh, Sanjeev Sharma, Mehi Lal, Kamlesh Malik, Anuj Bhatnagar, VK Gupta, Vinay Sagar, Somdutt, Prince Kumar, Hemant Kardile, Mohd. Abbas Shah, Sushil Kumar, Islam Ahmad, Yogesh Gupta, Vijay Paul (IARI), Subhash Chander (IARI), Parimal Sinha (IARI), Name Singh, Paresh Chaukhande, Sunayan Saha, Brajesh Nare, Subhash Katare, Pynbianglang Kharumunid, Preeti Singh & Rabindra Padariya (IARI)
5.	Integrated nutrient and water management for improved productivity of potato HORTCPRICIL500500133	**PI: Dr. Manoj Kumar, Associates:** Drs. VK Dua, Name Singh, Jagdev Sharma, Raj Kumar, Prince Kumar, SP Singh, Bapi Das, Shashi Rawat, Pooja Mankar, Dalamu, VU Patil, Sarla Yadav,Sushil Kumar, Yogesh, Divya K Lekshmanan, Preeti Singh & Janani P.

6.	Biology, epidemiology, modeling and management of insect pests, vectors and cyst nematodes of potato. HORTCPRICIL201500600134	**PI: Dr. (Mrs.) Kamlesh Malik, Associates:** Drs. Anuj Bhatnagar, Aarti Bairwa, Baswaraj Raigond, Ravinder Kumar, S Sundaresha, JK Tiwari, VK Dua, Vinod Kumar, Murlidhar Sadawarti, Sanjeev Sharma, EP Venkatasalem, Shashi Rawat, Vinay Sagar, Vinay Bhardwaj, Kapil Kumar Sharma, Mohamad Abas Shah, Priyank Matre, Kailash Chandra Naga, Gaurav Verma, Raghvendra KV, Subhash S, Subhash Katare, Rahul K Tiwari & Ashwani Sharma.
7.	Re-defining epidemiological parameters and management approaches for potato pathogens. HORTCPRICIL201500800136	**PI: Dr. Sanjeev Sharma, Associates:** Drs. Vinay Sagar, Baswaraj R, S. Sundaresha, Ravinder Kumar, Mehi Lal, Rahul Bakade, Shashi Rawat, Anuj Bhatnagar, Vinay Bhardwaj, Aarti Bairwa, EP Venkatasalam, VU Patil, Kamlesh Malik, Prince Kumar, MJ Sadawarti, Pinky Raigond, Mohamad Abas Shah, Priyank Matre, Murari Lal, Subhash Chand, Islam Ahmad, YP Singh, Kailash Chandra Naga, Subhash S, Rahul Tiwari, Gaurav Verma & Subhash Katare.
8.	Post harvest management and nutritional enhancement of potatoes HORTCPRICIL201500800136	**PI: Dr. Brajesh Singh, Associates:** Drs. Jagdev Sharma, SK Luthra, Vinay Bhardwaj, Vinay Sagar, Som Dutt, Pinky Raigond, Baswaraj Raigond, Bandana, S Sundaresha, Ratna Preeti Kaur, Dalamu, Sanjay Rawal, Hemant Kardile, Pynbianglang Kharumunid, Sushil Kumar, Abhijit Kar, Vineet Sharma, Yogesh Gupta, Shelly Chopra, Alka Joshi, Sushil Kumar Changan, N Sailo, Milan Kumar Lal, Dharmendar Kumar & Arvind Kumar Jaiswal.
9.	Resource optimization in potato based cropping system HORTCPRICIL201500900137	**PI: Dr. Sanjay Rawal, Associates:** Drs. RK Singh, VK Dua, Devendra Kumar, Kamlesh Malik, Jagdev Sharma, Vinay Singh, Sunil Gulati, Sukhwinder Singh, Anuj Bhatnagar, Dhruv Kumar, SP Singh, Ashwani Kumar Sharma, Shashi Rawat, EP Venkatasalem, Murlidhar Sadawarti, Mehi Lal, RP Kaur, Bandana, Tanuja Buckseth, Pooja Mankar, Prince Kumar, Clarissa Challam, Pynbiangland Kharumnuid, Divya K Lekshmanan, Brajesh Nare, Priyank Mhatre, Bapi Das, Harvir Singh, KP Singh, RK Samadhiya, Sanjay Sharma, TJ Purakayastha, Janani P, N Sailo, Raghvendra KV, Sugani Devi, RK Singh, Rajesh Kumar Rana & Preeti Singh.
10.	Assessment of potato technologies and its transfer to stakeholders for improving potato production HORTCPRICIL201501000138	**PI: Dr. NK Pandey, Associates:** Drs. RK Singh, Pynbiangland Kharumnuid, Ashok Chauhan & Arjun K Sharma.
11.	Production of nucleus and breeder seed of important notified varieties of potato HORTCPRICIL201501100132	**PI: Dr. RK Singh, Associates:** Drs., Devendra Kumar, Tanuja Buckseth, Ashwani Kumar, Shambhu Kumar, Raj Kumar, Vinay Singh, Dhruv Kumar, Prince, Ratna Preeti Kaur, SP Singh, MJ Sadawarti, Manoj Kumar, RK Singh, Rahul Bakade, EP Venkatasalem, Parvesh Jassal, Sumita Sharma, RK Verma, Balak Ram, KP Singh, Harveer Singh, NK Sood, Jasvir Singh, Santosh Kumar, Pushpender Kumar, Satinder Kumar, Kapil Kumar Sharma, Akhilesh, Arun Kumar Singh, YP Singh, RK Samadhiya, Sanjay Sharma, Raghvendra KV, N Sailo, Mohd. Abbas Shah, Sugani Devi & Subhash Katare.

DIVISION OF CROP IMPROVEMENT

PROGRAMME: MANAGEMENT AND ENHANCEMENT OF POTATO GERMPLASM

This programme serves the potato breeders and researchers by providing potato germplasm for use as parents and genotypes with diverse characters. The main activities of this inter-disciplinary programme are to import the germplasm, conserve the available collection safely, evaluate the collection for important biotic and abiotic stresses, and document the information in easily retrievable form for use by the researchers.

Collection

A total of 34 accessions were imported from various countries including 15 diploids from the US potato gene bank, 3 from the Peru, 15 from Ireland and 1 from Denmark. Presently more than 4550 accessions of cultivated and wild potato species, obtained from 30 countries, are conserved at the institute **(Table 1)**.

Table 1: Potato germplasm holding at CPRI, Shimla

Material	No. of Accessions				No. of donor countries
	Tuber	*In vitro*	True seed	Total	
a) Tuberosum (Cultivars / parental lines) **Indian**					
Cultivars bred at CPRI	56	60		**60**	
Advanced hybrids	86	50	-	**96**	
Indigenous varieties	51	107	-	**107**	
Indigenous samples	97	42		**97**	
Exotic	1837	2700	-	**2890**	30
b) Andigena	723	77	-	**762**	5
c) Wild/ semi-cultivated sps.	119 (40 species)	130 (29 species)	294 (70 species)	**540 (125 species)**	5
Total germplasm				**4552**	

Conservation

Field conservation: One thousand five hundred and ninety Tuberosum accessions, 741 Andigena accessions and 63 indigenous samples were maintained in fields at Jalandhar. Nearly 1325 Tuberosum accessions and 107 indigenous samples were maintained in fields at Kufri. Besides this, pollen of four potato varieties namely Kufri Anand, Kufri Ashoka, Kufri Jawahar and Kufri Sutlej were cry preserved in liquid nitrogen for future use. Ten dihaploids of Indian commercial varieties were maintained in glasshouses at Shimla. In wild species, 347 clones of 119 accessions representing 40 Solanum species were multiplied for maintenance breeding whereas, 294 accessions of 70 species were maintained in TPS form. In total, 540 accessions (in tuber / TPS/ *in vitro* form) of 125 species were conserved at CPRI, Shimla.

In vitro conservation: Nearly 2700 Tuberosum accessions and 130 accessions of 29 wild species were maintained in *in-vitro* form. Minitubers of 281 accessions from *in vitro* repository were produced and added to the germplasm collection maintained under field conditions at Kufri/ Jalandhar. Mericlones of different hybrids (2) and varieties (8) were excised and tested for their freedom from all viruses. During this year, 4 varieties namely Kufri Swarna, Kufri Himsona, Kufri Kanchan, Kufri Kesar and 1 advanced hybrid, MS/10-1529 were found free from all viruses.

Evaluation

Adaptability: Under temperate long days in Kufri hills, in single row trial, 219 accessions were evaluated along with Kufri Jyoti, Kufri Himalini and Kufri Girdhari as control. Twenty accessions viz., CP Nos. 3841, 3851, 3917, 3954, 3958, 3964, 3971, 3973, 3992, 3996, 4000, 4027, 4042, 4044, 4046, 4047, 4103, 4150, 4164 and 4368 out yielded the best control Kufri Himalini (560g / plant).

Among these 4 accessions namely CP3841, CP4000, CP4042 and CP4044 were promising for resistence to late blight also.

Under sub-tropical short days conditions in Jalandhar, One hundred (100) Tuberosum accessions were evaluated under spring planting conditions. The yield of germplasm accessions ranged from 40 to 320 g/plant, while best control variety was Kufri Jyoti (210 g/plant). Promising accessions were: CP3472 (300 g/plant) and CP3318 (280 g/plant).

In Modipuram, under early planting, 134 Tuberosum genotypes including germplasm lines, advance hybrids and control varieties were evaluated under heat stress conditions in replicated trial at 75 DAP. Genotypes namely MF 1, Kufri Lima, MS/14-0243, MS/15-758 and CP 4491 were identified based on at par performance with heat tolerant variety Kufri Surya (207g/plant). These genotypes fulfilled the criteria of ≥77% germination, ≥174/216 gram marketable/ total yield per plant, ≤15% mite burn and ≤13% hopper burn. Under normal planting, sixty-one genotypes including germplasm lines, advanced stage hybrids and control varieties were evaluated in replicated trial at 90 DAP. Promising genotypes namely CP3273, CP3368, CP3470, CP4143, CP4149, Kufri Arun, Kufri Neelkanth, Kufri Bahar, Kufri Lima, Kufri Sindhuri, SKL2019, and Kufri Lalit were identified based on genotypes fulfilling the criteria of ≥87% germination, ≥496/515 gram marketable/ total tuber yield / plant and 18% tuber dry matter **(Fig. 1)**.

Fig. 1: Germplasm evaluation under main planting conditions

Late blight resistance: Two hundred nineteen Tuberosum accessions along with controls Kufri Jyoti, Kufri Girdhari and Kufri Himalini were screened for foliar blight resistance under natural open epiphytotic condition at Kufri. Based on late blight incidence, recorded four times at an interval of seven days between two subsequent readings, 26 accessions viz., CPNos 1690, 1750, 1869, 1930, 1936, 2012, 3841, 3842, 3849, 3937, 4000, 4044, 4045, 4050, 4051, 4055, 4057, 4065, 4070, 4110, 4118, 4138, 4174, 4183, 4184 and 4191 were highly resistant (AUDPC < 250) while 18 accessions namely CPNos. 1685, 1724, 1742, 1867, 1940, 2010, 3819, 3828, 3850, 4042, 4089, 4102, 4131, 4170, 4187, 4192, 4402 and 4516 were resistant (AUDPC 251-350). Ninety-two accessions were moderately resistant (AUDPC 351-650) and remaining genotypes were either susceptible (AUDPC 651-1200) or highly susceptible (AUDPC >1200). Eleven accessions namely CPNos. 3841, 3842, 4000, 4045, 4065, 4070, 4118, 4138, 4171, 4187 and 4191were promising to late blight during last year also. At Shillong, 200 accessions including controls (Kufri Girdhari, Kufri Himalini anfd Kufri Jyoti) were evaluated for late blight resistance under natural epiphytotic. Based on AUDPC values, 3 accessions (CP1604, CP4174 and Kufri Girdhari) were highly resistant, two accessions (CP2161 & CP3495) were resistant and 23 accessions were moderately resistant.

By detached leaf method, 41 germplasm accessions were tested for foliage resistance to late blight. Nine accessions (CP Nos. 2313, 3497, 3510, 3537, 3759, 3848, 3851, 4447 and 4448) were resistant, whereas remaining accessions were moderately resistance. Out of 41 accessions tested for tuber resistance by tuber slice method, only two accessions (CP4444 & CP4456) were moderately resistant and remaining accession were susceptible.

Viruses: Forty germplasm accessions were screened for resistance through DAS-ELISA against PVX and PVY. Nineteen accessions namely CP Nos. 1698, 2313, 3510, 3514, 3537, 3654, 3732, 3773, 3849, 4093, 4291, 4399, 4447, 4460, 4502, 4506, 4513, 4534 and 4538 had combined resistance to PVX and PVY while 22 and 32 accessions showed resistance to PVX and PVY, respectively.

A total of 23 *in vitro* accessions found positive for PSTVd during previous years were tested for its confirmation through RT-PCR analysis. All of them were found infected to PSTVd. The infected accessions are being cleaned through long term conservation.

Leaf hopper and mites: Out of 134 accessions, 15 accessions (CP4516, Kufri Lima, CP4492, MS/15-0758, MSH/14-007, CP4502, MSP/15-12, MS/13-527, MSP/15-11, CP4423, Phulwa White, MSH/14-113, CP4494, MS/14-0243 and MSH/14-123) had mite damage below 10% and 15 accessions Kufri Lima, CP4502, MS/13-527, MSP/15-11, CP4423, Kala Aloo, CP4521, CP4506, President, HYB 3, MSP/15-12, MSP/15-56, CP4406, K Chipsona-3 and CP2375 had hopper burn below 1%.

Cyst nematodes: A total 50 Tuberosum accessions were screened against both the species of cyst nematodes viz. *Globodera pallida* and *G. rostochiensis* at Ootacamund. The data indicated that 23 accessions were found resistant to *G. pallida*, 16 were resistant to *G. rostochiensis* whereas 7 accessions (CP Nos. 1137, 1330, 1533, 4350, 4388, 4502 and 4510) were found resistant to both the species of PCN.

Keeping quality: One hundred Tuberosum accessions were evaluated for keeping quality at room temperature (14-38°C, 44-75% RH) in comparison to three control cultivars namely, Kufri Dewa, Kufri Ashoka and Kufri Pukhraj. Periodical observations on weight loss, sprouting and rottage in tubers were recorded at 30 days' interval up to 90 days of storage (DOS). Firmness was recorded on a scale of 1-5 with score 5 assigned to most firm as freshly harvested/cold stored potatoes. Accessions were rated in different categories on the basis of storage performance viz., weight loss, rottage, total loss and physical appearance of tubers after 90 DOS.

Out of the 100 accessions only 8 accessions namely CPNos. 3276, 3508, 3516, 3587, 3591, 3683, 3788 and 3861 were found as good keeper having total storage losses at par with best control Kufri Dewa (9.6%) whereas 15 accessions (CP Nos. 1442, 1476, 1490, 1546, 1555, 2017, 3242, 3448, 4446, 4452, 4455, 4458, 4459, 4469 and 4472) as good keeper with storage losses in the range of 10.52 to 14.97% comparable with control K. Ashoka (9.62%).

Chipping and physico-chemical constituents: At Jalandhar, 100 Tuberosum accessions were evaluated for processing quality parameters viz. chip colour, dry matter and reducing sugar and sucrose contents. Based on chip colour (acceptable score up to 3 on 1-10 scale of increasing dark colour), twelve accessions (CPNos.3503, 3510, 3516, 3534, 3540, 3574, 3588, 3645, 4080, 4256, 4383 and 4313) were found highly suitable for chipping. Seventy-five accessions were also evaluated for vitamin C content which varied widely between 14.89 to 43.21 (mg/100 g fr.wt) with minimum and maximum values registered by CP 2298 and CP2333, respectively. Ten top most accessions for vitamin C content (mg/100g fr.wt.) were: CP2333 (43.21), CP2365 (41.26), CP2394 (39.74), CP2355 (39.52), CP2418 (38.67), CP 2302 (36.18), CP2422 (38.06), CP2379 (35.65), CP2350 (35.63) and CP2399 (35.38).

Micronutrients: Sixty-four accessions were evaluated for iron and zinc content. Iron content varied from 18.11 ppm (Dwarf Culture) to 40.27 ppm (Lal Jyoti) whereas the range for Zn content was from 13.67ppm (VK/JG 9) to 26.71(NJ-130) The topmost five accessions for Zn content (ppm) were: NJ 130(26.71), Desi No.1(25.65), JG-1(25.29), Lal Jyoti (24.92) & Sathoo (24.91) and for Fe content (ppm) were: Lal Jyoti (40.27), JG-22(39.04), Aruconia (36.78), JG-2(36.45) and Lalmutti-1(36.10).

Protein content: The protein contents were found in the range of 0.43 % (CP2082) to 1.61% (CP3470) on fresh weight (FW) basis. Of the 50 accessions, 28 accessions were found to have more than 0.8% soluble protein (FW basis) of which 8 accessions had more than 1.0 % soluble protein. These were: CP1539 (1.19%), CP 2012 (1.01%), CP 3086 (1.11%), CP3156 (1.31%), CP3435 (1.28%), CP 3470 (1.61%), CP 3471 (1.20%) and CP 3622 (1.17%) **(Fig. 2)**.

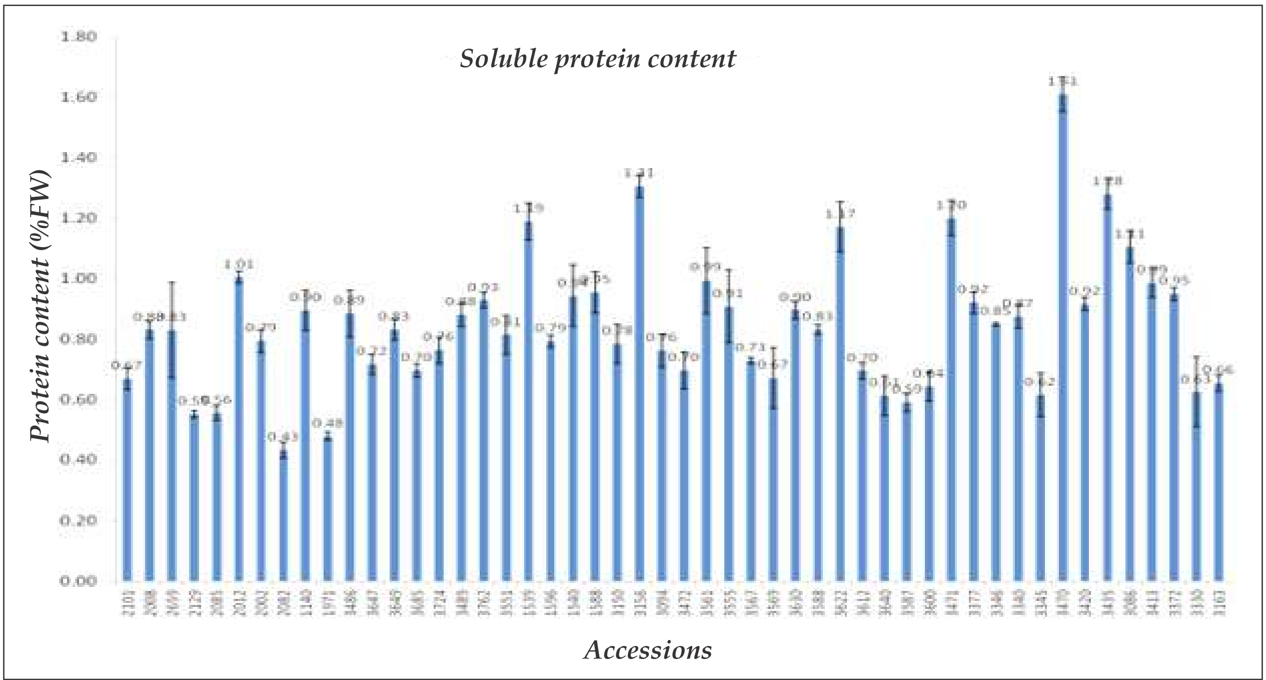


Fig. 2: Total soluble protein content of 50 accessions of potato

Water use efficiency: Twenty-six accessions were evaluated at 3 moisture regimes i.e. 0.20-0.25, 0.40-0.45 and 0.60-0.65 bars/atm soil moisture tension at 15 cm soil depth for higher yield and water use efficiency. Three accessions namely CP3359, CP3464 and CP3599 gave equal yield as produced by control variety Kufri Bahar at all irrigation level. But, tuber yield of these accessions were less than the yield of variety Kufri Pukhraj.

Foliage maturity: Out of 212 Tuberosum accessions screened for foliage maturity at Patna, 18 accessions namely CP Nos.1671, 1746, 2132, 2192, 2370, 3179, 3196, 3265, 3292, 3293, 3336, 3364, 3376, 3420, 3450, 3451, 3774 and 4242 were found early maturing having >80% foliage maturity at 70-75 DAP.

Wild Species: Eleven wild potato species were characterized for late blight resistance and SSR markers (STU6SNRN and STIIKA). STU6SNRN (PIC: 0.92 and alleles: 15) showed higher polymorphism than STIIKA (PIC: 0.89 and alleles: 14) and clearly distinguished the species. STU6SNRN (175, 178, 184, 190 and 202 bp) and STIIKA (188, 192, 195, 203, 209 and 214 bp) were the most predominant SSR alleles. Total alleles count using both markers was 132, of which LES29 and PLD47 (15 each) recorded maximum number of alleles followed by CPH62, MCD24, STO40 and PNT43 (13 each) and minimum in TRF22 (7). All wild species were highly resistant to late blight (BER57, CPH62, IOP59, JAM07, LES29, MCD24, PLD47, PNT43, STO61, TRF22 and VER58) having AUDC value between 0 (LES29) to 12.5 (TFR22) compared to controls 167.5 (Kufri Jyoti: susceptible) and 21.25 (Kufri Girdhari: highly resistant) **(Fig. 3-4)**.

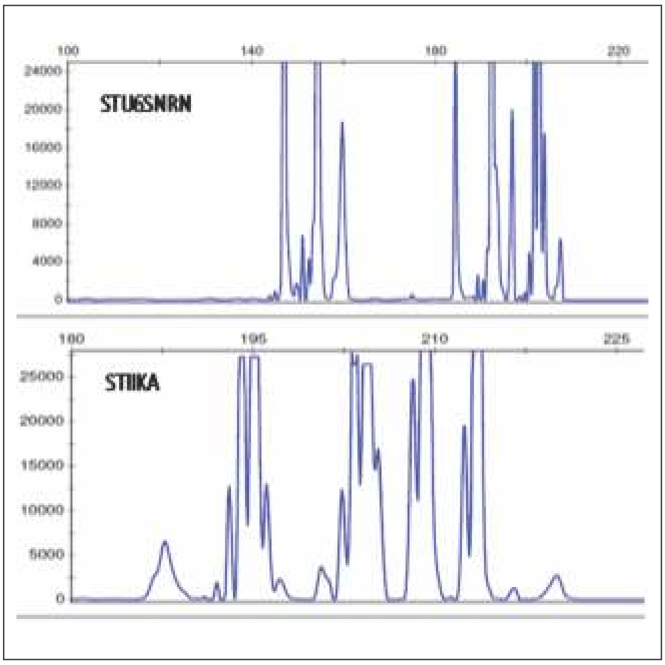


Fig. 3: SSR profile of wild potato species *Solanum polyadenium* (PLD47) using STU6SNRN and STIIKA markers.

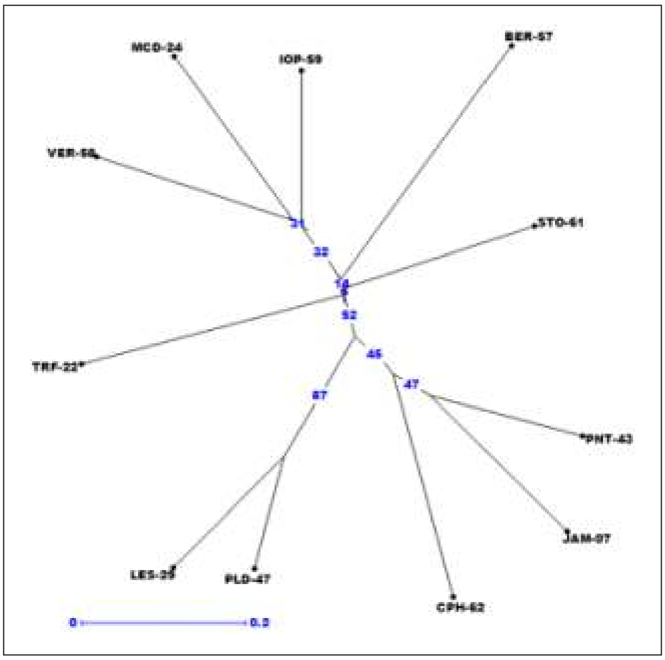


Fig. 4: Diversity analysis in late blight resistant wild potato species using SSR markers.

Fig. 5: MSH/14-113 (INGR19101)

In another study, 52 clones belonging to 22 accessions of 18 wild species were evaluated for late blight resistance under natural disease condition at Kufri. Thirteen clones (2837-11, 2837-09, 2838-05, 2846-05, 2846-06, 2895-01, 2895-03, 2937-02, 3005-02, 3013-02, 3114-02, 3124-02, 3125-0) showed immune reaction (0 AUDPC), five clones showed below 50 AUDPC and 29 clones observed >100 AUDPC. Based on the results of two years, the clones 2895-01 and 3125-0 showed immune reaction to late blight.

Germplasm registration

Two elite germplasm stocks were registered with NBPGR, New Delhi.

I MSH/14-113 (**INGR19101):** An advance hybrid with interspecific background involving somatic hybrid somatic hybrid 'P8' [*Solanum tuberosum* dihaploid 'C-13' (+) *S. pinnatisectum*)] and cv. Kufri Jyoti for high resistance to late resistance and high dry matter **(Fig. 5)**.

ii J.93-58(**INGR19105): ** An advance hybrid developed by crossing Kufri Pukhraj and MS/82-797 for better water use efficiency and high yield.

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.

PROGRAMME: BREEDING TO EVOLVE TRAIT SPECIFIC VARIETIES FOR PRODUCTIVITY, QUALITY AND RESISTANCE TO BIOTIC AND ABIOTIC STRESSES

Research activity 1: Breeding for table potato varieties

Hybridization: In all, 5, 03, 735 true potato seeds were obtained from 182 crosses undertaken at Jalandhar, Modipuram and Patna.

Seedling stage: A total of 65,452 seedlings were raised in the field from sowing of 1, 40, 817 true potato seeds of 127 crosses. At harvest, 4,739 promising clones were selected.

Initial clonal stages: In initial clonal stages (F_1C_1, F_1C_2 and F_1C_3), 9,491 clones were evaluated at 60/75/90 days and at harvest 2,214 promising clones were selected.

Advanced stage trials: In all, 96 advanced stage hybrids were evaluated in 11 yield trials at 60/75/90 days at Jalandhar, Modipuram and Patna, and 48 promising hybrids were selected. In five preliminary yield trials, 25 promising hybrids and in three confirmatory yield trials, 15 promising hybrids were selected. In three final yield trial, 8 advanced hybrids namely J/12-1, J/12-10, J/12-31, J/12-54, J/12-60, J/12-146 (Jalandhar), MS/14-243 and MS/9-2196 (Modipuram) were selected.

Promising advanced stage hybrids identified: Based on consistently good performance over years, six advanced stage hybrids J/12-10, J/12-54, J/12-146, MS/14-243, PS/14-10, PS/14-21 were identified for proposing their inclusion in AICRP Potato **(Table 1, 2, 3)**.

Table 1. Potato germplasm holding at CPRI, Shimla

Genotypes	Total tuber yield (t/ha)							
	2017-18		2018-2019		2019-2020		Average	
	60 days	75 days	60 days	75 days	60 days	75 days	60 days	75 days
J/12-10	16.6	31.4	30.1	43.1	26.1	36.5	24.3	37.0
Kufri Pukhraj	15.4	27.2	25.8	38.9	19.5	30.6	20.2	32.2
Kufri Khyati	15.6	27.7	24.8	38.8	19.7	31.1	20.0	32.5
CD (0.05)	1.3	2.9	2.7	3.2	1.8	2.2		
J/12-54	18.8	30.2	30.2	42.2	25.6	36.5	24.9	36.3
Kufri Pukhraj	14.1	27.7	25.8	38.9	19.5	30.6	19.8	32.4
Kufri Khyati	14.4	29.3	24.8	38.8	19.7	31.1	19.6	33.1
CD (0.05)	1.0	2.1	2.7	3.2	1..7	2.2		
J/12-146***	18.9	30.8	30.6	43.5	24.8	38.6	24.8	37.6
Kufri Pukhraj	15.4	27.2	25.8	38.9	19.5	30.6	20.2	32.2
Kufri Khyati	16.6	28.8	24.8	38.8	19.7	31.1	20.4	32.9
C.D. 5%	1.5	2.3	2.7	3.2	1.7	2.2		

Table 2. Promising advanced stage hybrid identified at Modipuram

Genotypes	Total tuber yield (t/ha)							
	2017-18		2018-2019		2019-2020		Average	
	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days
MS/14-243	38.5	48.9	38.3	47.3	31.9	46.9	36.2	47.7
Kufri Bahar	34.5	40.5	33.8	44.6	32.5	41.9	33.6	42.3
Kufri Pukhraj	43.1	45.1	39.1	46.3	35.0	47.3	39.1	46.2
C.D. 5%	1.9	2.1	2.0	2.0	2.0	1.5		

Table 3: Promising advanced stage hybrid identified at Patna

Genotypes	Yield (t/ha)							
	2017-18		2018-2019		2019-2020		Average	
	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days
PS/14-10	21.8	22.4	16.9	20.5	33.5	38.5	24.1	27.1
PS/14-21	20.7	21.5	16.4	19.1	36.7	40.1	24.6	26.9
Kufri Lalit	15.2	19.0	15.8	19.9	27.5	32.5	19.5	23.8
Kufri Lalima	14.8	15.9	13.8	16.4	24.5	25.9	17.7	19.4
Kufri Manik	19.2	20.3	15.5	18.2	28.4	30.8	21.0	23.1
CD (0.05)	3.2	4.0	5.8	4.9	3.9	4.0	-	-

J/12-10: It gave 20% and 14% higher yield over control Kufri Khyati at 60 and 75 days harvests, respectively. It produces white ovoid tubers with shallow eyes and cream flesh colour.

J/12-54: It produced 26% and 10% higher yield over control Kufri Khyati at 60 and 75 days harvests, respectively. It produces yellow ovoid tubers with shallow eyes and pale yellow flesh colour.

J/12-146: It yielded 22% and 14% higher yield over control Kufri Khyati at 60 and 75 days harvests, respectively. It produces white oblong tubes with shallow eyes and pale yellow flesh colour.

MS/14-243 (CP2160 x K. Garima): The hybrid with total tuber yield of 36 t/ha (75 days) and 48 t/ha (90 days) showed superiority of 8% and 13% over Kufri Bahar (34 and 42 t/ha). The hybrid produces attractive white-cream, ovoid tubers with shallow-medium eyes and white-cream flesh. The hybrid possesses 20% tuber dry matter at 90 days, very good keeping quality and slight resistance (AUDPC:660) to late blight as compared to Kufri Bahar (AUDPC:1060).

PS/14-10 (CP2366 X CP2340): The hybrid with total tuber yield of 24 and 27 t/ha showed advantage of 23 and 14% at 75 and 90 days over Kufri Lalit (19 and 24 t/ha). The hybrid produces red ovoid tubers with shallow medium eyes and yellow flesh having 19% tuber dry matter, good keeping quality and moderate level of resistance to late blight.

PS/14-21 (2005P75 x CP3770): The hybrid with tuber yield of 25 and 27 t/ha showed advantage of 26 and 13% at 75 and 90 days over Kufri Lalit (19 and 24 t/ha). The hybrid produces red round ovoid tubers with medium eyes and yellow flesh with red ring in cortex, 18% tuber dry matter, good keeping quality and moderate level of resistance to late blight.

Advanced hybrids introduced in AICRP: Introduced advanced stage hybrids MS/13-391, MS/14-505, MS14-1381 and CP4406 **(Fig.1)** in AICRP for multi-location testing.

Fig. 1. Tubers of advanced stage hybrids introduced in AICRP for multi-location evaluation

MS/13-391 (K.Gaurav x CP2340): The hybrid with total tuber yield of 38 t/ha (75 days) and 49 t/ha (90 days) showed superiority of 19% and 17% over Kufri Bahar (33 and 47 t/ha). The hybrid produces attractive yellow, ovoid tubers with shallow eyes and yellow flesh. The hybrid possesses 17% tuber dry matter at 90 days, very good keeping quality and slight resistance (AUDPC:660) to late blight as compared to Kufri Bahar (AUDPC:1060).

MS/14-505 (CP4171 x MS/7-1947): The hybrid with total tuber yield of 36 t/ha (75 days) and 46 t/ha (90 days) exhibited superiority of 18 and 26% over Kufri Lalima (31 and 37 t/ha) at 75 days and 90 days, respectively. The hybrid produces attractive dark red ovoid tubers with medium eyes and yellow flesh. The hybrid possesses 15% tuber dry matter at 90 days, very excellent keeping quality and slight resistance (AUDPC: 505) to late blight as compared to Kufri Lalima (AUDPC:712) Kufri Bahar (AUDPC:1003). However, through detached leaf method, hybrid showed moderate resistance to late blight.

MS/14-1381 (CP3391x K Sutlej): The hybrid with total tuber yield of 37 t/ha (75 days) and 46 t/ha (90 days) exhibited superiority of 20 and 25% over Kufri Lalima (31 and 37 t/ha) at 75 days and 90 days, respectively. The hybrid produces attractive red ovoid tubers with shallow-medium, eyes and yellow flesh. The hybrid possesses 16% tuber dry matter at 90 days, excellent keeping quality and slight resistance (AUDPC:499) to late blight as compared to Kufri Lalima (AUDPC:712) Kufri Bahar (AUDPC:1003).

CP4406-397079.6 (Maria Tambena x C93.154): The hybrid with total tuber yield of 37 t/ha (75 days) and 49 t/ha (90 days) showed superiority of 9 and 25% over Kufri Bahar (34 and 39 t/ha). The hybrid produces attractive white-cream ovoid with shallow eyes and cream flesh. The hybrid possesses 18% tuber dry matter at 90 days, very good keeping quality and slight resistance (AUDPC:561) to late blight as compared to Kufri Bahar (AUDPC:1003).

Release of new potato variety: New drought tolerant variety CP4175 was recommended for release by 37th Group Meeting of AICRP (Potato) held during 3-4 September, 2019 at JNKV, Jabalpur, Madhya Pradesh in agro-climate zone viz., Central Gangetic Plains Region (Zone 4, Uttar Pradesh), Upper Gangetic Plains Region (Zone 5, Uttar Pradesh), Trans-Ganga Plains Region (Zone 6, Haryana), Eastern Plateau and Hills (Zone 7, Chhattisgarh) and Western Dry Region (Zone 14, Rajasthan). Its plants are medium and vigorous with resistance to late blight. It is a water use efficient variety with high drought tolerance index and lower water requirement. The variety produces attractive, light yellow, ovoid tubers (7-8) with shallow eyes and light yellow flesh **(Fig. 2)**, possess 20-21% tuber dry matter and very good keeping quality. It has ability to produce up to 30 t/ha under less water (<20%) availability and 35 t/ha under normal irrigation regime.

Optimizing agro-technology of new varieties/ advanced stage hybrids: The optimum requirement of 240, 30 and 120 kg/ha N, P_2O_5 and K_2O respectively was worked out Kufri Neelkanth. The optimum crop geometry for Kufri Neelkanth was 60 X 25 cm, which recorded 37.8 t/ha total tuber yield. The optimum nitrogen requirement of CP4175 (water stress tolerant), CP4393 and MS/11-664 was found to be 240, 160 and 240 kg N/ha, respectively. Advanced stage hybrids MS/9-2196 showed optimum requirement of 240 N, 30 P_2O_5 and 80 K_2O kg/ha.

Fig. 2. Morphological characteristics of CP4175: Leaf, flowers, sprout & tuber

Evaluation for late blight resistance at Modipuram: Among the 71 genotypes evaluated for late blight screening in field most of the hybrids showed less AUDPC than highly susceptible variety Kufri Bahar. Among 57 advanced stage hybrids, minimum AUDPC was recorded in CP4510 (47) and maximum in MSP/16-375 (656) as compared to standard Kufri Bahar (872).

Research activity 2: Breeding for processing varieties

Hybridization: In total, 1,37,417 TPS of 48 crosses were produced at Kufri/Modipuram.

Seedlings stage: A total of 1,37,417 TPS of 48 crosses were sown in nursery bed and 1,140 clones were selected from 25,399 seedlings transplanted.

Initial clonal stages: A total of 1,356 clones of F_1C_1, F_1C_2 and F_1C_3 stage were evaluated and 339 clones respectively were retained based on tuber characters and chip colour.

Preliminary yield trails at Modipuram: In F_1C_4 stage, 6 genotypes namely MP/15-207, MP/15-651, MP/15-750, MP/15-667, MP/15-698 and MP/15-699 were selected out of 9 hybrids evaluated.

Confirmatory yield trials at Modipuram: Our of 14 hybrids evaluated, on the basis of total tuber yield, processing grade yield, chip colour and tuber dry matter, 11 hybrids namely MP/14-169, MP/14-171, MP/14-635, MP/14-1003, MP/14-1029, MP/12-105, MP/12-223, MP/13-602, MP/13-662, MP/13-1045 (for chips/French fries) and MP/13-1040 (for table) were selected.

Evaluation at Burdwan (West Bengal): Among the 8 hybrids and 7 control varieties evaluated at 95 days MP/13-1040 (52 t/ha) and MP/13-1045 (44 t/ha) were found to be superior as compared to controls K Chip-3 (41 t/ha) and Kufri Frysona (38 t/ha).

CPRI-ITC collaborative trials in Southern & Eastern India: In Karnataka, among the 9 genotypes evaluated, MP/13-1045 produced higher total tuber yield (31 t/ha) and recorded acceptable quality traits than Kufri Jyoti (28 t/ha). In Telangana, MP/11-142 with total tuber yield (15 t/ha) exhbibited acceptable quality traits. In Bankura (West Bengal), MP/9-45 (39 t/ha), MP/13-662 (37 t/ha) produced higher total tuber yield and recorded acceptable quality traits than the Kufri Pukhraj (27 t/ha). However, Kufri Sangam recorded maximum tuber yield (43 t/ha).

Identification of advanced hybrid for AICRP: MP/12-223 (CP 4051 x MP/99-322): Based on last three year performance at Modipuram, MP/12-223 has been identified for introduction into AICRP. It produced 16 % higher mean processing (38 t/ha) and 10% higher total (43 t/ha) tuber yields than Kufri Chipsona-1 however; it remained at par with Kufri Chipsona-3. It produces attractive white cream, ovoid-tubers with shallow eyes and cream flesh. The hybrids possess 22% dry matter and acceptable fry (3.3) colour score **(Table 4 and 5)**.

Advanced stage hybrid introduced into AICRP

MP/11-30 (K. Chipsona-3 x HT/97-727): Based on

Table 4: Performance of advanced stage hybrid MP/12-223 at 90 days during 2017-2020.

Genotypes	Processing grade yield (t/ha)				Total tuber yield (t/ha)			
	2019-20	2018-19	2017-18	Mean	2019-20	2018-19	2017-18	Mean
MP/12-223	34.1	43.3	36.8	38.1	40.4	47.1	41.9	43.1
Kufri Chipsona-1	34.9	30.6	32.8	32.8	39.5	39.1	39.6	39.4
Kufri Chipsona-3	37.7	37.5	38.0	37.7	42.1	42.7	43.5	42.8
Atlantic	33.8	29.9	37.8	33.8	36.5	32.3	40.1	37.1
C.D. 5%	4.1	2.57	2.5		3.3	2.59	1.9	

Table 5: Quality attributes of advanced stage hybrid MP/12-223 90 days during 2017-2020.

Genotypes	Tuber dry matter (%)				Chip Colour			
	2019-20	2018-19	2017-18	Mean	2019-20	2018-19	2017-18	Mean
MP/12-223	20.2	22.0	22.9	21.7	2.5	3.0	4.3	3.3
Kufri Chipsona-1	18.2	20.9	19.7	19.6	3.5	3.5	2.4	3.1
Kufri Chipsona-3	19.5	21.0	20.6	20.4	3.0	2.3	5.0	3.4
A Atlantic	18.2	21.7	20.3	20.1	2.5	2.7	2.3	2.5

superior performance during last three years, MP/11-30 suitable for French fries has been introduced in AICRP. It produced 40 % higher processing (37 t/ha) and 19% total (42 t/ha) tuber yield than controls. It produces attractive white cream, ovoid-oblong tubers with shallow medium eyes and white cream flesh **(Fig.3)**. The hybrids possess 20% dry matter and very close to acceptable fry colour score (4.0).

MP/12-126 (CP4047 x MP/99-322): MP/12-126 suitable for French fries has been introduced in AICRP. It produced 10% higher processing (37 t/ha) and 5% total (41 t/ha) tuber yields than controls. It produces attractive white cream, ovoid-oblong tubers with shallow medium eyes and white cream flesh **(Fig.3)**. The hybrids possess 20% dry matter and very close to acceptable chip colour score (3.6).

New dual purpose variety recommended: Advanced stage hybrid MP/6-39 (Kufri Sangam) has been recommended for release in 37^{th} group meeting of AICRP (Potato) held during 03-4 Sep., 2019 at JNKVV, Jabalpur, Madhya Pradesh.

Fig. 3. Tubers of MP/11-30 & MP/12-126

It produces white-cream ovoid tubers with shallow eyes and white flesh **(Fig.4)**. It is medium maturing (90-100 days) with yield potential of 35-40 t/ha, moderate level of late blight resistance and excellent storability (11% weight losses) than Kufri Chipsona-3 (14%) and Kufri Bahar (13%). It possesses very good taste and aroma, mealy texture, excellent tuber appearance and no tuber cracking, tuber dry matter (20%), reducing sugars are <150mg/100 g of fresh weight. Kufri Sangam has been recommended for release in Gujarat plains and Hills region (Zone 13), Central Plateau and Hills region (Zone 08) and Eastern plateau and Hills region (Zone 07) for processing and in Trans-Gangetic plains region (Zone 06) and Upper Gangetic plains region (Zone 05) for table purpose.

Processing quality of varieties/advanced hybrids at Jalandhar: Among the 15 genotypes evaluated for processing quality at 90 DAP, highest tuber dry matter was recorded in MP/13-662 (24%) followed by MP/13-602 (23%). Chip colour score of three hybrids, MP/11-30; MP/12-1045; MP/13-662 was within acceptable range. Whereas, French fries colour of all hybrids was within acceptable range.

Fig. 4. fries of dual purpose variety Kufri Sangam
Crop, Flower, sprouts, tubers and French

Processing quality of genotypes at 10-12°C storage with CIPC: Among the 12 genotypes evaluated during 80 days of storage, all hybrids recorded more than 21% dry matter. Initial (0 day) reducing sugar (RS) contents were acceptable (<150 mg/100 g frwt) for chips in Atlantic, Lady Rosetta, MP/11-34 and MP/12-223, which were also acceptable for making French fries. Reducing sugar contents (mg/100 g frwt) increased during storage with mean minimum contents recorded in these two hybrids, MP/12-223 (123) followed by MP/11-34 (130), which were less or at par with control cultivars (105-203 mg/100g fr. wt.).

Optimizing agro-technology of advanced stage hybrid MP/06-39 (Kufri Sangam): The NPK optimum doses as 240 kg N/ha, 40 kg P_2O_5 and 100 kg K_2O/ha were worked out.

Research activity 3: Breeding for biotic stresses (late blight, viruses & cyst nema-todes)

Hybridization: In all, 1,61,315 true potato seeds were obtained from the 134 crosses attempted at Shimla, Ooty and Shillong involving late blight and potato cyst nematode resistant parents.

Seedling stage: A total of 17,005 seedlings derived from 60,059 TPS of 20 crosses were screened and at harvest, 2,275 clones were selected at Kufri and Ooty.

Initial clonal stage: In initial clonal stages (F_1C_1 to F_1C_4), 3,995 clones were evaluated and 2,636 clones were selected at Kufri, Ooty and Shillong.

Advanced stage trials at Shimla, Ooty and Shillong: At Kufri, among the five F_1C_5 hybrids evaluated, three hybrids namely SM/08-04, SM/10-12 and SM/10-121 were selected. In F_1C_6 stage five hybrids were evaluated and hybrid SM/10-246 showed 19% yield gain over the best control Kufri Jyoti and also found resistant to late blight. In F_1C_7 stage, five hybrids namely SM/09-163, SM/10-139, SM/11-120, SM/10-103 and SM/10-255 were selected. All the selected hybrids were resistant to late blight disease. SM/09-163 and SM/10-103 were significantly superior to control Kufri Himalini.

At Ooty, 27 advanced stage hybrids were evaluated and four hybrids were selected, whereas in another trial two hybrids OS/08-44 and OS/08-63 were selected.

Fig. 5: Tubers of SM/13-163

At Shillong, 23 advanced stage hybrids in F_1C_6 stage were evaluated and 10 promising hybrids were selected. Besides hybrid, SS/11-295 yielded significantly higher than controls with medium resistant to late blight disease and dry matter (20%).

Evaluation at Modipuram: Among the 48 late blight resistant hybrids (4 trials) evaluated, eight hybrids SM/10-05B, SM/13-150, SM/15-574, SM/14-342, SM/14-19 and SM/13-152 SM/14-347 and SM/10-174 yielded significantly higher than Kufri Bahar. The yield performance of the four hybrids viz., SM/13-150, SM/10-05B, SM/13-163 and SM/10-253 was consistent during last two years. The late blight resistant hybrids, SM/13-150 and SM/13-163 was identified for proposing in AICRP (P) **(Fig. 5)**.

Screening of advanced stage hybrids at Modi-puram: Among the 33 advanced stage hybrids/control varieties evaluated for late blight, all hybrids showed less AUDPC than Kufri Bahar. Minimum AUDPC was recorded in SM/14-182 (5), SM/10-174 (7), SM/14-111 (15), SM/09-161 (18), SM/14-213 (103) and SM/10-220 (276) as compared to Kufri Bahar (872). Under laboratory condition, by detach leaf method two hybrids viz, SM/10-174, SM/14-213 were found highly resistant (HR) and two (SM/09-161 & SM/14-111) were found resistant (R) while, seven (SM/09-13, SM/13-172, SM/14-182, SM/14-225, SM/14-347, SM/15-165 and SM/15-739) were moderately resistant.

PCN screening at Kufri: A total of 17 hybrids with standard checks Kufri Jyoti, Kufri Girdhari and Kufri Himalini were screened against both the species of potato cyst nematodes at Kufri and one hybrid (SM/11-120) was found immune and another, SM/00-42 was found moderately resistant (MR) to both the species of *Globodera.*

Evaluation of potato hybrids against whitefly (*Bemisia tabaci*): Three hybrids viz., SM/13-122, SM/11-120 SM/13-172 along with Kufri Girdhari and Kufri Himalini were screened against whitefly under choice assay. The hybrids, SM/11-120 and SM/13-172 recorded the lowest and highest number of immature stages, respectively. SM/11-120 has shown significant low level of non-preference to whitefly and can be used as resistance source for the management of whitefly **(Fig. 6)**.

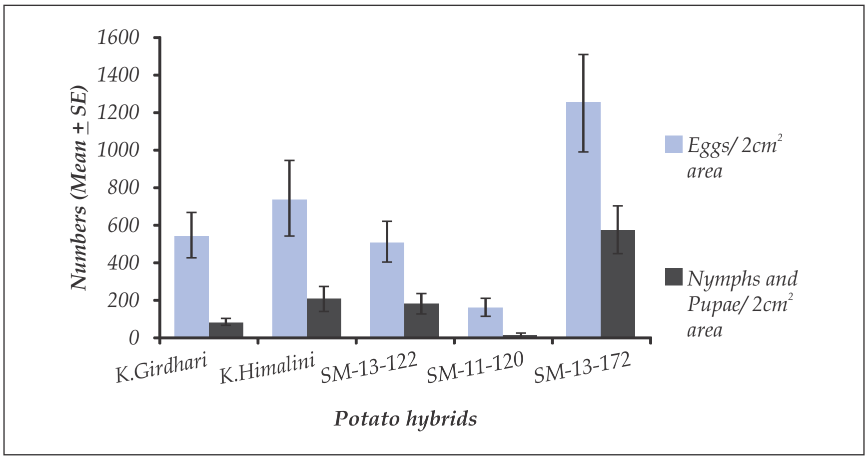


Fig. 6: Performance of potato genotypes against whitefly in choice assay for relative egg laying preference and number of nymphal instars.

Molecular Breeding

Hybridization: A total of 6,105 TPS were obtained from 4 crosses to combine multiple resistance genes in a common genotypic background mainly for late blight (*R1, R2* and *R3*), PVY (Ry_{adg}, Ry_{sto}) and potato cyst nematodes (*H1, HC_QRL* and *Gro1-4*) using molecular assisted selection.

Characterization of parental lines for late blight, viruses and PCN resistance genes: A set of 217 *tuberosum* and 72 *andigena* accessions were screened for late blight, viruses (PVY & PVX) and potato cyst nematode (PCN) resistance through marker assisted selection (MAS) using robust markers for extreme resistance **(Fig 7a-d)**. Solitary or combined late blight resistant genes (R1, R2, R3a and R3b) presence was observed in 52 and 5 *tuberosum* and *andigena* accessions, respectively. For virus resistance, PVY genes Ry_{adg} and Ry_{sto} were found in 42 and 51, and PVX resistance genes *Rx1* and *Rx2* were found in 25 and 23 *tuberosum* and *andigena* accessions, respectively. For PCN resistance, six markers showed 45 and 36 resistant *tuberosum* and *andigena* accessions, respectively. For late blight, the tuberosum accessions viz., CP2399, CP3917, CP3636, CP2314, CP3625, CP3639 were carrying three resistance genes, while 12 andigena accessions (JEX/A-202, JEX/A-390, JEX/A-459, JEX/A-506, JEX/A-616, JEX/A-912, JEX/A-920, JEX/A-1046, JEX/A-1061, JEX/A-1081, JEX/A-1092, JEX/A-1152) showed the presence of both Ry_{adg} and Ry_{sto} genes for PVY resistance. Four tuberosum (CP4226, CP2049, CP3696 and CP3651) and six andigena (JEX/A-232, JEX/A-267, JEX/A-638, JEX/A-683, JEX/A-1061, JEX/A-1092) accessions had both *Rx1* and *Rx2* genes for PVX resistance. For PCN resistance, only one tuberosum accession (CP2049) while six andigena accessions (JEX/A-202, JEX/A-298, JEX/A-457, JEX/A-506, JEX/A-638, JEX/A-683) showed the presence of both *H1* and *HC* genes along with GPa_2. Four andigena accessions viz., JEX/A-202, JEX/A-506, JEX/A-638 and JEX/A-683 had combined resistance for PVY, PVX and PCN.

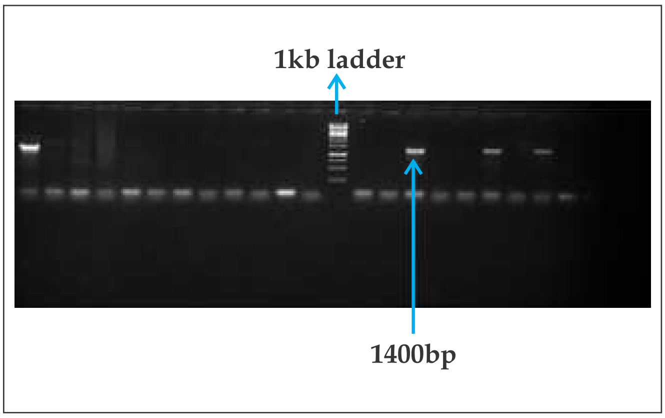


Fig 7a: Parental lines possessing *R1* (AS) (1400bp) marker

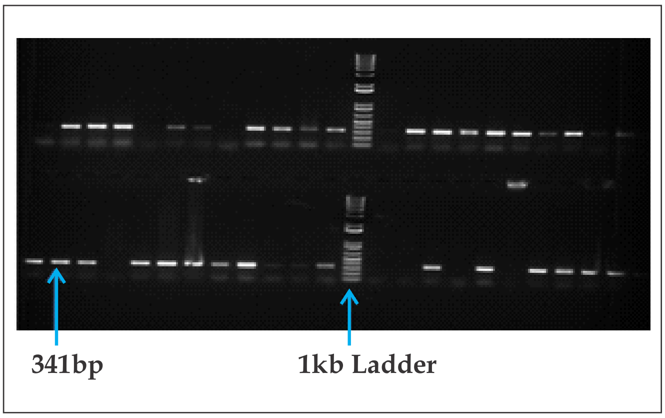


Fig 7b: Parental lines possessing Ry_{sto} *PVY_STM_YES3A* (341 bp) marker/gene

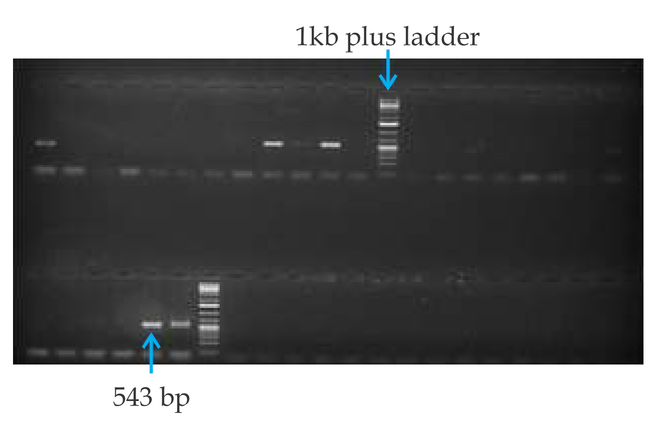


Fig 7c: Parental lines possessing *Rx1* (*Rx adg*)_PVX gene/marker

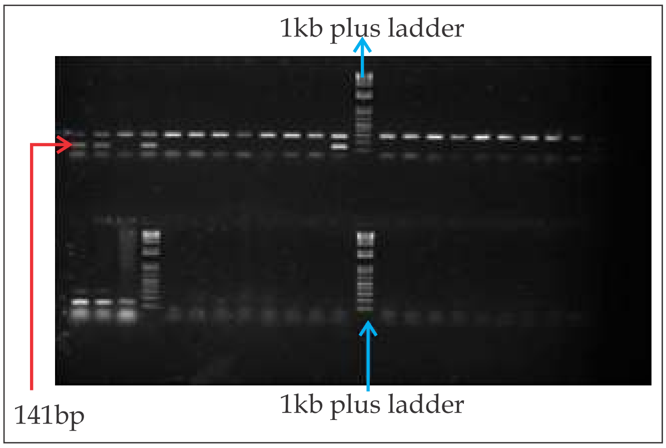


Fig 7d: Parental lines possessing TG 689 *H1*-PCN gene/marker

Research activity 4: Breeding for abiotic stresses (Heat and water)

Breeding for heat tolerance

Hybridization: A total of 1,54,162 TPS were obtained from 54 successful crosses involving parents having earliness and heat tolerance.

Seedling stage: In all 4,248 seedlings were recovered from 42,830 TPS of 32 crosses and at harvest 458 selections were made.

Screening of single tuber clones: A total of 68 selections of 7 crosses were made from evaluation of 168 clones derived from single tubers

Screening of TPS in the heated glasshouse: Based on screening of 471 seedlings of 11 crosses in glass house maintained with 35-38^{0}C day and 22-24^{0}C night temperature, 118 clones were retained based on tuberization.

Initial clonal stages: In all 609 clones of F_1C_1, F_1C_2& F_1C_3 were multiplied and evaluated at Modipuram and 172 clones were retained at harvest.

Advanced stage: Seventeen (17) advanced hybrids were evaluated in early season planted crop and at harvest 10 hybrids were selected and among selection, HT/12-834, (15 t/ha), HT/12-116 (14 t/ha), HT/12-43 (13 t/ha) were found to be promising as compared to Kufri Surya (14 t/ha).

Advance stage trial at Pune and Bhubaneswar: At Pune (Maharashtra), among 8 advanced hybrids evaluated under Kharif planting at 90 days, significantly higher total tuber yield was obtained in HT/12-834 and HT/12-43 (17 t/ha) as compared to best control Kufri Surya (12 t/ha).

Identification of promising hybrid for entry into AICRP: Based on four year trials during early planting season at Modipuram, and two year trials at Pune, advanced stage hybrid HT/12-834 (Kufri Chipsona-1 x Kufri Khyati) has been identified for entry into AICRP. HT/12-834 produced higher total tuber yields at Modipuram (8%) and Pune (19%) over the best control Kufri Surya **(Fig. 8)**. It produced white cream, round ovoid tubers with shallow eyes and cream flesh **(Table 6)**. It has 17% dry matter, long dormancy period and very good keeping quality under country store conditions.

Optimizing agro-technology HT/04-1329 in early planting: The HT/04-1329 responded significantly up to 180 kg N/ha, 40 kg P_2O_5/ha and 100 kg K_2O/ha.

Fig. 8: Tubers of HT/12-834

Breeding for drought tolerance

Seedling stage: In all 2500 seedlings were recovered from 48,200 TPS of 9 crosses and at harvest 247 selections were made under optimum growing conditions.

Table 6. Total tuber yield (t/ha) of HT/12-834 (2016 to 2019) at Modipuram and Pune

Genotypes	Modipuram					Pune		
	2016	2017	2018	2019	Mean	2018	2019	Mean
HT/12-834	16.3	16.0	12.7	15.3	15.1	17.1	16.8	16.9
Kufri .Lauvkar	9.2	13.3	9.2	10.3	10.5	11.2	14.8	13.0
Kufri .Surya	14.4	15.9	11.5	14.0	13.9	16.6	11.9	14.2
C.D. 5%	2.3	2.5	1.2			0.4	2.8	1.6
% Advantage Over K Surya					8.1			19.0

Evaluation in Initial clonal stages: In all 365 clones of F_1C_1, F_1C_2 & F_1C_3 were multiplied and evaluated and 94 clones were retained at harvest. The evaluation was under deficit water stress in F_1C_3 stage.

Initial evaluation under water stress: A total of 24 hybrids were exposed to water stress executed through delayed irrigation. Considering the uniformity in tuber shape, particularly deformity as a response to stress, yield performance, 11 hybrids were selected.

Final Yield Trial: Five hybrids were evaluated under water stress (two irrigations) and well-watered control (four irrigations). Considering the various parameters three hybrids WS/13-135, WS/13-192 and WS/09-609 were selected.

Identification of promising hybrid for entry into AICRP: Based on superiority in traits associated with drought tolerance hybrid WS/09-609 has been identified for entry into AICRP. It produced 6% high total tuber yield (37 t/ha) under semi dry

Fig. 9: Tubers of WS/9-609

(0.60-0.65 bars) as compared to Kufri Bahar (34 t/ha). It produces white-cream round tubers with shallow eyes and white-cream flesh **(Fig. 9)** with >19% dry matter, medium dormancy, very good keeping quality and very good organoleptique taste.

Release of new variety: WS/05-146 was recommended for release as new water use efficient variety for growing in East coast plains and Hills region (Zone 11) and Middle Gangetic plains region (Zone 04) during 37th group Meeting AICRP 3-4, September, 2019 at Jabalpur MP. It produces white-cream round-oval tubers with shallow-medium eyes and cream flesh. It has medium maturity (90-100 days) with 30-35 t/ha yield under less water (≤ 20%) availability. It has good taste with typical potato flavor, acceptable texture, dry matter (19%) and devoid of tuber cracking. It is a water use efficient hybrid as it recorded very low drought susceptibility index (DSI) and yield reduction (YR) under deficit irrigation regime bestowed with very good storability at par with popular variety Kufri Bahar.

Effect of deficit water on root parameters: Washed root samples of nine genotypes stored in 20% ethanol under refrigerated conditions are under investigation for scanning on a flatbed scanner (Epson Perfection V700 Photo) using 450 dpi resolution. Root length, root surface area (RSA; cm^2), and average diameter (AVD; mm) will be determined using WinRhizo software.

Optimizing agro-technology of water stress tolerant hybrids: The optimum NPK requirement for WS/7-113 were 180 kg N/ha, 30 kg P_2O_5/ha and 80 kg K_2O/ha and WS/9-609 were 180 kg N/ha.

Research activity 5 & 6: Development of nutritionally superior varieties & Breeding for enhanced micronutrient content in potato

Hybridization: A total of 60, 000 TPS were produced from 22 crosses involving 12 diverse parental lines with desirable nutritional values.

Seedling stage: In all, 40, 946 true potato seeds of 16 crosses having nutritionally superior parents in their background were used for seedling raising and 1,2042 seedlings were recovered and transplanted in the field. At harvest, 318 promising clones of 14 families were retained.

F_1C_1 stage: One hundred ninety-three (193) clones of 14 families were evaluated at 90 days in short row trial and 36 promising clones were selected from 12 families.

F_1C_2 stage: Among the selections, MSH/18-06, MSP/18-16 and MSP/18-68 produced high total tuber yield and MSH/18-1 and MSP/18-19 produced at par total tuber yield with control varieties Kufri Bahar, Kufri Lalima and Kufri Lalit.

F_1C_3 stage: Among the selections, MSP/17-147 produced significantly high total tuber yield than Kufri Bahar. Nutritional profile is shown in **(Fig. 10 and 11)**.

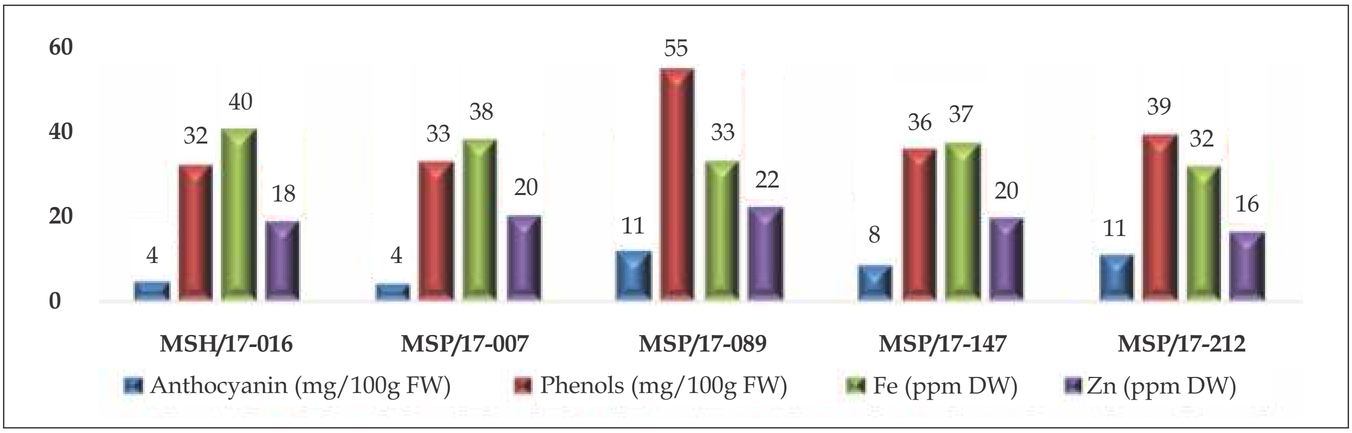


Fig. 10: Phytonutrients in potato clones

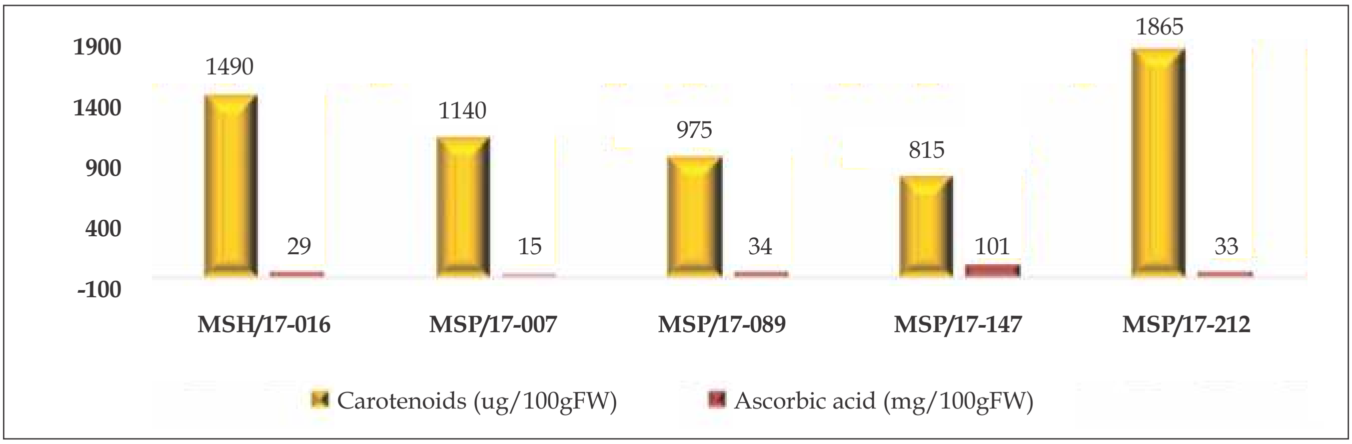


Fig. 11: Carotenoids and ascorbic acid content in potato clones

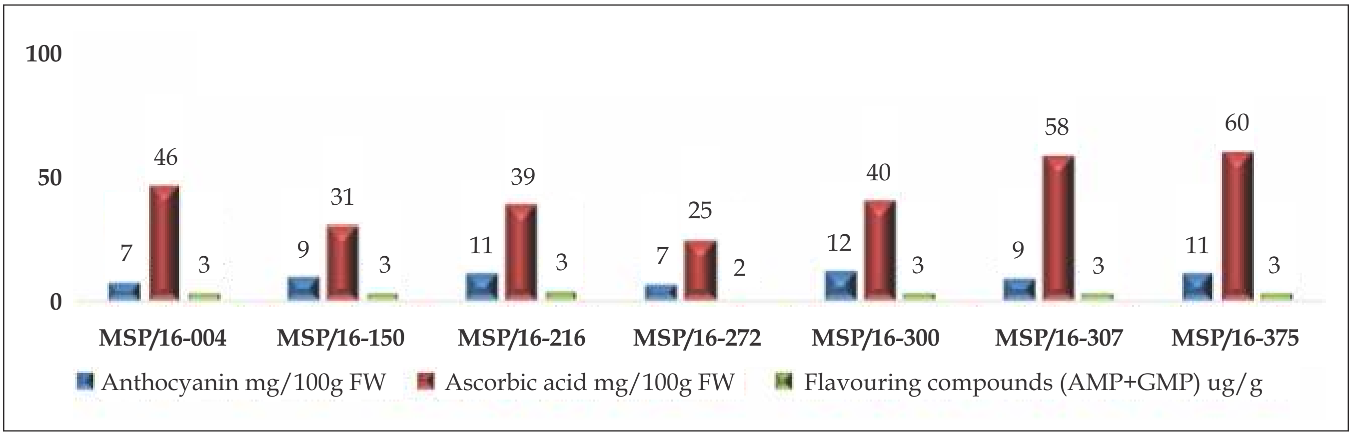


Fig. 12: Phyto-nutrients in potato clones

Advanced stage trial: Six advanced stage hybrids namely MS/15-60, MSP/16-216, MSP/16-272, MSP/16-300, MSP/16-307 and MSP/16-375 were retained for further evaluation. MSP/15-60 have attributes of producing large number of smaller tubers (19). MSP/16-300 (50 t/ha) and MSP/16-307 (54 t/ha) and MSP/16-375 (48 t/ha) produced significantly high total tuber yield at 90 days as compared to controls Kufri Bahar (40 t/ha), Kufri Lalima (42 t/ha), Kufri Lalit (44 t/ha) and Kufri Neelkanth (45 t/ha). The nutritional analysis of six clones pertaining to cross Bareilly Red x CP3770 over four years along with parents indicated that anthocyanin content (mg/100g FW) in flesh ranged between 3 (MSP/15-60) to 17 (MSP/15-51). Nutritional profiles of selected genotypes are shown in **(Fig. 12-16)**.

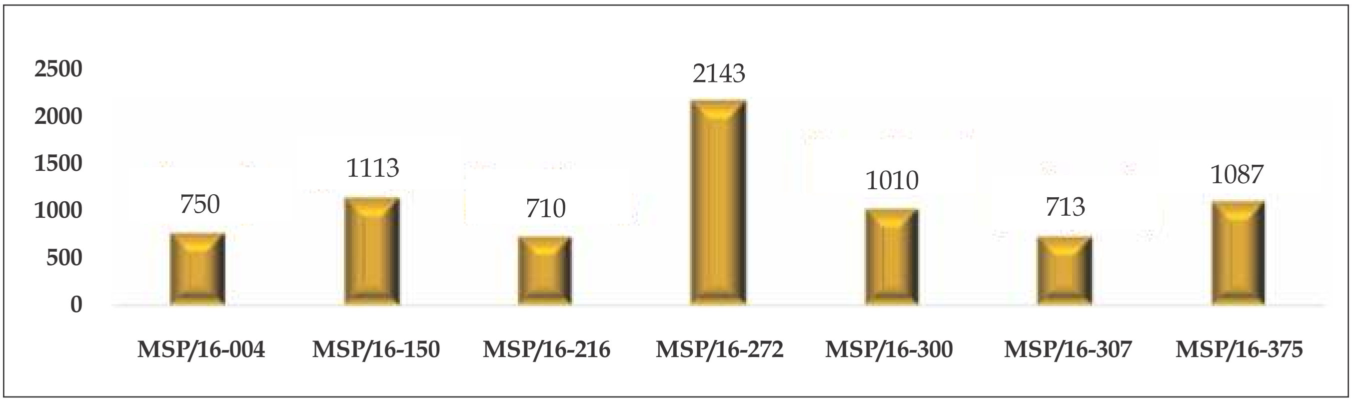


Fig. 13: Carotenoids (ug/100g) in potato clones

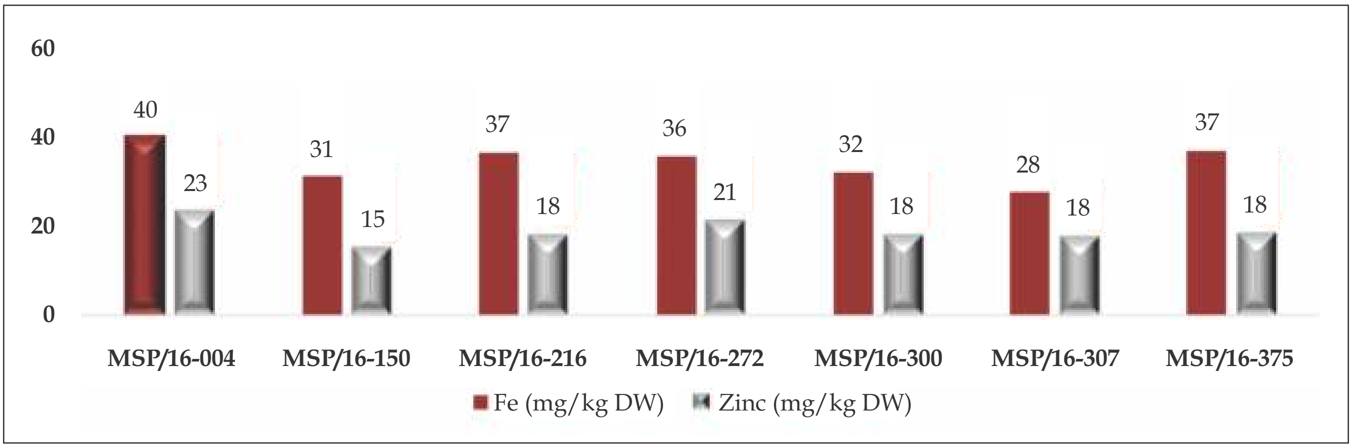


Fig. 14: Micro-nutrients content in potato clones

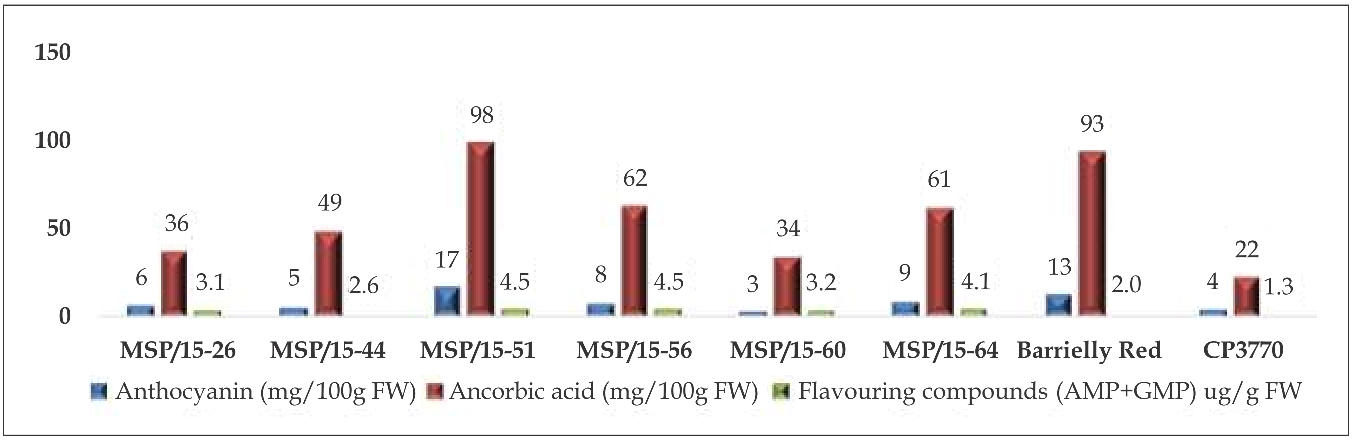


Fig. 15: Nutritional components in potato clones

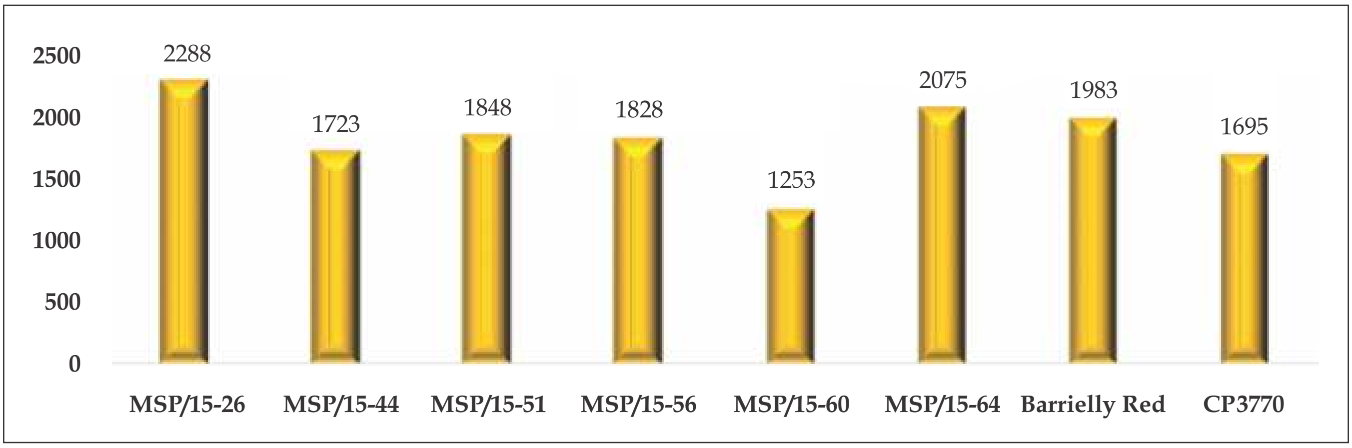


Fig. 16: Carotenoids (ug/100g FW) in potato clones

Late blight reaction at Kufri: Based on late blight screening at Kufri indicated that moderately resistant (AUDPC 351-650) clones/varieties were MSP/15-26, MSP/15-44, MSP/15-51, MSP/15-64, MSP/16-272, MSP/17-7, MSP/17-89, MSP/17-147, MSP/17-212, MSP/17-532, MSP/17-537, MSH/17-16, MSH/17-25, Kufri Jyoti, Kufri Himalini, Kufri Lalit, Kufri Neelkanth, Kufri Garima, Kufri Lalima, Kufri Mohan, Kufri Ganga, Kufri Pukhraj, Kufri Sindhuri, VDS-5, CP4406 and JEX/A-122. The susceptible (AUDPC>650) clones/varieties were MSP/15-56, MSP/15-60, MSP/16-04, MSP/16-150, MSP/16-216, MSP/16-300, MSP/16-307, MSP/16-375, MSP/17-241, MSP/17-345, Lady Rosetta, Kufri Lima, Kufri Arun, Atlantic, Kala Aaloo, Barrielly Red and Kufri Surya. However, K Girdhari was found highly resistant and Kufri Chipsona-3 was found resistant (AUDPC 251-350).

Research activity 7: Development of nutrient and water use efficient cultivars

Hybridization: A total of 3, 34, 175 true potato seeds of 87 crosses were obtained.

Raising of seedlings: A total of 50,142 seedlings obtained from 1,00,784 seeds of 23 crosses were transplanted in field and 12,360 selections were made.

Evaluation in initial clonal stages: In all 9,215 clones were evaluated in F_1C_1, F_1C_2 and F_1C_3 stage and 1,145 clones were retained at harvest.

Evaluation in replicated yield trial: In three preliminary yield trials, 49 advanced stage hybrids were evaluated at 90 days and 22 hybrids namely N/15-4, N/15-96, N/15-101, N/15-104, N/15-178, N/15-183, N/15-17, N/15-48, N/15-53, N/15-81, N/15-82, N/15-128, N/15-136, N/15-169, N/15-54, N/15-83, N/15-109, N/15-114, N/15-159, N/15-177, N/15-179 and N/15-180 were retained. In two confirmatory trials, 11 advanced stage hybrids were evaluated and nine hybrids namely N/14-133, N/14-150, N/14-151, N/14-256, N/14-59, N/14-75, N/14-79, N/14-85 and N/14-230 were selected.

Release of water use efficient hybrid: The advanced stage hybrid J/92-167 (JN 2207 x Kufri Jyoti) has been recommended for release as water use efficient variety for Transgangetic plains, Upper gangetic plains and Eastern plateau and hills region by 37th AICRP Potato Group Meeting held at JNKVV Jabalpur from to 3-4 September 2019. It produces white round-ovoid tubers with shallow eyes and creamy flesh colour **(Fig. 17)**.

Fig. 17: Tubers of J/92-167

Research activity 8: Diploid potato breeding

Screening new germplasm: A set of 35 in-vitro multiplied accessions were raised and evaluated for ploidy analysis using flow cytometry and 19 were confirmed as diploids. Besides, randomly selected 50 plants raised from three diploid populations (DMxM18, DMxM6 and USW4xM6) were confirmed as diploids.

Sli gene transfer: TPS of six crosses were raised to undertake the selfing and berries were formed in 10 plants of four crosses CP4020 x 4539 (115 TPS), CP3927 x 4539 (200 TPS), CP3736 x 4539 (250 TPS) and CP3936 x 4539 (100 TPS).

Maintenance and inbreeding in diploid populations: The three diploid populations (DM x M18, DM x M6 and USW4 x M6) were maintained in the form of tubers and selfing was done for inbreeding **(Fig. 18)**. Four clones each of DM x M18, USW4 x M6, and three clones of DM x M6 were maintained in the form of tubers **(Fig. 19 & 20)**. In the S_1 generation, 1335, 1331 and 10 TPS of DM x M18, DM x M6 and USW4 x M6 were planted and observed for flowering. Selfing was attempted in S_1 plants for homozygosity at Shimla, which resulted in 100 and 640 S_2 TPS in DM x M18 and DM x M6 populations, respectively. The flowering was scarce in S_1 generation plants, resulting in limited selfing.

Fig. 18: Diploid populations multiplication and evaluation a) F1 diploid plants c) S2 generation selfed berries in diploid population plants

Fig. 19: Tubers of F_1 generation progenies in the diploid population USW4 x M6

Fig. 20: Tubers of F_1 generation progenies in the diploid population DM x M18

PROGRAMME: GENETIC ENHANCEMENT OF POTATO THROUGH MOLECULAR AND GENOMIC TOOLS

Transcriptome analysis under N stress in potato: Potato crop requires high dose of nitrogen (N) to produce high tuber yield. Excessive application of N causes environmental pollution and increases cost of production. Hence, knowledge about genes is essential to strengthen research on N metabolism in this crop. We analysed transcriptomes (RNA-seq) in potato tissues (shoot, root and stolon) collected from plants grown in aeroponic culture under controlled conditions with varied N supplies i.e. low N (0.2 milli molar N) and high N (4 milli molar N). High quality data ranging between 3.25 to 4.93 Gb per sample were generated using Illumina NextSeq500 that resulted in 83.60-86.50 % mapping of the reads to the reference potato genome. Differentially expressed genes (DEGs) were observed in the tissues based on statistically significance ($p \leq 0.05$) and up-regulation with ≥ 2 $\log_2$ fold change (FC) and down-regulation with ≤ -2 $\log_2$ FC values. In shoots, of total 19730 DEGs, 761 up-regulated and 280 down-regulated significant DEGs were identified. Of total 20736 DEGs in roots, 572 (up-regulated) and 292 (down-regulated) were significant DEGs. In stolons, of total 21494 DEG, 688 and 230 DEGs were significantly up-regulated and down-regulated, respectively. Venn diagram analysis showed tissue specific and common genes. The DEGs were functionally assigned with the GO terms, in which molecular function domain was predominant in all the tissues. Further, DEGs were classified into 24 KEGG pathways, in which 5385, 5572 and 5594 DEGs were annotated in shoots, roots and stolons, respectively. We identified a few potential DEGs responsive to N deficiency in potato such as glutaredoxin, Myb-like DNA-binding protein, WRKY transcription factor 16 and FLOWERING LOCUS T in shoots; high-affinity nitrate transporter, protein phosphatase-2c, glutaredoxin family protein, malate synthase, CLE7, 2-oxoglutarate-dependent dioxygenase and transcription factor in roots; and glucose-6-phosphate/phosphate translocator 2, BTB/POZ domain-containing protein, F-box family protein and aquaporin TIP1;3 in stolons, and many genes of unknown function. Our study highlights that these potential genes play very crucial roles in N stress tolerance in potato **(Fig. 1, 2 & 3)**.

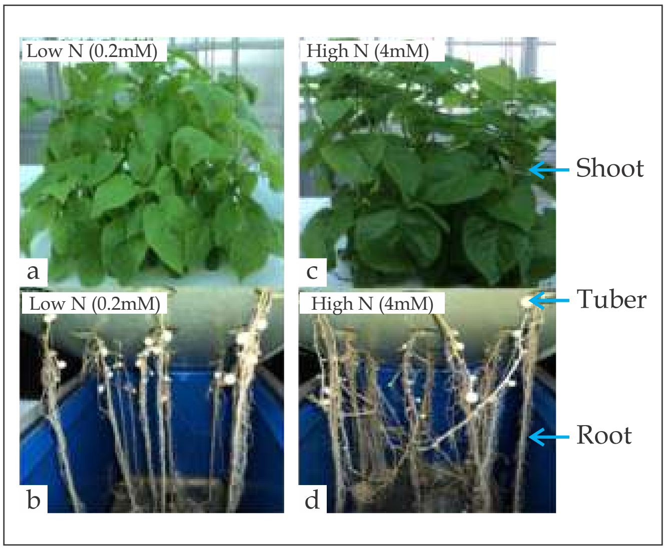


Fig. 1: Phenotypes of potato plants grown in aeroponic with low N (0.2 mM) and high N (4 mM).

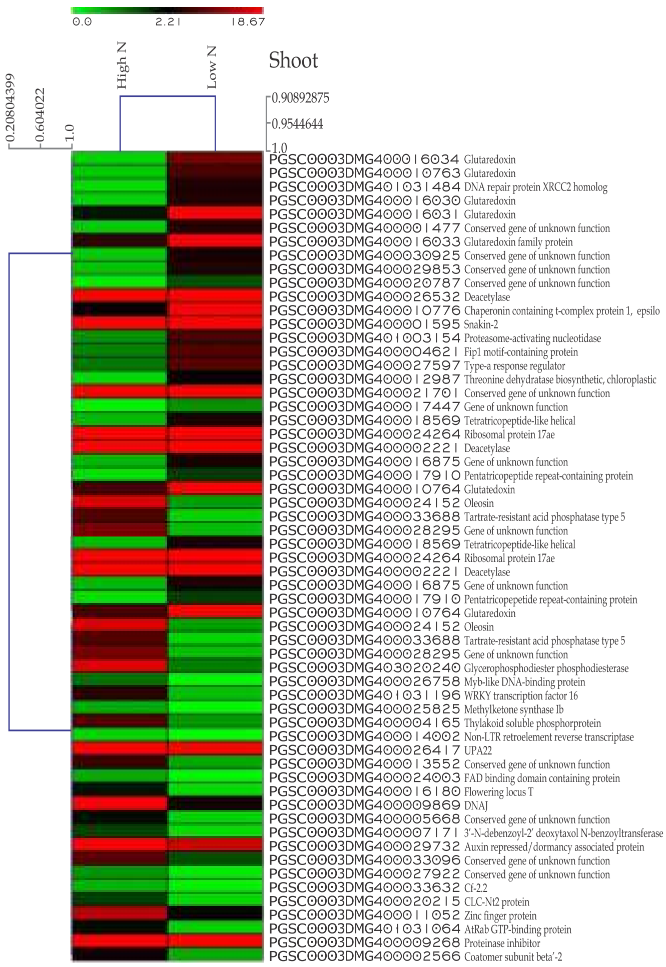


Fig. 2: Heat maps of top 50 differentially expressed genes in shoot of potato plants grown in aeroponic culture with low N (0.2 mM) and high N (4 mM, control).

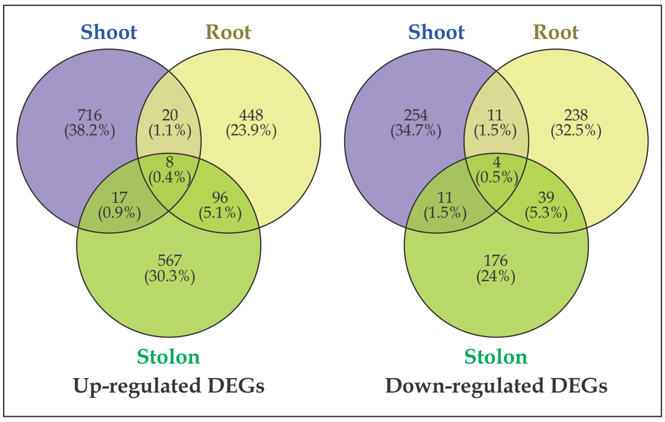


Fig. 3: Venn diagrams of up-regulated and down-regulated DEGs showing distribution of tissues-specific and tissues-independent genes in potato shoot, root and stolon.

Small RNA sequencing for low nitrogen stress in potato: Small RNA were sequenced in potato grown in aeroponic under two contrasting N (high: 25 mM, and low: 1 mM) regimes. In preliminary analysis, a total of 119 conserved miRNAs belonging to 41 miRNAs families, and 1002 putative novel miRNAs were identified **(Fig. 4)**. Small RNA plays important role in gene expression regulation in plant.

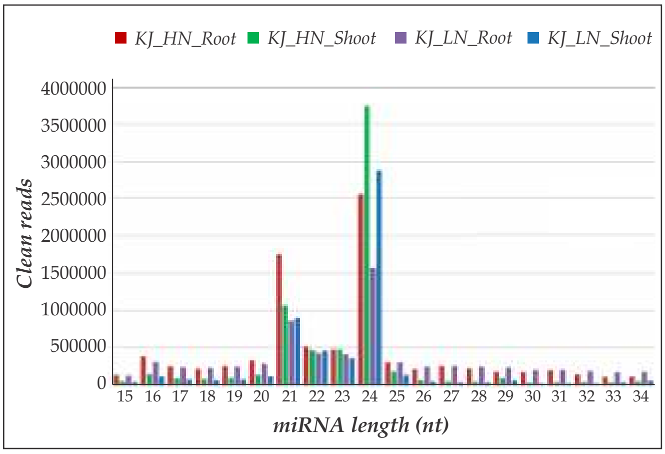


Fig. 4. Length distribution of cleaned reads of miRNAs by small RNA sequencing in potato under low N and high N.

Genome-wide transcriptome analysis for tuber shape variation in potato cv. Kufri Bahar: Total RNA was used for transcriptome sequencing using leaf tissues of mother tuber (M1) and tissue culture-derived variant tuber (M2) shape in cv. Kufr Bahar. DEGs were analysed between M1 (control) and M2. A total of 20,747 DEGs were identified, of which statistically significant ($P \leq 0.05$) were 280 (up-regulated) and 612 (down-regulated). Gene ontology (GO) analysis of 20,747 DEGs showed that maximum of molecular function (26571) followed by biological process (19458) and cellular component (18518). The KEGG pathways analysis classified 5,527 genes into 24 different functional categories, of which signal transduction was maximum (665) followed by translation (530) and carbohydrate metabolism (486) processes. A few highly up-regulated DEGs (7.62-2.03 $\log_2$ FC) in M2 were glycine-rich protein A3, abscisic acid and environmental stress-inducible protein TAS14, protein phosphatase 2C AHG3 homolog, sucrose synthase, zinc finger protein, universal stress family protein, MADS-box transcription factor MADS-MC, auxin repressed/ dormancy associated protein, MYB transcription factor, WRKY transcription factor 4 etc. Similarly, some highly down-regulated DEGs (-4.79 to -3 $\log_2$ FC) in M2 were 14 kDa proline-rich protein DC2.15, primary amine oxidase, endo-1,4-beta-glucanase, cytochrome P450, glycine-rich protein, chlorophyll a-b binding protein 3C chloroplastic, Sn-1 protein, MYB transcription factor **(Fig. 5).**

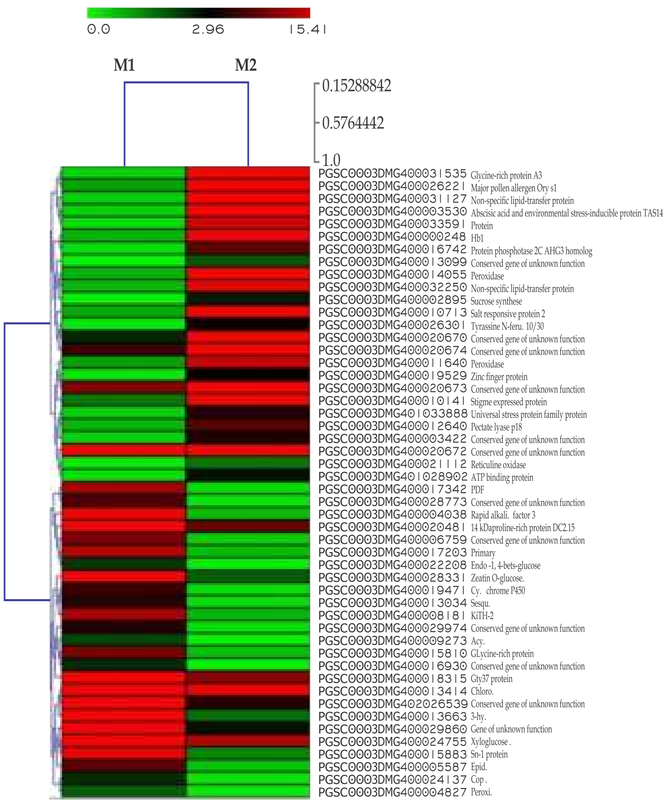


Fig. 5. Heat map of top 50 differentially expressed genes (DEGs) in mother tuber (M1, control) and variant tuber (M2).

Genome-wide variation analysis in potato somatic hybrid, parent and progeny: Genome (re)sequence data of interspecific somatic hybrid (P8), wild parent (*Solanum pinnatisectum*) and progeny (MSH/14-112) were generated using Illumina approach. In addition, earlier we generated draft genome data of *Solanum tuberosum* dihalaploid 'C-13'- another fusion parent of the somatic hybrid. Genome-wide data analysis is in progress to analyze genomic variation in the somatic hybrid, its parents and a hybrid progeny (MSH/14-112)- developed by crossing with a cultivated potato variety Kufri Jyoti in comparison with the reference potato genome sequence **(Fig. 6)**. In the genotypes data ranging between 34-36 Gb per sample of 244-255 million reads were generated.

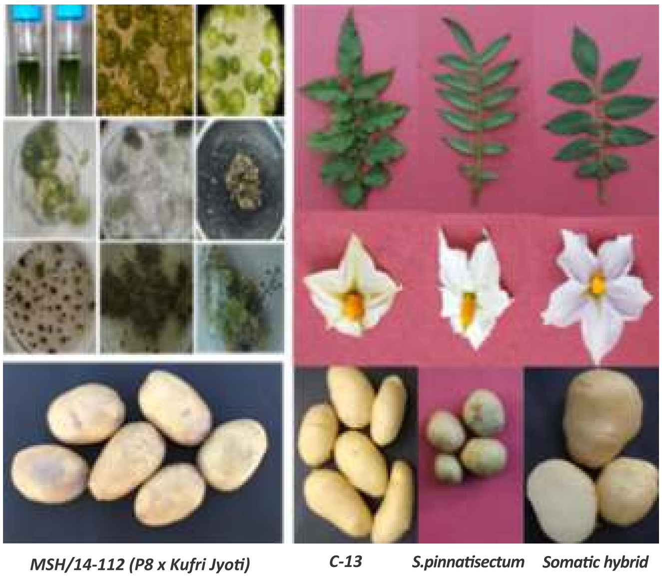


Fig. 6: Interspecific potato somatic hybrid, parents and progeny used for genome analysis.

Improvement of somatic hybrids: ***Seedling stage:*** In all 11888 true potato seeds of 12 crosses developed by crossing somatic hybrid (C13 + *S. pinnectisectum/S.cardiophyllam*) with indigenous varieties were grown for seedling raising and 646 seedling (10 crosses) were recovered/transplanted in the field. At harvest, 53 clones of 2 crosses were selected. ***F_1C_1 stage:*** 247 clones of 13 crosses (developed using somatic hybrids (C13 + *S. pinnectisectum/ S.cardiophyllam*) as parent in combination with indigenous varieties were evaluated in short row trial (5 tubers) at 90 DAP. At harvest 47 clones of 12 crosses were retained. ***F_1C_2 stage:*** Six clones of two crosses were evaluated in duplicate row trial at 90 DAP and at harvest and clones MSH/18-1 (K.Chipsona-1 x P2) and MSH/18-6 (K.Garima x P6) was retained. ***F_1C_3 stage:*** Two clones of two crosses were evaluated in multiple row trial at 90 DAP and at harvest one clones namely MSH/17-16 (Kufri Garima x Card 6) was retained. ***Replicated yield trials:*** Advanced stage hybrids MSH/14-7 was evaluated at 75 and 90 DAP in replicated yield trial. At harvest, advanced stage hybrid. MSH/14-07 (43 t/ha) produced significantly high tuber yield than Kufri Bahar (41 t/ha) at 90 days. ***Evaluation under early crop:*** Among the six clones evaluated under early crop at 75 days, MSH/14-7 (8.5/5), MSH/14-113 (5/10), MSH/14-123 (7.58/10), showed low indicence of hopper/mite than heat tolerant variety Kufri Surya (10/18%).

Introduction of advanced stage hybrids in AICRP: MSH/14-07 (Kufri Garima x SH (Mix pollen): The hybrid with total tuber yield of 46 t/ha (90 days) produced 14% high total tuber yield than K. Bahar (40 t/ha). The hybrid produces attractive light yellow ovoid tubers with shallow eyes and light yellow flesh **(Fig. 7)**. The hybrid possesses 20% tuber dry matter at 90 days, very good keeping quality and slight resistance (AUDPC:744) to late blight as compared to Kufri Bahar (AUDPC:1003). However, through detached leaf method, hybrid showed moderately resistant to late blight.

Fig. 7: Advanced stage hybrid MSH/14-07

Development of SSR markers for identification of somatic hybrids: SSR markers were analysed to reveal allelic variations in wild species and interspecific somatic hybrids of potato. SSR allelic profiles showed high polymorphism and distinctness in the samples. A total of 131 alleles of 13 polymorphic SSR loci were scored in 48 samples of wild species and somatic hybrids of potato. Alleles per locus ranged from 6 (STM5127/ STM5114/ STM1053/ STI0030) to 20 (STM1052) whereas PIC value varied between 0.81 (STM5127/ STM5114) to 0.94 (STM1052) in the samples. This study suggests that SSR-based genotyping and development SSR markers dataset would strengthen their utilization in identification and molecular characterization of wild species and somatic hybrids of potato **(Fig. 8-9)**.

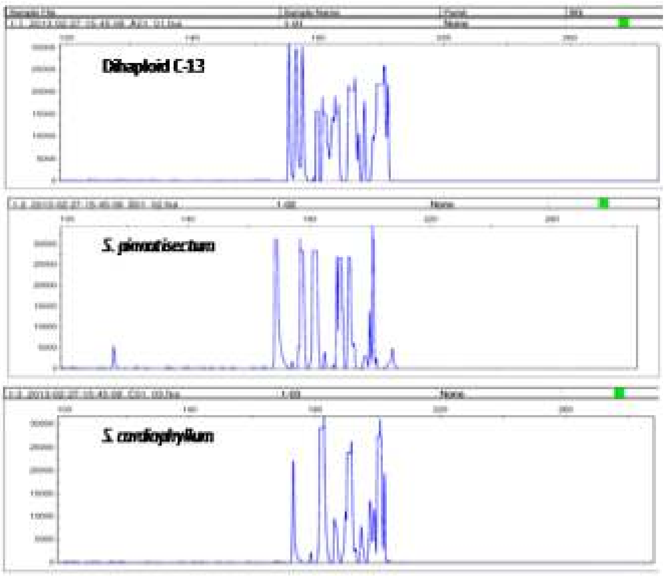


Fig. 8: SSR allelic profiles of wild species and dihaploid C-13 by STU6SNRN marker

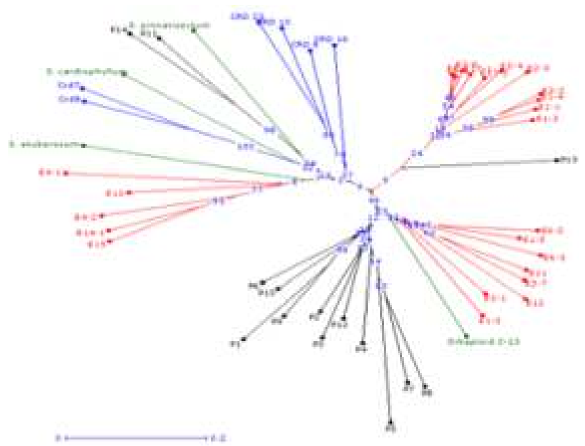
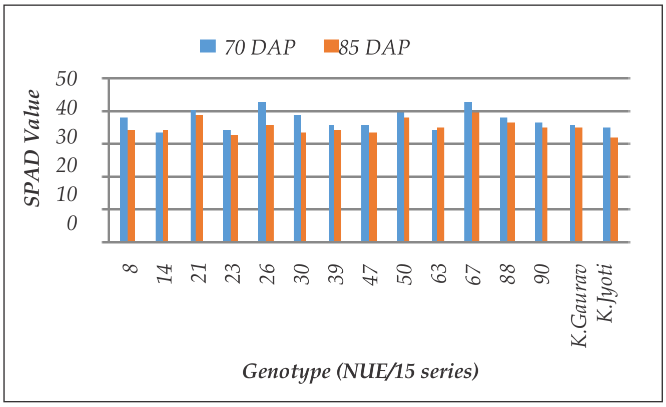


Fig. 9: Cluster analysis of somatic hybrids including parents using SSR markers.

Development of potato genotypes for higher NUE

A total of 13 clones (F_1C_5) selected on the basis of field phenotyping from the cross 'Kufri Jyoti x Kufri Gaurav' were evaluated in 90 days replicated field trials under deficit nitrogen (50 kg N/ha). Remarkable variation was noticed in SPAD values during tuber bulking Stage. Stay green trait (higher greenness > 70% and above) helped achieve tuber yield either comparable or higher than Kufri Jyoti (28.8 t/ha). Composition of tuber numbers suggest a very strong sink capacity in NUE/15-8 as total tuber exceeded >1000. Total tuber yield varied between 29.0 t/ha (NUE/15-26) to 54.9 t/ha (NUE/15-23, about 50% higher) than control Kufri Gaurav (36.1 t/ha). Based on tuber shape, depth of eyes, uniformity of the produce and yield composition, a total of four genotypes namely NUE/15-8, NUE/15-14, NUE/15-23 and NUE/15-67 were selected for further evaluation **(Fig. 10-11)**. Tuber dry matter in all the four selected genotypes was found in acceptable range (16.9 to18.0%).



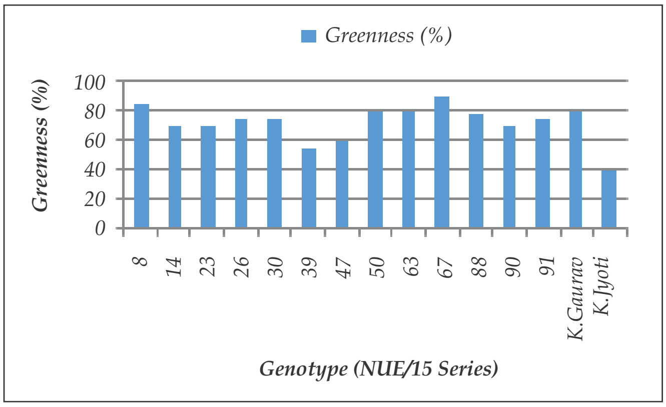
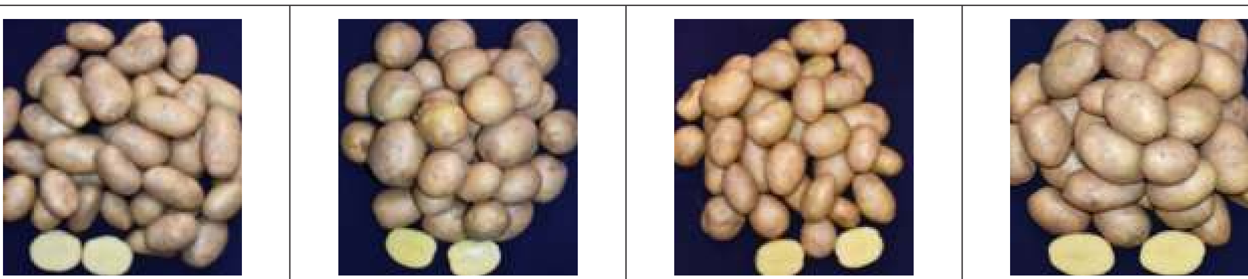


Fig. 10. SPAD values during active tuber bulking phase (70 and 85 DAP) and percent greenness of foliage (90 DAP) in field grown genotypes evaluated under low N (50 kg/ha).



NUE/15-8 | NUE/15-14 | NUE/15-23 | NUE/15-67

Fig. 11: Tubers and flesh colour of selected genotypes for improved NUE

RB transgenic potato for late blight resistance

Under ABSP-II project USDA, developed RB resistance lines in Kufri jyoti potato variety by crossing with SP951 event (Barrowed from Wisconsin University, USA). *RB gene* conferring broad-spectrum resistance in *S. bulbocastanum* has been cloned and provide stable late blight resistance over generations and identified five promising genotypes with very high late blight resistance and other desirable traits. The site of integration, expression and copy number of the inserted RB gene in the event SP951 and KJ lines was determined through molecular analysis. Bio efficacy of SP951 against late blight was validated under containment facility and lab conditions. The application for BRL trail for SP951 and KJ-77 has been submitted to the DBT, Govt. of India **(Fig. 12)**.

Overexpression of CDF1.2 allele mediates early maturity and tuberisation in Kufri Girdhri

Fig. 12: Efficacy of RB KJ lines under containment facility against *Phytophthora infestans*.

Cycling dependent DNA with one finger transcription factor (CDF) circadian gene family, that underlies a major quantitative trait locus QTL for timing of tuber initiation and it has been well demonstrated in short day Andigena population. We developed transgenic in Kufri Girdahri over expressing the CDF1.2 gene. Out of 95 transformed lines, 35 were found *nptII* PCR positive and these positive lines were subjected to phenotyping for tuberisation. Aanalysed phenotypicaly for maturity and early tuberization, in whcih 25 of the transformed lines were tuberising 13 days early and senescence phenotype in comparsion to the non transgenic Kufri Girdhari. 6 lines of second clonal generation subjected to long day condition phenotype and observed significant early and more number of tubers and size in promised CDF1.2 lines compare normal KG line. qRT-PCR analysis of StCDF1.2, StSP6A gene showed more than 5 fold to 16 fold expression compared to control. To support the CDF1.2 expression, analysed the StSP5G and CONSTANS gene expression, showed down regulation of the transcript (<1 fold compare to control KG showed 1 RQ value. This study demonstrated that role of CDF1.2 allele in enhancing the tuberisation and forms the basis of the domestication of potato in tropical latitudes of the Indian continent **(Fig. 13)**.

Generation of functional mutants in potato using activation tagging

Limited functional genetic resources in potato is hampers the breeding programme. Therefore, activation tagging approach was used to overcome these problems by generating gain of function mutants. In the current study, we have generated 17 activation tagged lines of potato cv. K. Jyoti and 15 K. Chipsona lines out of 1000 putative transformants. These lines were further screened for two generations for stable expression using PCR with primers of *Bar* and *Hpt* genes. Positive activation tagged lines (5) showed lateral multiple shoot outgrowth compared to control plants. These lateral shoot outgrowth may facilitate their adaptation to changing environmental conditions and need to be validate for various challenging triats of potato. Also, these lines were found to have enhanced number of tubers along with total biomass compared to control plants. These lines need to validate at molecular and at phenotypic level to assign the functionality of the mutants. Hence, activation tagging approach can be used to produce functional genetic mutants of potato having improved morphological traits which will lay the foundation for genetic improvement of potato in the era of food and nutritional security **(Fig. 14)**.

Fig. 13: Number of tubers in *CDF1.2* Kufri Girdhari lines

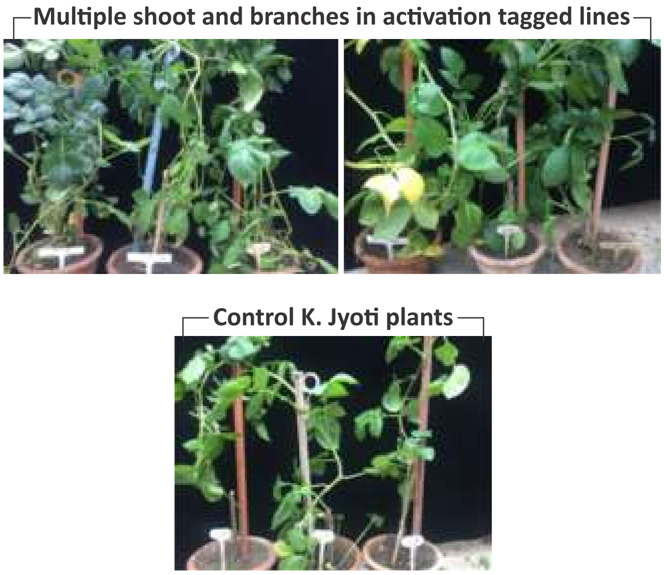


Fig. 14: Phenotyping of activation tagged mutants of Kufri Jyoti showing shoots and branches

DIVISION OF CROP PRODUCTION

PROGRAMME: IMPACT, ADAPTATION AND MANAGEMENT STRATEGIES FOR CLIMATE RESILIENT POTATO PRODUCTION

Potato production is highly sensitive to climate and affected by the long-term trends in average rainfall, temperature and interannual climate variability. Climate change impacts on potato production vary substantially in space and hence environment-specific adaptation strategies may confer advantages. As climate changes, potato production strategies must change too and hence keeping the above issues into consideration, this program is aimed at the use of crop modelling to analyze the likely impact of projected climate scenarios on potato yield, modelling disease pest dynamics and to develop improved management strategies for sustainable potato production in the India.

Impact of climate change on potato productivity in West Bengal: The climate change impact studies were carried out in West Bengal for three potato cultivars (Kufri Jyoti, Kufri Badshah and Kufri Pukhraj) of different maturity groups at thirteen representatives locations of the state under RCP 4.5 and 6.0 using WOFOST Model. The overall productivity of Kufri Badshah, Kufri Jyoti and Kufri Pukhraj were 35.2, 33.7 and 35.4 t/ha respectively under baseline scenario. Under the future climate scenarios when the combined effect of temperature and CO2 fertilization is considered, the productivity of Kufri Badshah is likely to increase in 2030 (1.4%) and 2050 (0.3%) but might reduce in 2080 (2.4%) over the baseline under RCP 4.5. A significant increase in Kufri Jyoti is expected in 2030 (1.4%) and 2050 (0.1%), which might decline in 2080 (2.8 %) when compared with baseline yield. The increase in productivity, from 35.4 to 35.8 t/ha (1.13 %) in 2030 and decline (35.4 to 35.3 t/ha) which is 0.3% in 2050 and 3.7% (34.1 t/ha) is expected in Kufri Pukhraj. The results of the simulation studies under RCP 6.0 showed that when the combined effect of temperature and CO2 fertilization is considered, the productivity of Kufri Badshah is likely to increase in 2030 (4.0%), 2050 (5.1%) and 2080 (2.7%) over the baseline. A significant 4.2, 4.5 and 0.9% yield increase might be expected in 2030, 2050 and 2080 in Kufri Jyoti (33.7 to 35.1 t/ha in 2030, 35.2 t/ha in 2050 and 34 t/ha in 2080. The maximum increase in productivity, from 35.4 to 37.0 t/ha (4.5%) in 2030, 4.2% (36.9 t/ha) in 2050 and decrease in 0.3% (from 35.4 to 35.3 t/ha) in 2080 can be expected in Kufri Pukhraj **(Fig. 1)**.

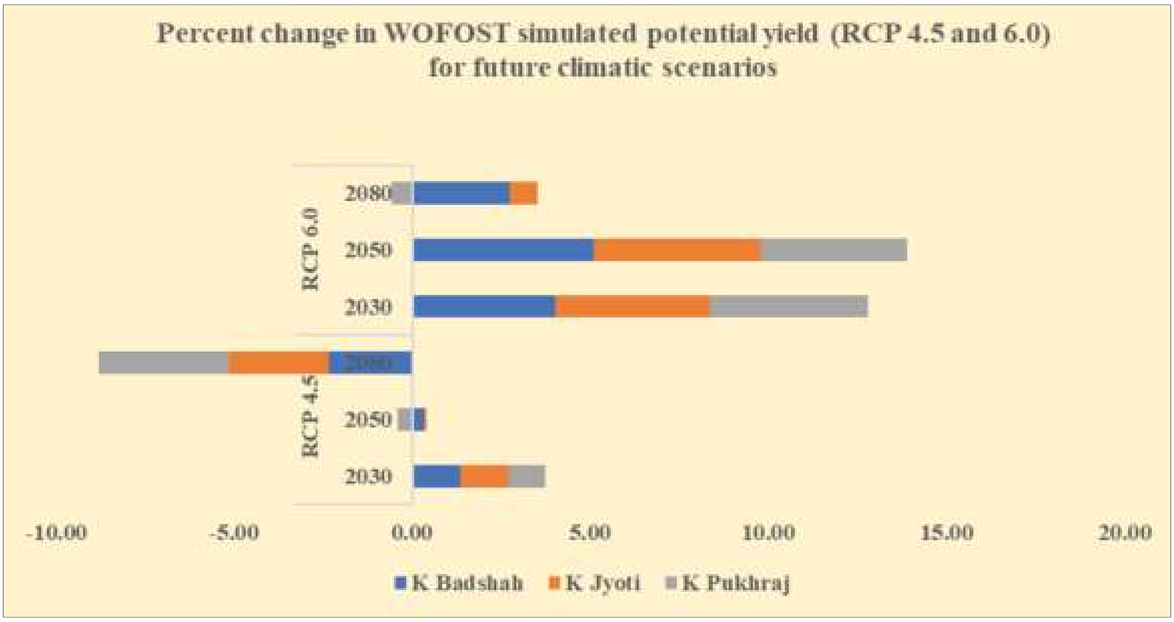


Fig. 1: Projected changes in WOFOST simulated potential yield (t/ha) of potato cultivars under baseline and future climate scenarios (RCP-4.5 and 6.0) in West Bengal (combined effect of temperature and CO_2)

Impact of climate change on potato productivity in Gujarat: The productivity potential of Kufri Badshah, a late maturity variety, was minimum at Jamnagar (29.2 t/ha) and maximum at Banaskantha (50.8 t/ha), with an overall productivity of 33.3t/ha, under baseline scenario. Under the future climate scenarios, when the effect of temperature and CO_2 fertilization was considered together, the productivity of Kufri Badshah might decrease in 2030 (1.4 %), 2050 (6.7%) and 2080 (12.5%) over the baseline under RCP 4.5. The productivity of Kufri Jyoti, ranged from 25.5 (Navsari) to 38.7 t/ha (Banaskantha) with mean potential productivity of 29.8 t/ha under the baseline. A decline might be observed in Kufri Jyoti by 1.9% in 2030, 8.5% in 2050 and 16.8% in 2080, when compared with baseline yield. Kufri Pukhraj, had a productivity range 25.9 (Jamnagar) to 40.8 t/ha (Banaskantha) with average productivity of 31.0 t/ha under baseline studies. The maximum increase in productivity, from 30.0 to 30.2 t/ha (0.7 %) in 2030 and maximum decline from 30.0 to 27.6 t/ha (8.6%) in 2050 and 20.0% (24.8 t/ha) in 2080 is expected in Kufri Pukhraj under RCP 4.5. The results of the simulation studies under RCP 6.0 showed that under the future climate scenarios, when the effect of temperature and CO_2 fertilization was considered together productivity of Kufri Badshah might decline in 2030 (1.1%) but likely to increase in 2050 (1.8%) and in 2080 (4.3%) over the baseline. A significant (1.7%) yield increase might be expected in 2030, whereas reduction in yield 2.1 and 5.7% in 2050 and 2080 in Kufri Jyoti (29.8 to 30.3 t/ha in 2030, 29.2 t/ha in 2050 and 28.1 t/ha in 2080). In Kufri Pukhraj, productivity varied from 25.9 (Jamnagar) to 40.8 t/ha (Banaskantha) with average potential productivity of 31.0 t/ha under the baseline. The maximum increase in productivity, from 31.0 to 32.1 t/ha (3.6%) in 2030 while, decrease of 0.3% (from 31.0 to 30.9 t/ha) in 2050 and 4.8% (29.5 t/ha) in 2080 can be expected in this cultivar **(Fig. 2)**.

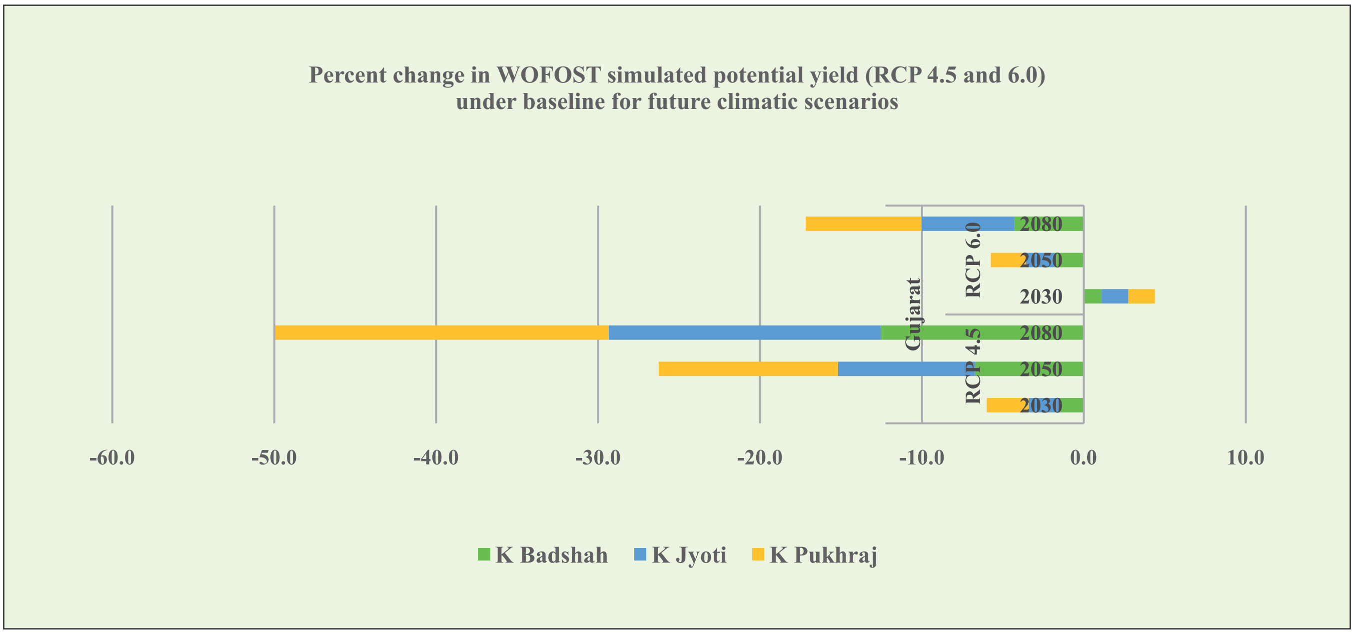


Fig. 2: Projected changes in WOFOST simulated potential yield (t/ha) of potato cultivars under baseline and future climate scenarios (RCP-4.5 and 6.0) in Gujarat (combined effect of temperature and CO_2)

Potential impact of climate change on potato late blight outbreak in West Bengal using Indo-Blightcast model

West Bengal is the second largest producer of potato in the country and late blight is the major bottleneck in the successful cultivation of potato in the state. The potential impact of climate change on late blight appearance in West Bengal was analysed using Indo-Blightcast model. The model was run using districts level data on minimum and maximum temperature (°C) of Indian Meteorological Department's normals for baseline (year

2000) and future climate scenarios (years 2030 and 2050) for 13 districts. The model predicted that, in general, late blight favourable period is likely to be reduced in all the studied districts except Kolkata, Malda, Parganas N1 and Puralia where it is likely to remain as a threat in the future climate (2030 and 2050) scenarios.

Appearance of late blight and insect-pests in climate analogues

Climate analogues are important to study the appearance of late blight and subsequent effect on its incidence in future climate change scenarios. Late blight may appear either at same time or at different times in similar climate analogues. Hence, observations on appearance of late blight in different climate analogues were recorded. It was observed that at Agra (26.753 °N, 78.773 °E) late blight appeared during 15-20 December, 2019 while its analogous Etah (27.739 °N, 78.729 °E) it appeared during 25-30 December, 2019. Similarly, at Jalandhar late blight appeared on 21 Nov, 2019 while its analogous Baghpat (29.274 °N, 77.191°E) it appeared during last week of December (25-30 Dec., 2019). However, at Patna (25.617 °N , 85.167 °E) late blight appeared during last week of December (27-31 Dec., 2019) and its analogous Agra (26.753 °N, 78.773 °E), it appeared during second week of December (15-20 Dec., 2019). At Kannauj (27.055 °N, 79.918°E) late blight was observed during first week of December (5-7 Dec., 2019) while at its analogous Bijnor (29.313 °N, 78.377 °E) during second week of December (14-20 Dec., 2019; **Table 1**).

Table 1: Locations and their climate analogous for late blight appearance

Sr. No.	Location	Late blight appearance	Analogous	Late blight appearance
1.	Agra: 27.167 °N, 78.033 °E	*Second week of December (15-20 Dec, 2019)	Etah: 27.739 °N, 78.729 °E	Last week December (25-30 Dec, 2019)
2.	Kannauj: 27.055 °N, 79.918 °E	*First week of December (5-7 Dec, 2019)	Bijnor: 29.313 °N, 78.377 °E	Second week of December (14-20 Dec, 2019)
3.	Jalandhar: 31.326 °N, 75.579 °E	Third week of Nov (21 Nov, 2019)	Baghpat: 29.274 °N, 77.191°E	Last week December (25-30 Dec, 2019)
4.	Patna: 25.617 °N, 85.167 °E	Last week December (27-31Dec, 2019)	Agra: 26.753 °N, 78.773 °E	Second week of December (15-20 Dec, 2019)

**observation recorded by telephonic communication*

Periodic generation of data on arrival and build-up of aphid and whitefly population in Potato

The population of peach-potato aphid, *Myzus persicae* (Sulzer), and other aphid species, and whitefly was monitored at Jalandhar at weekly interval in unsprayed potato fields from the 3rd week of October 2019 till the third week of December, 2019. Aphid population was recorded as 100 leaf count from 34 randomly selected plants. Aphid flight activity was monitored with yellow sticky traps (YSTs). *Myzus persicae* first appeared on the potato plants in the 1st week of November and did not cross the threshold limit till the last week of December **(Fig. 3)**. The population increased gradually till the 2nd week of December and then sluggishly due to sudden drop in daily mean temperature. The production of alate and alatiform morphs started from the 3rd week of December.

The population of the winged morphs of other aphids started out at 70 aphids per 100 compound leaves in the last first week after emergence of the crop **(Fig. 4)**. The population declined then and fluctuated between 14 and 35 aphids per 100 compound leaves. Similar to *Myzus persicae*, other aphids also experienced a sudden dip in population size after the 3rd week of December due to sudden drop in mean daily temperature. The flight activity of all the aphids followed a similar trend **(Fig. 5)**.

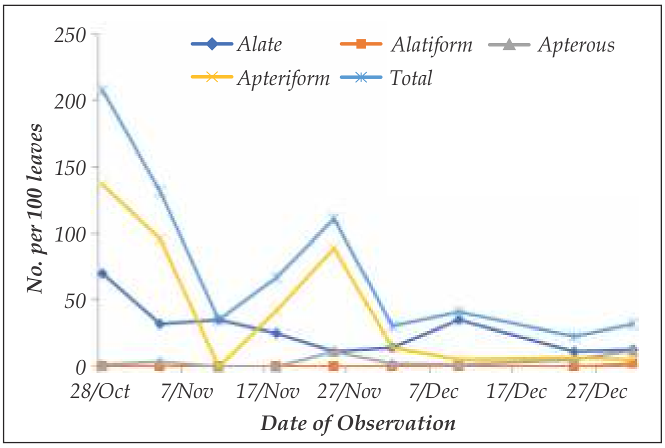


Fig. 4: Population dynamics of aphids (other than *M. persicae*) on potato at CPRS, Jalandhar (2019-20).

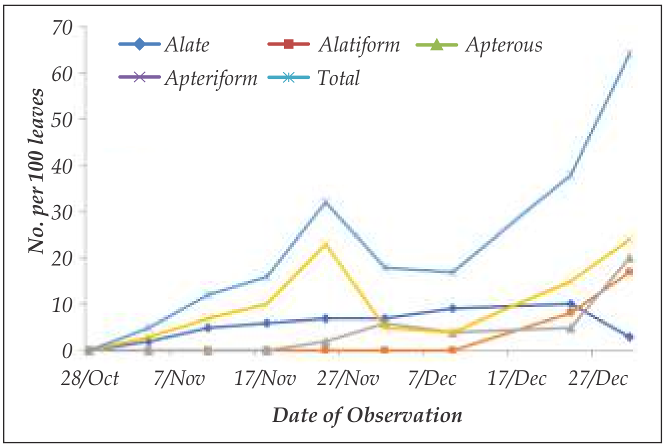


Fig. 3: Population dynamics of Myzus persicae on potato at CPRS, Jalandhar (2019-20).

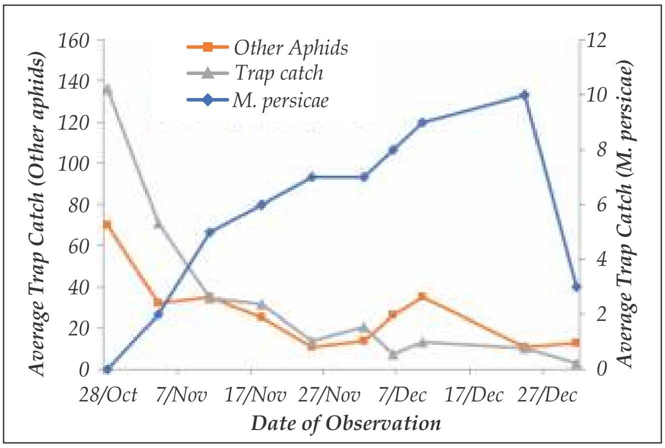


Fig. 5: Comparison of the dynamics of alate aphids and average YST catch on potato at CPRS, Jalandhar (2019-20).

PROGRAMME: INTEGRATED NUTRIENT AND WATER MANAGEMENT FOR IMPROVED

To develop site specific nutrient management techniques for precision farming and better soil health

Site specific nutrient management provides tools and strategies to determine when and how much nutrients are to be applied under actual growing conditions in a specific season and location. With this objective studies were conducted using different techniques and sources of nutrients at different locations for site specific nutrient management. Studies were also conducted to study the soil fertility status of different potato growing soils and fertilizer application by farmers. The results of different experiments are presented below:

Optimization of nutrient through omission plot technique: Omission plot technique was used to find out the most yield limiting nutrient and to find out nutrient supply capacity of soil. At ICAR-CPRS, Shillong, Meghalaya cultivar Kufri Girdhari and Kufri Megha recorded higher yield (18.42 and 14.96 t ha^{-1}) from fully fertilized plots (100% RDF). The lowest yield (3.50 and 1.75 t/ha) was recorded in control (no NPK and FYM application) plot. Omission of nitrogen significantly reduced the potato yield in all the treatments and it was the most limiting nutrient for potato production followed by phosphorous and potassium. Interaction between varieties and treatment was non-significant and suggested all the varieties responded in same way to the applied fertilizers.

Optimizing starter dose of phosphorus (P) fertiliser in high P soils: Continuous application of P has resulted in its build-up in many soils. Thus studies were conducted to determine the starter dose of P. In the acid soils of Meghalaya, a field experiment was conducted to optimise P dose using graded doses of recommended dose of phosphorous (RDP). Phosphorus fertilizer as diammonium phosphate (DAP) was applied at eight different levels; 0 kg/ha (T_1), minus P (control) + FYM (T_2), 10% RDP (T_3), 20% RDP (T_4), 30% RDP (T_5), 40% RDP (T_6), 50% RDP (T_7) and 100% RDP (T_8). Kufri Girdhari produced higher yield (22.16 t ha^{-1}) with application of 30% RDP which was at par with par with 40 % RDP **(Fig. 1)**. The lowest yield (5.06 t ha^{-1}) was recorded in control (no P and FYM application) plot. At Ooty, starter dose of P fertilizer was determined for four cultivars in soils having high available P content. Kufri Girdhari produced maximum yield with 40% of the recommended P (42.2 t/ha), and Kufri Sahyadri (18 t/ha) produced highest yield with the application of 30% of the recommended P. Cultivar Kufri Swarna resulted maximum yield with 40% P (16.7 t/ha) and cultivar Kufri Jyoti with 30% P (10.11 t/ha). The study showed that depending up on variety 30 to 40% of the recommended dose is sufficient in soils having high available P content.

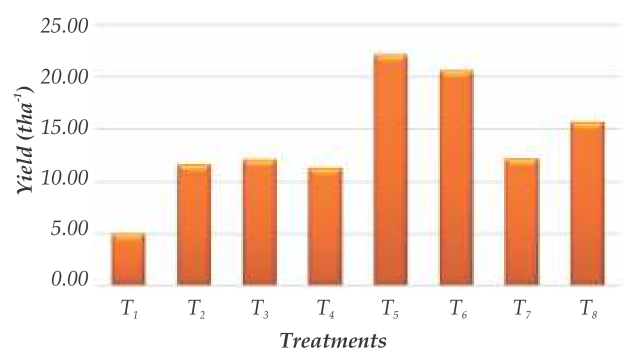


Fig. 1: Effect of varying levels of phosphorous on tuber yield (t ha^{-1}) of Kufri Girdhari

Optimization of nutrient through omission plot technique: A field experiment conducted at ICAR-CPRS, Shillong, Meghalaya with the aim to find out nutrient supply capacity of acid soil of these region. The experiment conducted with three replications in afactorial randomized block design and found that the cultivar Kufri Girdhari and Kufri Megha recorded higher yield (18.42 and 14.96 t ha-1) from fully fertilized plots (100% RDF). The lowest yield (3.50 and 1.75 t/ha) was recorded in control (no NPK and FYM application) plot.Omission of nitrogen significantly reduced the potato yield in all the treatments and it suggest nitrogen is the most limiting nutrient for potato production followed by phosphorous and potassium. Interaction between varieties and treatment statistically non-significant and suggests all the varieties responds same way to the applied fertilizers.

Effect of rock phosphosphate, biofertilisers and and lime application on potato yield in the acid soils: Individual and combined effect of rock phosphate (RP) and *Bacillus megaterium* a phosphorus solubilizing bacteria (PSB) application on potato yield was studied in Shillong and Ooty. At Shillong the experiment comprised of eight levels of nutrients, *viz.*, control (no P and no PSB), only PSB, 25% RDP through RP, 25% of RDP through RP and PSB, 50% of RDP through RP, 50% of RDP through RP and PSB,75% RDP through RP and 100 % RDP (140 kg P_2O_5/ha) through RP. Increasing phosphorus levels from 0 to 140 kg ha $^{-1}$significantly increased the marketable and total tuber yield of potato **(Fig. 2)**. Application of 100 % RDP through RP along with PSB produced highest yield (18.3 t ha^{-1}). The treatment in which 75% of recommended P (as RP) was applied along with PSB recorded tuber yield at par with those obtained in treatment received 100% recommended P, indicating 25% saving of cost on P with the application of PSB. The results of this study suggest that 75% RDP through RP along with seed inoculation with PSB can be recommended for higher yield of potato in the acidic soils of Meghalaya.

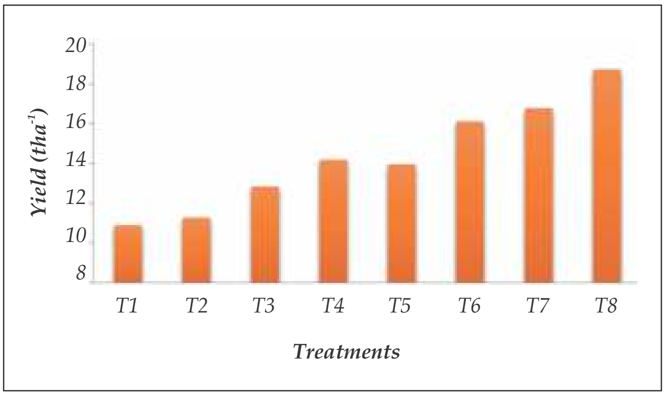


Fig. 2: Effect of rock phosphate along with seed inoculation with PSB on potato tuber yield (t ha^{-1})

At Ooty, experiment was conducted to work out the P requirement of cultivar Kufri Sahyadri with or without lime (5t/ha) and PSB (20 kg/ha) during summer season. Different doses of P were 0, 25, 50 and 100% of recommended dose (135 kg/ha) were applied. Highest tuber yield was recorded with 100% P + PSB (24.8 t/ha) followed by 50% P + PSB + lime (22.4 t/ha) and 50% P + PSB (21.6 t/ha) . The treatment with no application of phosphorus (T1) recorded lowest yield (11.7 t/ha) .

At Ooty rock phosphate with and without application of PSB, was compared with the recommended application of single super phosphate. Kufri Swarna recorded maximum yield with 100% P (rock phosphate) +PSB, which was on par with 25% P + PSB and 50% P when P was applied in the form of rock phosphate. Kufri Sahyadri recorded maximum yield in the treatment where P was given as 100% single super phosphate followed by 50% P + PSB, 25% P, 25% P + PSB and 50% P as rock phosphate. The treatments where no phosphorus was applied produced the lowest yield in both cultivars. This study showed that rock phosphate in combination with PSB is a suitable source of P in these soils.

Response of potato cultivars to N fertilization: The experiment was conducted at ICAR- CPRS, Shillong during 2018-19 to evaluate yield response of potato varieties *viz.*, Kufri Jyoti, Kufri Himalini and *Kufri Girdhari* for the graded levels of N application (0, 70, 140 and 175 kg ha^{-1}). Application of application of N @ 175 kg ha^{-1}recorded highest tuber yield of 22.01 t ha^{-1}in Kufri Himalini and 19.86 t ha^{-1} Kufri Girdhari, while in Kufri Jyoti highest yield (21.64t ha^{-1}) was obtained with application of N @140kg ha^{-1}.

Relationship between SPAD values and leaf nitrogen content: Leaf chlorophyll is an indicator of nitrogen status of plants. Apart from standard laboratory procedures, one of the tools used in many crops in different countries to diagnose N status of plant is SPAD meter. However, the chlorophyll meter readings are influenced by leaf thickness which in turn is a varietal character. Thus, relationship between SPAD readings and compound leaf nitrogen status was studied at three different growth stages in Kufri Gandhari variety at Shimla during 70-105 days after planting (DAP).

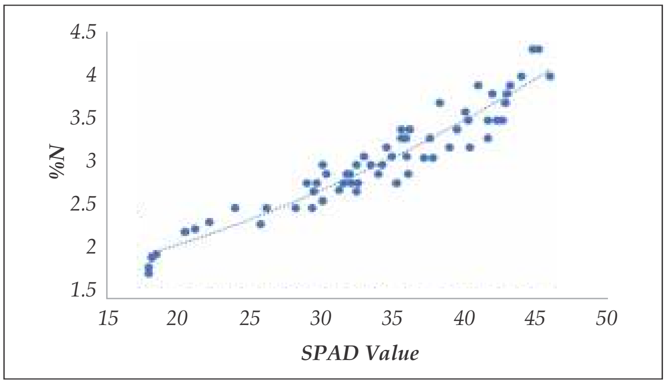


Fig. 3: Relationship between leaf nitrogen content and SPAD index in Kufri Girdhari across the stages

A positive relationship between leaf nitrogen concentration and SPAD index across the growth stages was observed which is depicted in **(Fig 3)**. This indicated that leaf nitrogen content can be assesesd by using chlrophyll metere provided other nutrient deficienceis are not influcing the chlorophyll content.

Relationship between extractable and total potassium and phosphorus in potato leaves: Potassium (K) and phosphorus (P) play important roles in plant growth and development. Information on potassium (K) and phosphorus (P) concentration in potato leaves is useful to researchers and producers for diagnosing possible nutrient deficiencies and determining the precise amount of fertilizers to be applied. Common procedures for estimating total leaf potassium and phosphorus concentrations generally involve digestion techniques which require concentrated and harmful acids and consume considerable time and energy hence in this study. Acetic acid extractable K and P and total leaf K (as determined by acid digestion method) was compared in leaf potato samples collected from the experimental plots having a wide range of available P and K and grown under diverse growing conditions **(Fig. 4).** Acetic acid extractable potassium (R^2 = 0.98) and phosphorus (R^2 = 0.84) concentration in leaves showed a very high degree of significant correlation with their respective contents determined by acid digestion method (total K and P), indicating thereby that acetic acid extractable potassium and phosphorus can also be an alternative of acid digestion method.

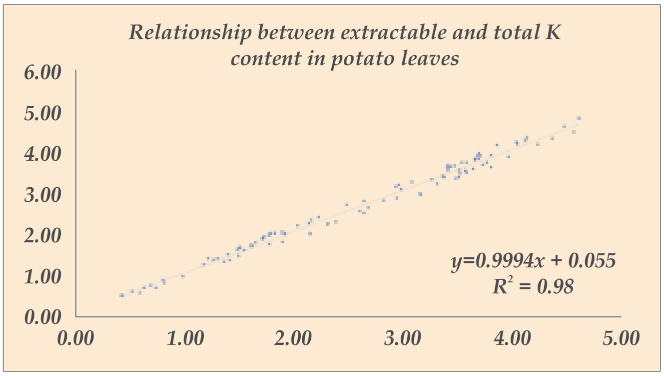


Fig. 4: Relationship between extractable and total potassium in potato leaves

Quality of irrigation water in important potato growing areas of Punjab: Most farmers do not consider irrigation water nutrient concentrations while developing a fertilization program. This overlooked source of plant nutrients is important and can save producers money and prevent adding of nonessential quantities of nutrients to the agri-ecosystem. Quality of irrigation water affects both productivity and quality of the produce. Thus 100 water samples from potato growing farms weretested for quality attributes where borewell depth ranged from 45 to 400 foot. The Electrical conductivity of samples ranged from 0.35 to 0.96 dS/m which was within safe limits for growing potatoes. pH ranged from 7.1 to 8.5 and chloride concentration ranged from 2 to 5 meq/liter. Nitrate content varied from 1.90 to 130 ppm with an average value of 40 ppm indicating that it can substantially contribute towards nitrogen nutrition of the crop. Thus we can conclude that recommendations for nitrogenous fertilizers can be and should be rationalized keeping in view the nitrate content of the irrigation water to reduce the expenditure on nitrogenous fertilizers and water pollution. The water samples also contained traces of micro-nutrients and average Zn, Fe, Cu and Mn concentration was 0.06, 0.07, 0.11 and 0.03 mg/L, respectively. Average concertation of Ca (67 mg/L), Mg (32 mg/L) and Na (55 mg/L) in these samples was enough to influence the crop growth significantly. Thus while developing fertilization program, contribution of nutrients from irrigation water should also be considered.

Soil fertility status of potato growing soils of Punjab and Himachal: For site specific nutrient management, information on soil fertility status is required. For this purpose 102 surface soil samples from different potato growing districts of Punjab were analysed for major nutrient status in order to develop sound nutrient management indices. **(Fig. 5)**. Based on general soil fertility classification for majority of crops, excluding potato, 96% soils were deficient (<170 kg/ha) in available nitrogen and 55% contained low level (<0.5%) of organic carbon. Only nine percent (9%) soils were deficient in available P whereas 41 % soil had high level of available P. None of the soil was found deficient in potassium. From potato crop point of view, available P content was below critical limit of 10 ppm in 49 % soils whereas only 26% soils had available (ammonium acetate extractable) potassium below the critical limit of 105 ppm K.

To assess available soil micronutrient status of important potato growing areas of Himachal Pradesh 150 samples were collected. Soil samples were collected from potato fields of Mandi and Lahaul Spiti and analysed for available Zn, Fe, Cu,

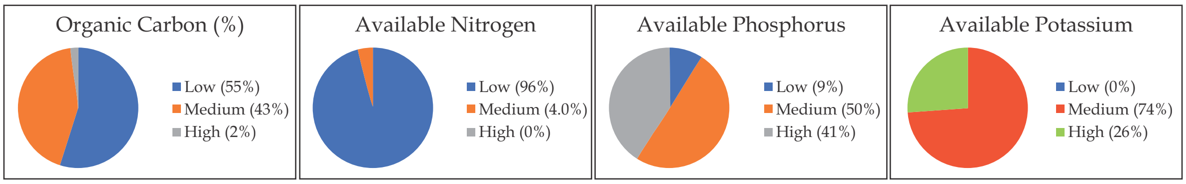


Fig. 5: Status of nutrients in potato growing soils of Punjab

Mn and B content .All the soils had high to very high contents of Zn, Fe, Cu and Mn cations. Only one sample was found deficient in Zn. However, B was found to be the most deficient micronutrient and about 90 % soil samples analysed contained B below critical limit (0.5 ppm).

Fertilizer usage and potato yield in Punjab: The inappropriate fertilization not only affects the crop yield but also impacts the soil health and environment negatively. In order to understand the causes of variable yields obtained by different potato growers in Punjab a survey was carried out in major potato growing areas yield and fertilizer (NPK) input data for Kufri Pukhraj, an important variety in this region, was recorded. Data revealed that most of the farmers (59%) obtained an average yield of 25-30 t/ha **(Fig. 6)** and only 12 per cent of the farmers harvested a yield of more than 30 t/ha in these areas. The average amount of macro-nutrient application by the growers was compared with the recommended and required doses of these nutrients. It was observed that on an average farmers applied about 80 kg less nitrogen, 60 kg more phosphorus and 54 kg less potassium compared to recommended dose. Studies also revealed that N influenced the yield of potato crop noticeably. The average native nitrogen was 131.7, 147.4, 159.18 and 211 kg/ha in soils with average yield range of 15-20, >20-25, >25-30 and >30-35 t/ha, respectively. Little variation in applied N application rates was observed amongst the different yield groups. The average N application rate were 152.6, 157.9, 161.3 and 167.1 kg ha^{-1} in average yield group of 15-20, >20-25, >25-30 and >30-35 t/ha, respectively. Variation in yield in these soils can be attributed to its positive relationship with native (R^2=0.79) and applied nitrogen (R^2=0.97). Relationship between applied P and K doses and harvested yield was poor. Thus, soil test based fertilizer application is important to avoid wasteful expenditure and improve fertilizer use efficiency.

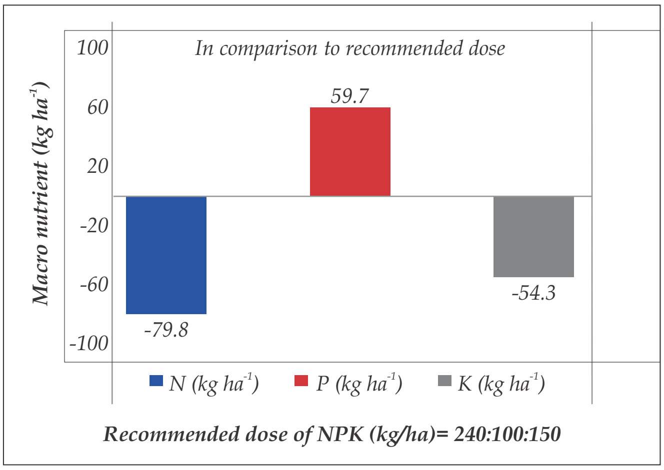


Fig. 6: NPK application by potato growers in comparison to recommended dose

Evaluation of organo- mineral fertiliser as source of potassium in potato: Field experiment was conducted at Galu farm of ICAR-CPRI, Shimla to study the effect of Organo-Mineral Fertilizer (OMF, a product obtained from ICAR-CAZRI, Jodhpur), as a source of potassium on growth and yield of potato variety Kufri Girdhari. Four levels of potassium (0, 50, 75 and 100% K_2O) from muriate of potash (MOP) and OMF source) and two levels of potassium consisting 50% K_2O (from MOP and OMF) along with 15 ton FYM/ha were applied. Potassium application in the form of OMF did not increase the yield significantly over control (zero K) as compared to zero K (24.0 t/ha) treatment. No significant effect of the source of K on tuber yield was recorded, though substantial impact of FYM was observed on tuber yield. Significant effect of K nutrition was observed on leaf potassium concentration. At a given level of potassium, MOP resulted in significantly higher potassium concentration in leaves compared to OMF at 50 days after planting (DAP). At 70 DAP K applied at 100% RDF resulted significantly higher potassium concentration compared to all other treatments. Compared to no potassium application, OMF also increased the potassium concentration when applied at the rate of 100% K without FYM or and 50% K along with FYM. Although inferior to MOP, the results of present study indicated that OMF has the potential to be used as potassium source to potato crop as indicated by leaf analysis.

PROGRAMME: RESOURCE OPTIMIZATION IN POTATO BASED CROPPING SYSTEM

Field experiments and laboratory studies were conducted in this programme under nine research project activities during 2019. Output of production technology for organic potatoes Indian GAP documentation, potato based cropping systems, long term experiment, agro-technology for *kharif* potato and development of farm machines, manual tools for potato cultivation and handling has been reported under this programnme. Research activity wise salient findings and conclusions are as follows:

Organic potato production technology

In view of growing interest in organic farming organic potato production technology of first generation for hills and plains has been developed and documented in the form of a technical bulletin.

Organic seed potato production at Gwalior: A field experiment was conducted using five manurial treatments. Split application of FYM produced higher tuber yield. Application of 100% FYM (50% at planting+ 50% at earthing up) produced highest total tuber yield (29.7 t/ha) followed by 75% FYM at planting+ 25% FYM at earthing up (29.6 t/ha). Lowest tuber yield (28.0 t/ha) was recorded with control **(Fig. 1)**.

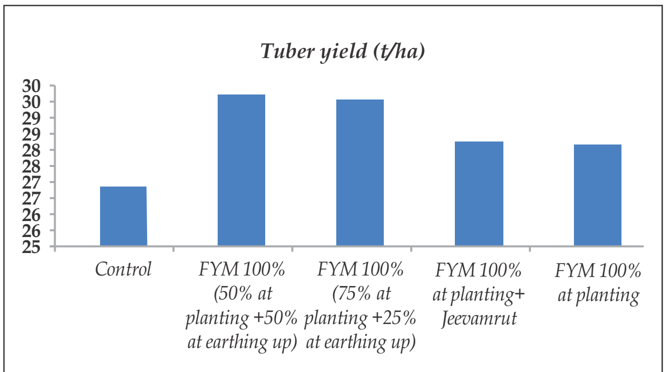


Fig. 1: Tuber yield (t/ha) as affected by different sources of nutrition

Performance of potato varieties in organic farming systems: At Modipuram, twelve varieties were evaluated in organic farming (CPRI technology) and zero budget organic farming. Growth and physiological parameters including chlorophyll content (SPAD value) an indicator of photo-synthetic efficiency were influenced In general, higher SPAD values **(Fig. 2)** were observed in inorganic system (43.1-55.6) followed by CPRI technology (33.0-51.0) and zero budget organic farming (37.0-47.0). CPRI technology and zero budget organic farming observed more or less comparable SPAD values among different cultivars.

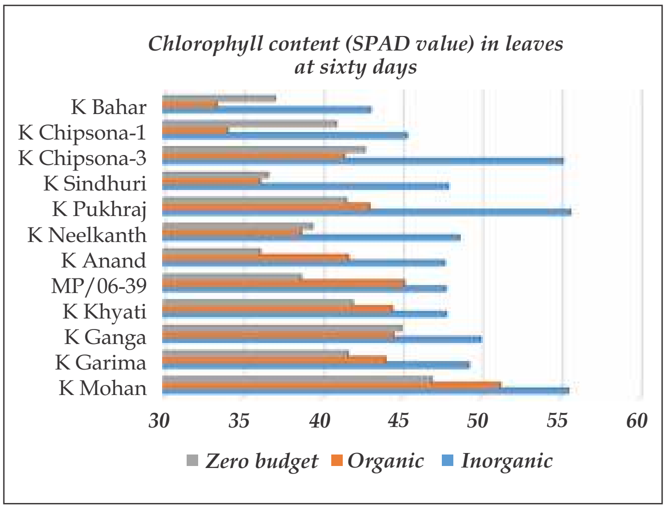


Fig. 2: Influence of organic and inorganic nutrition on leaf chlorophyll content (SPAD values)

Effect of nutrition sources on tuber nutrient composition: Sources of nutrition affect the composition of tubers. Thus effect of organic and inorganic fertilizer sources on tuber N, P, K, Ca, Mg and micronutrients content of ten varieties was studied during 2018 and 2019. Significant differences were noticed for N, K, Mg and Zn concentration. In first year, tubers raised on organic nutrition contained significantly lower N and Zn content, while higher K and Mg concentration was higher. Apart from significant reduction in N and Zn concentrations, Cu and Mn concentrations were also lower under organic nutrition during second crop season, whereas, concentration of K and Mg was consistently higher. Reduced concentration of nutrients like N and Zn are a cause of concern from dietary intake point of view. Total removal of all the nutrients by tubers was higher under inorganic nutrition during both the years as tuber yield was substantially lower under organic nutrition **(Fig. 3)**.

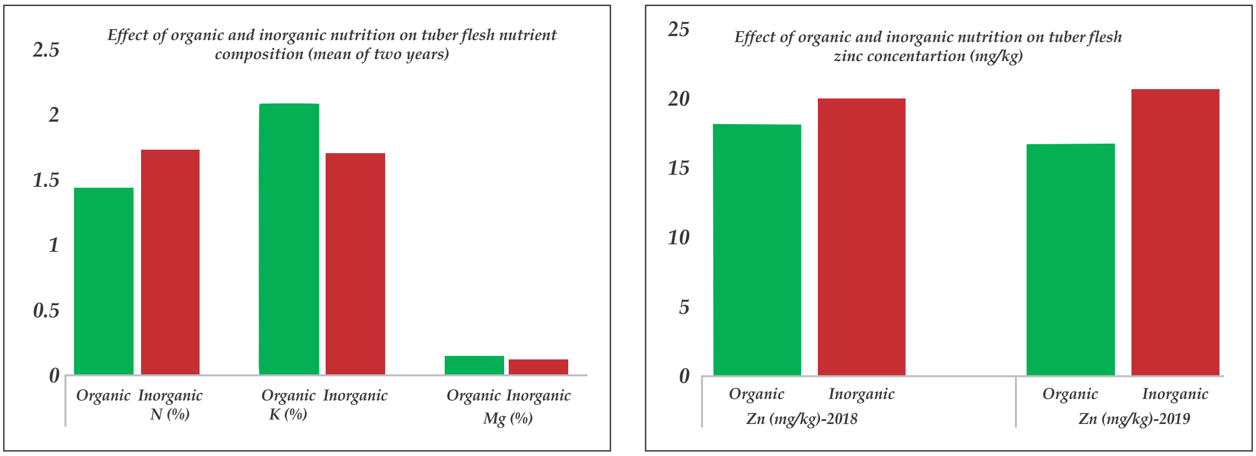


Fig. 3: Effect of organic and inorganic fertilizer sources on tuber nutrient concentration

Post-harvest quality of organic potatoes: Post-harvest quality parameters (chip colour, reducing sugars and sucrose etc.) were studied in organically and inorganically grown potatoes. Chip colour score was better in organically produced potatoes in comparison to inorganically produced. Chip colour under organic nutrition varied from 1.0 in Kufri Chipsona-1 to 9.5 in Kufri Ganga, while in inorganic treatments it varied from 2.0 in Kufri Chipsona-1 to 10.0 in Kufri Anand **(Fig. 4)**. Glucose accumulation (mg/100 g FW) was higher in inorganic treatments as compared to organic plots. Glucose content in tubers ranged from 3.0 in Kufri Chipsona-3 to 294.9 mg/100 g FW in Kufri Ganga. Processing potato varieties had less glucose content compared to table purpose varieties **(Fig. 5)**. Sucrose content reduced in organic tubers of cv. Kufri Anand, Kufri Chipsona-1 and Kufri Chipsona-3. Inorganic and organic tubers retained almost similar values in varieties like Kufri Bahar, Kufri Chipsona-3, Kufri Ganga and Kufri Pukhraj **(Fig. 6)**.

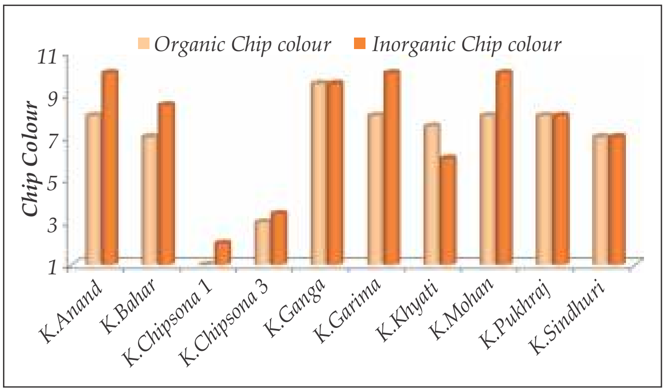


Fig. 4: Chip colour score of organic and inorganic potatoes

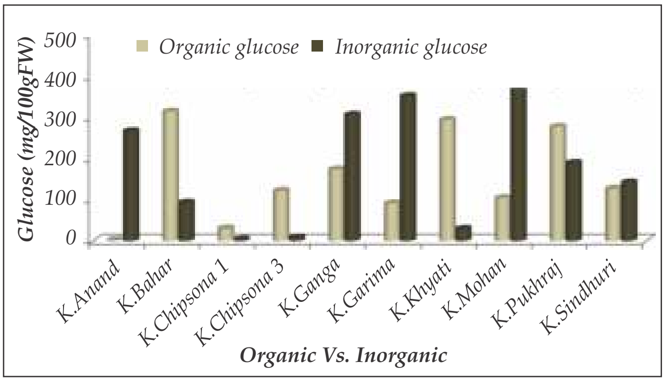


Fig. 5: Glucose content in organic and inorganic potatoes

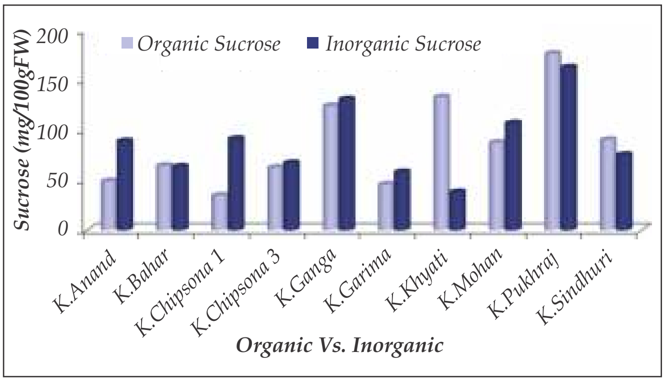


Fig. 6: Sucrose content in organic and inorganic tubers

Comparison of biochemical traits in inorganic and organic potatoes: Aantioxidants (total phenols, anthocyanins, ascorbic acid), antidiabetic compounds *viz.* biguanide and related compounds (BRCs), protein, total amino acids, glutamine, and flavouring compounds *viz.* 5' nucleotides [{adenosine monophosphate (AMP)+guanosine monophosphate (GMP)} and glutamate)] were evaluated from organic and inorganic potatoes of ten Indian potato varieties *viz.* Kufri Bahar, Kufri Ganga, Kufri Pukhraj, Kufri Khyati, Kufri Anand, Kufri Sindhuri, Kufri Chipsona-3, Kufri Mohan, Kufri Chipsona-1 and Kufri Garima. Total phenols in organic potatoes ranged between 32 (Kufri Bahar) - 68 (Kufri Mohan) mg/100g FW and between 38 (Kufri Anand) - 79 (Kufri Garima) mg/100g FW in inorganic potatoes. Organic potatoes of cv. Kufri Pukhraj, Kufri Khyati and Kufri Mohan contained more phenols as compared to inorganic potatoes. Anthocyanin content ranged between 1.69 (Kufri Anand) - 3.17 (Kufri Chipsona-3) µg/g FW in organic potatoes and between 1.30 (Kufri Mohan) - 4.40 (Kufri Pukhraj) µg/g FW in inorganically grown potatoes. Varieties Kufri Bahar, Kufri Ganga, Kufri Chipsona-3, Kufri Mohan and Kufri Garima contained more anthocyanin content when grown under organic cultivation **(Fig. 7)**. Ascorbic acid ranged between 28 (Kufri Pukhraj) - 54 (Kufri Chipsona-1) mg/100g FW in organic potatoes. In inorganic potatoes, it varied from 24 (Kufri Anand) to 55 (Kufri Chipsona-1) mg/100g FW. Six varieties *viz*. Kufri Bahar, Kufri Ganga, Kufri Khyati, Kufri Anand, Kufri Sindhuri and Kufri Mohan contained more ascorbic acid in organic potatoes as compared to inorganic ones **(Fig. 8)**.

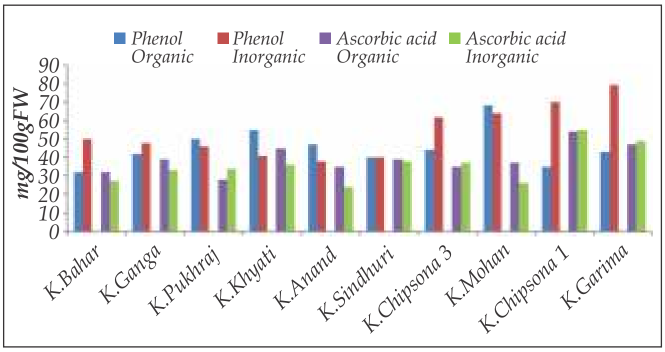


Fig. 7: Glucose content in organic and inorganic potatoes

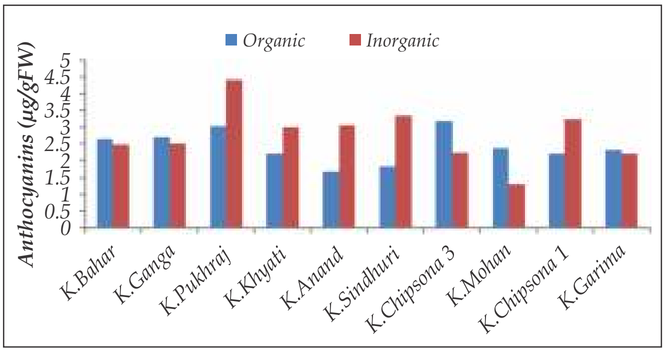


Fig. 8: Anthocyanins in organic and inorganic potatoes

BRCs in organic potatoes ranged between 0.22 (Kufri Chipsona-1) - 0.53 (Kufri Ganga) mg/g FW and in inorganic potatoes from 0.31 (Kufri Ganga) to 0.66 (Kufri Khyati) mg/g FW. Only Kufri Ganga showed higher BRCs concentration under organic cultivation. BRCs were more in inorganic potatoes of rest of the varieties **(Fig. 9)**.

Protein content ranged between 0.58 (Kufri Mohan) - 1.53 (Kufri Chipsona-1) per cent on fresh weight basis in organic potatoes. In inorganic potatoes, it varied between 0.94 (Kufri Mohan) - 1.84 (Kufri Chipsona-1) per cent. Varieties Kufri Bahar and Kufri Garima showed higher protein content under organic cultivation **(Fig. 8)**. Total amino acid content ranged between 90 (Kufri Anand) - 300 (Kufri Mohan) mg/100g FW in organic potatoes. This trait was reported higher in inorganic potatoes among all varieties and it ranged between 266 (Kufri Anand) - 514 (Kufri Mohan) mg/100g FW **(Fig. 10)**. Similarly, glutamine content was higher in all cultivars grown under inorganic nutrition as compared to organic one. Free glutamine content in organic boiled potatoes ranged between 34 (Kufri Garima) - 73 (Kufri Mohan) mg/100g FW, while in inorganic boiled potatoes it ranged between 65 (Kufri Sindhuri) - 147 (Kufri Chipsona-3) mg/100g FW **(Fig. 11)**.

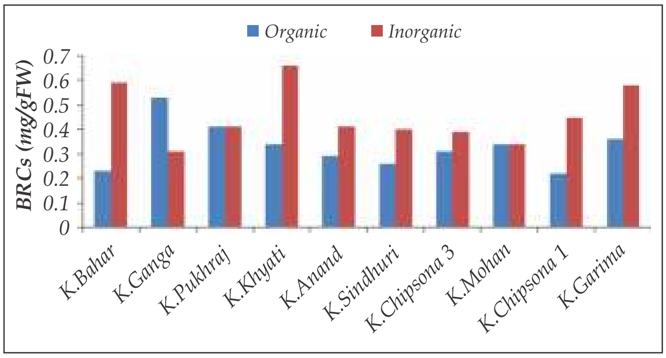


Fig. 9: BRCs in organic and inorganic potatoes

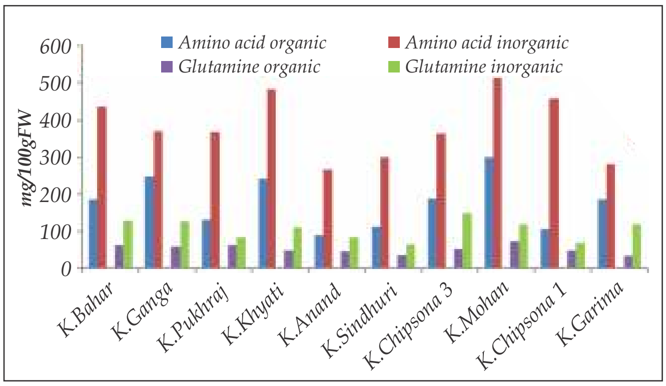


Fig. 10: Amino acids (raw tubers) and glutamine (boiled tubers) in organic and inorganic potatoes

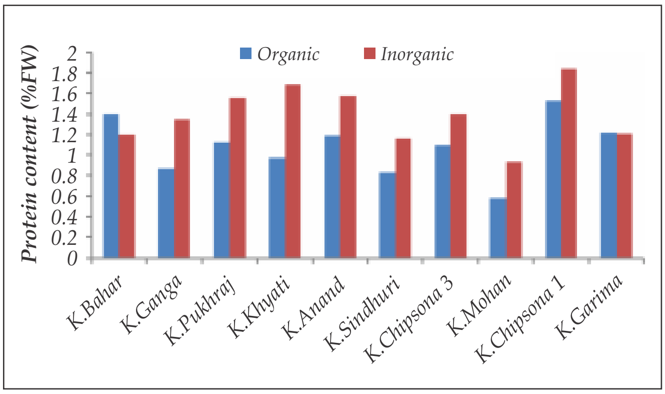


Fig. 11: Protein content in organic and inorganic potatoes

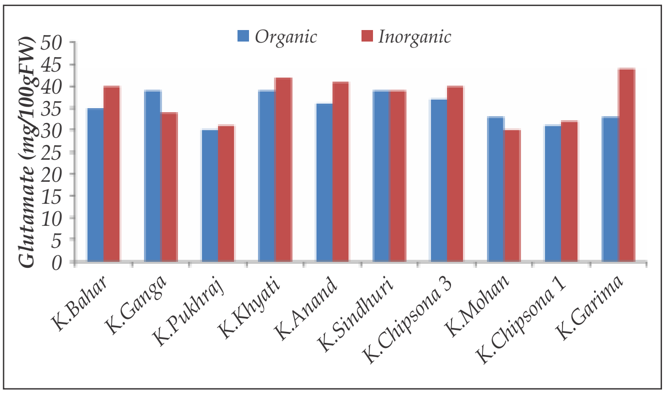


Fig. 13: Glutamate in organic and inorganic potatoes

Flavouring compounds *viz*. AMP+GMP varied between 0.51 (Kufri Garima) - 5.04 (Kufri Khyati) µg/g FW in microwaved organic potatoes. In microwaved inorganic potatoes, these compounds varied between 1.47 (Kufri Garima) to 6.64 (Kufri Khyati) µg/g FW. The varieties Kufri Pukhraj and Kufri Mohan contained more concentration of AMP+GMP in organic potatoes **(Fig. 12)**.

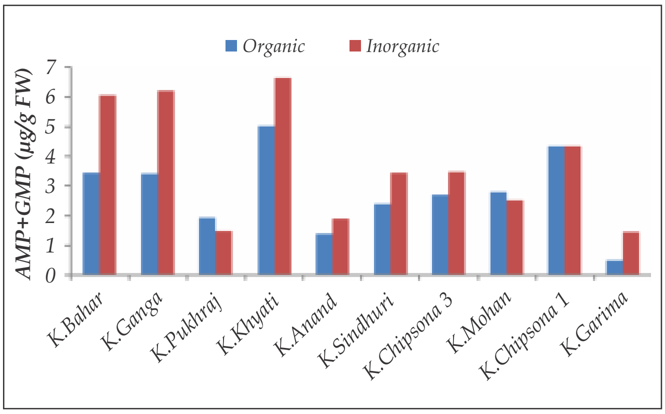


Fig. 12: Flavouring compounds AMP+GMP in organic and inorganic potatoes

Glutamate that is also considered as a main flavouring compound in potato, ranged between 31 (Kufri Chipsona-1) - 39 (Kufri Ganga and Kufri Sindhuri) mg/100g FW in boiled organic potatoes. In boiled inorganic potatoes, glutamate ranged between 30 (K. Mohan) - 44 (K. Garima) mg/100g FW. Cv. Kufri Ganga and Kufri Mohan contained higher glutamate content in organically grown potatoes **(Fig. 13)**.

Total amino acids and glutamine were only parameters which showed significant differences between organic and inorganic potatoes. Differences in rest of the parameters were quite low for organic and inorganic potatoes. Also the results showed that some varieties were more responsive under organic cultivation than inorganic nutrition.

Developing organic potato production technology for north-eastern region: An experiment at Shillong depicted significant variations between different sources of plant nutrients in respect to growth and yield parameters **(Fig. 14)**. The results showed that crop receiving 50% of recommended dose of N through FYM and remaining 50% N through vermi-compost positively influenced graded and total tuber yield of cv. Kufri Girdhari (14.5 t/ha).

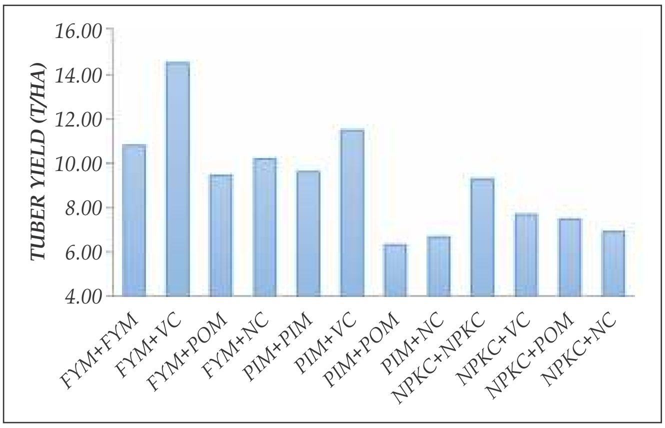
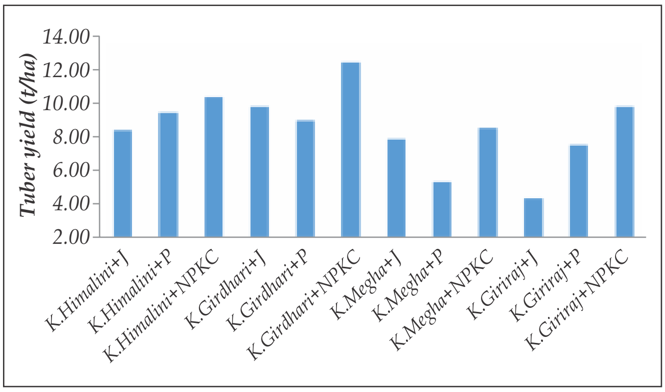


Fig. 14: Effect of organic nutrition on tuber yield (t/ha) in K. Girdhari

In another study at Shillong performance of four high yielding potato varieties (Kufri Himalini, Kufri Megha, Kufri Girdhari and Kufri Giriraj) was evaluated for soil and foliar application of Jiwamritha (10%), Panchagavya (3%) and N-P-K consortia (1%). No statistically significant differences were observed in tuber yield (t/ha) with soil or foliar application. Soil application in combination with foliar spray of N-P-K consortia produced highest yield of 12.5 t/ha in K. Girdhari **(Fig. 15)**.



(J: Jiwamritha; P - Panchakavya and NPKC- NPK consortia)

Fig. 15: Effect of soil application and foliar spray of organic compounds on tuber yield (t/ha)

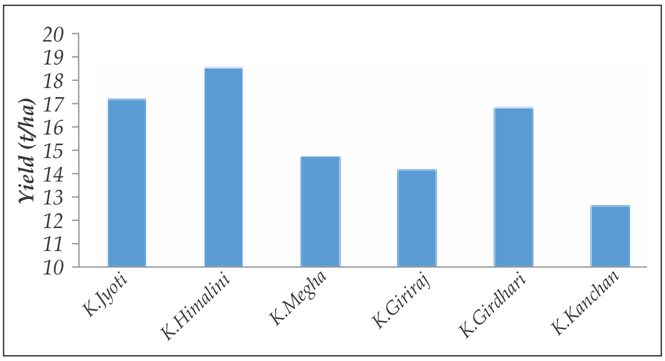


Fig. 16: Performance of promising potato varieties in Meghalaya

Evaluation of table potato varieties for commercial cultivation in Meghalaya: Performance of table potato varieties viz., Kufri Himalini, Kufri Girdhari, Kufri Jyoti, Kufri Megha, Kufri Kanchan and Kufri Giriraj was evaluated for commercial cultivation in Meghalaya with recommended dose of N-P-K (140-120-60 kg/ha). Variation among varieties was observed in growth and yield parameters **(Fig. 16)**. Kufri Himalini (18.6), Kufri Jyoti (17.3), Kufri Girdhari (16.9), Kufri Megha (14.8) and Kufri Giriraj (14.2) recorded significantly higher total tuber yield (t/ha) over Kufri Kanchan (12.7).

Evaluating the efficacy of bio-fungicide for late blight management: A field trial was conducted at Shillong during summer season of 2019 to study the efficacy of bio-pesticides *viz*. Biofor PF, Biozin PTB, Bioveer (P), Bioveer (L) obtained from AAU, Jorhat, and *Trichoderma harzianum* and *Pseudomonas fluorescens* from SBCL, Shillong for management of late blight in potato **(Fig. 17 and 18)**. The experiment was conducted in natural epiphytotic conditions using Kufri Jyoti variety as a test crop. Results revealed that none of the evaluated bio-pesticides when used singly gave partial or complete protection to crop against late blight. Maximum yield was recorded with Biozin (20.9 t/ha) biopesticide followed by Bioveer (P) (20.5 t/ha) as compared to control (14.0 t/ha).

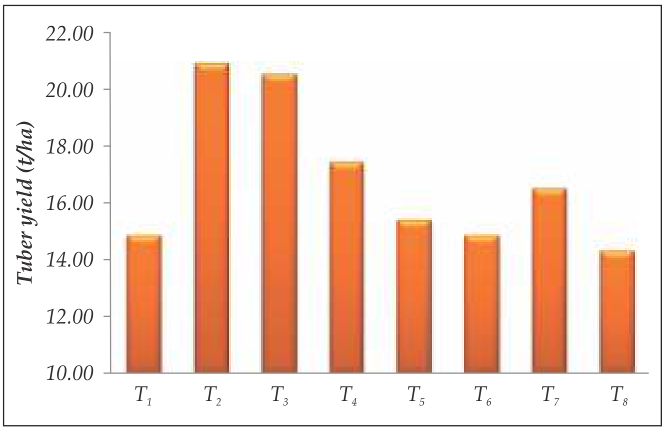


Fig. 17: Effect of different bio-fungicides on potato tuber yield (t/ha)

Development of potato based cropping systems for different agro-ecologies

Evaluation of potato based cropping systems at Gwalior: Inclusion of green manure in rotation and

Fig. 18: Preparation of bio-fungicide formulation for soil application

organic amendments benefit potato through their effect on soil structure and organic matter, water holding capacity and root development and other 'non-nutrient' benefits as well as through direct nutrient effects. These benefits can persist for many years after a single amendment application. At Gwalior, rice was grown under four treatment combinations *viz*. recommended NPK level, crop residue, zero budget and control. Among all the treatments highest rice yield was recorded with zero budget (2.7 t/ha) followed by crop residue application (1.9 t/ha), control (1.0 t/ha) and recommended NPK (0.8 t/ha) under upland system. Lowest yield under recommended NPK treatment was associated highest damage of blast and lodging before flowering as vegetative growth was also highest in this treatment. Three organic and one inorganic treatment in different combinations was tried for potato **(Fig. 19)**.

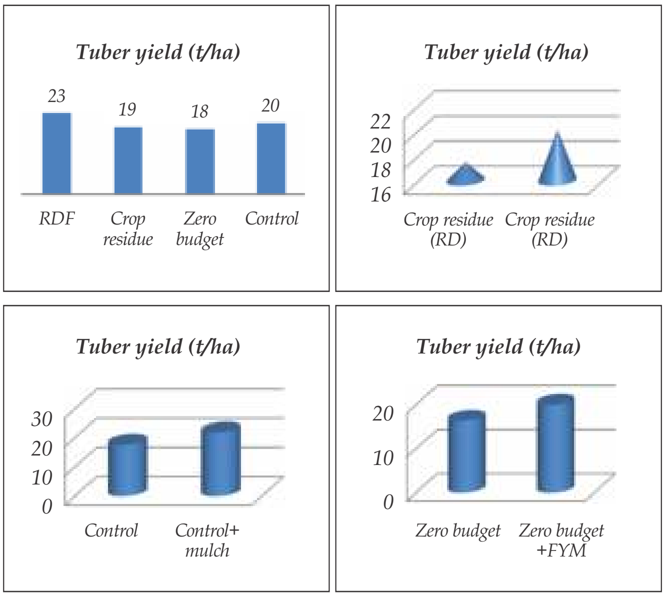


Fig. 19: Tuber yield as affected by different organic and inorganic treatments

Potato was planted after harvest of rice. Among four treatments, highest tuber yield (23.0 t/ha) was recorded in recommended NPK followed by control (19.0 t/ha) and crop residue (18.0 t/ha). Lowest tuber yield was recorded under zero budget farming. Application of higher dose (HD) crop residue (50 t/ha) recorded 20.0 t/ha tuber yield which was 17% higher than recommended crop residue (25.0 t/ha). Application of paddy straw mulch resulted in 11% higher tuber yield (22.0 t/ha) over non mulch (18.0 t/ha). Application of FYM in combination with zero budget resulted in 25% higher tuber yield (20.0 t/ha) over conventional zero budget (16.0 t/ha).

Long term plant nutrition studies in potato based cropping systems

In twelfth crop cycle, 100% inorganic treatment produced total tuber yield (27.1- 31.0 t/ha) which was comparable to 100% inorganic nutrition+ secondary/ micro nutrients or crop residue in rice-potato- wheat and groundnut- potato- green gram system. Combination of 100% inorganic nutrition+ secondary/ micro nutrients combination resulted in better tuber (31.8) and system productivity (66.7) in maize- potato- onion cropping system as compared to 100% inorganic nutrition, which recorded 29.6 and 57.4 t/ha of tuber and system yields, respectively. Absolute control (no fertilizer input) produced tuber yields of 7.1- 9.1 t/ha under different cropping systems. Under 100% organic nutrition, potato crop could maintain 49.3- 64.5% productivity followed by onion (85.8%) in comparison to 100% inorganic treatment. Productivity of rice, wheat, maize, groundnut and green gram was similar in organic and inorganic nutrition. Mean system productivity was highest in maize-potato-onion (47.7 t/ha) followed by rice-potato-wheat (46.4 t/ha), while lowest system productivity (39.1 t/ha) was observed in groundnut-potato-green gram sequence **(Fig. 20 to 22)**.

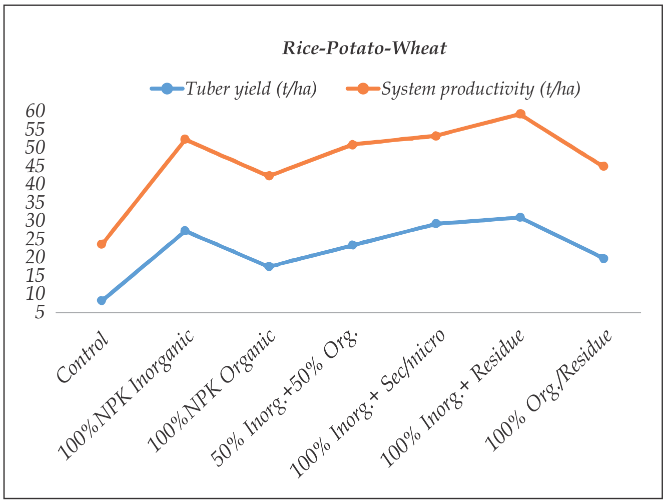


Fig. 20: Plant nutrition effect on tuber and system productivity

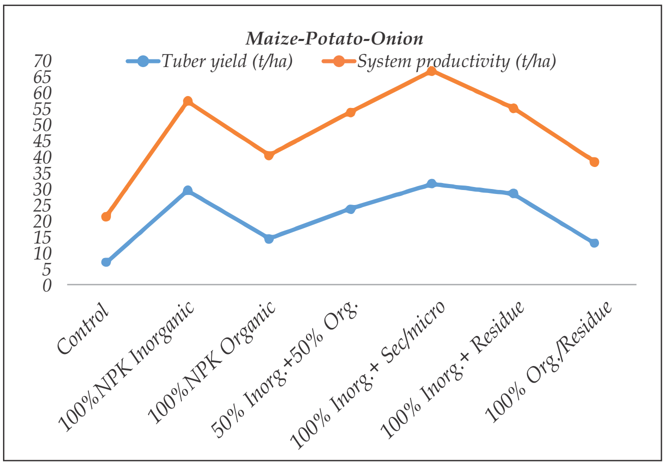


Fig. 21: Plant nutrition effect on tuber and system productivity

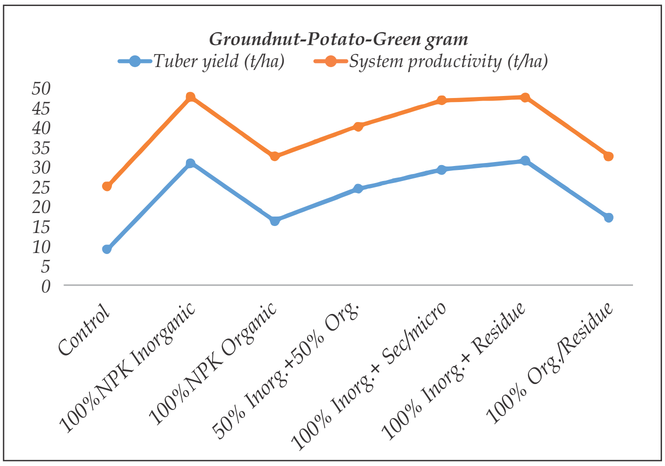


Fig. 22: Plant nutrition effect on tuber and system productivity

Soil Health: Physico-chemical study of soil from long term fertility experiment was carried out by taking fifteen parameters into consideration. These were % soil moisture content (SMC), pH, electrical conductivity (EC: dS/m), total dissolved salts (TDS), % organic carbon content (OC), available N (AN: kg/ha), P (AP: kg/ha) and K (AK: kg/ha)n Total N (TN: %), P (TP: %) and K (TK: kg/ha) were also estimated **(Table 1)**. Among micro-nutrients, available Zn (ppm), Cu (ppm), Fe (ppm) and Mn (ppm) were analysed. All samples in this study were collected from three treatments i.e. no fertilizer (control), 100% recommended NPK through chemical fertilizer and 100% recommended NPK through organic manures. Long term application of chemical fertilizers increased soil pH and organic manures decrease the soil pH and improved SMC. Organic nutrition increased EC, TDS and %OC. Availabile contents of N, P and K was not markedly influenced by source of nutrition. Total N and P were highest in organic treatment, while total K was highest in control.

Disease incidence: Sources and amount of plant nutrients influence pathogens hence incidence of diseases in rice, maize, groundnut, onion, wheat and green gram in three cropping systems *viz.* potato-wheat-paddy (C1), potato-onion-maize (C2) and potato-green gram-groundnut (C3) was studied **(Fig. 23)**. In paddy crop of C1 system, highest disease incidence (DI) of sheath blight was recorded in treatment of 50% NPK organic + 50% inorganic (41.11%) followed by 100% NPK through inorganic + crop residue (38.89%). Highest incidence of *bakane* disease was observed in treatment of 100% NPK through inorganic + crop residue (12.78%) followed by 100% NPK through inorganic fertilizer (12.60%). Maximum severity of brown spot was recorded in control (no nutrient applied) followed by 100% NPK organic + crop residue. In maize crop of C2 system, highest incidence of banded sheath blight was recorded in 100% NPK through inorganics (32.22%) followed 100% NPK through inorganic + secondary nutrient **(Fig. 24).** Incidence of *Alternaria* leaf spot of onion was also observed in this sequence. In groundnut crop of C3 system, disease severity of leaf spot and dry root was observed. Maximum disease severity of leaf spot was recorded in 100% NPK organics +

Table 1: Physico-chemical analysis of soil in long term fertility experiment

Treatment	SMC (%)	pH	EC (dS/m)	TDS (ppm)	OC (5)	AN (kg/ha)	AP (kg/ha)	AK (kg/ha)	TN (%)	TP (%)	TK (%)
Organic	12.94^{a}	6.77^{c}	0.14^{a}	91.5^{a}	0.47^{a}	148.9^{a}	49.6^{a}	265.8^{a}	0.84^{a}	1.63^{c}	7571^{b}
Inorganic	7.81^{b}	7.80^{b}	0.09^{b}	63.1^{b}	0.29^{b}	140.1^{a}	45.3^{a}	279.8^{a}	0.69^{b}	1.61^{b}	7399^{b}
Control	8.69^{a}	7.90^{ab}	0.09^{b}	55.5^{b}	0.26^{a}	142.2^{a}	26.7^{b}	222.1^{a}	0.63^{a}	1.57^{a}	10998^{a}

crop residue (45.00%) followed by 100% NPK through organic manure **(Fig. 25)**. Similarly, highest dry root disease incidence was found in treatment of 100% NPK organics+ crop residue (40.00%). Incidence of dry root rot of green gram (2-5%) also occurred in C3 system.

Pest Incidence: Population of thrips in groundnut, % stem borer damage in maize, and % leaf folder and stem borer damage in rice did not differ significantly among various treatments. However, maximum incidence of blister beetle was recorded in ground nut in 100% NPK+ secondary nutrients followed by 100% NPK+ crop residue. Similarly, highest incidence of leafhoppers in groundnut was recorded in 100% organic+ crop residue. Incidence of whitefly and thrips was observed in green gram and onion crops, respectively. Sporadic incidence of pod borer was also recorded in green gram. Maximum bird damage in maize cobs was recorded in treatments of 100% organic + crop residue. Population buildup of leafhopper and mite was observed in potato crop. Whitefly incidence in potato did not show significant differences among different treatments of C1, C2 and C3 cropping systems, however, in C1 and C2 systems, 50% organic + 50% inorganic treatment recorded maximum incidence of whitefly. It was maximum in 100% NPK inorganic in C3 system **(Fig. 26 to 28)**. Cutworm damage (%) in tubers was highest in 100% NPK + secondary nutrients in C3, in 100% organic in C2 and in 100% organic + crop residue in C1 cropping system **(Fig. 29)**.

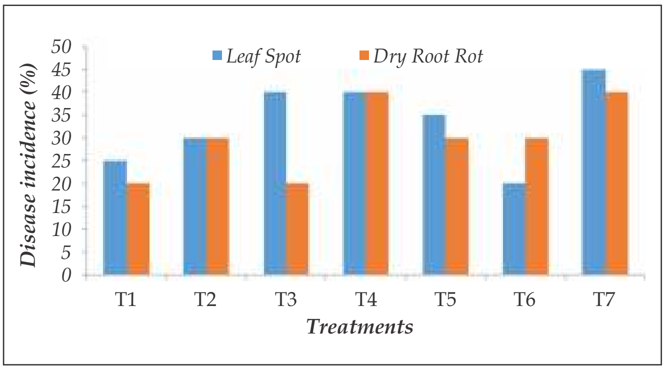


Fig. 25: Incidence of leaf spot and dry root rot of groundnut (potato-green gram-groundnut)

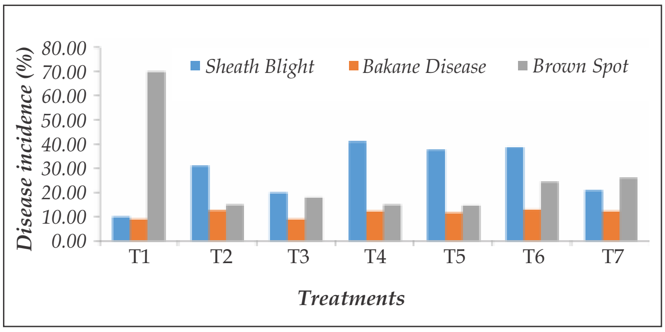


Fig. 23: Incidence of sheath blight, *bakane* disease and brown spot of rice in potato-wheat-paddy cropping system

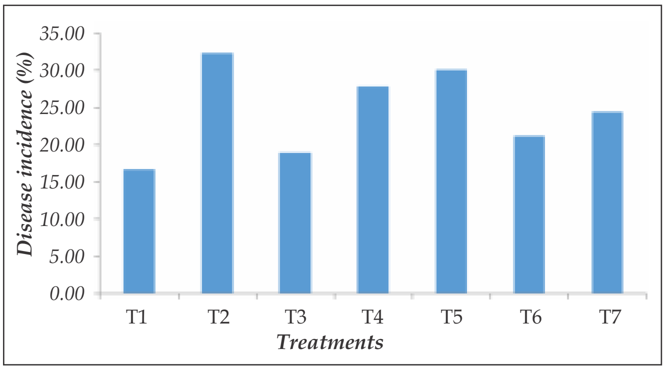


Fig. 24: Incidence of banded sheat blight of maize in potato-onion-maize cropping system

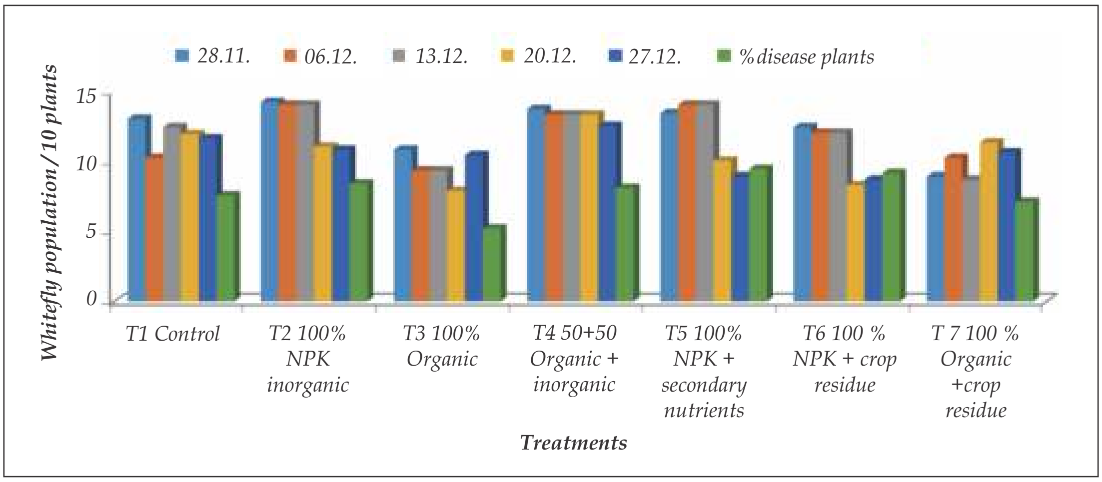


Fig. 26: Whitefly population in potato and % disease plants (potato-green gram-groundnut)

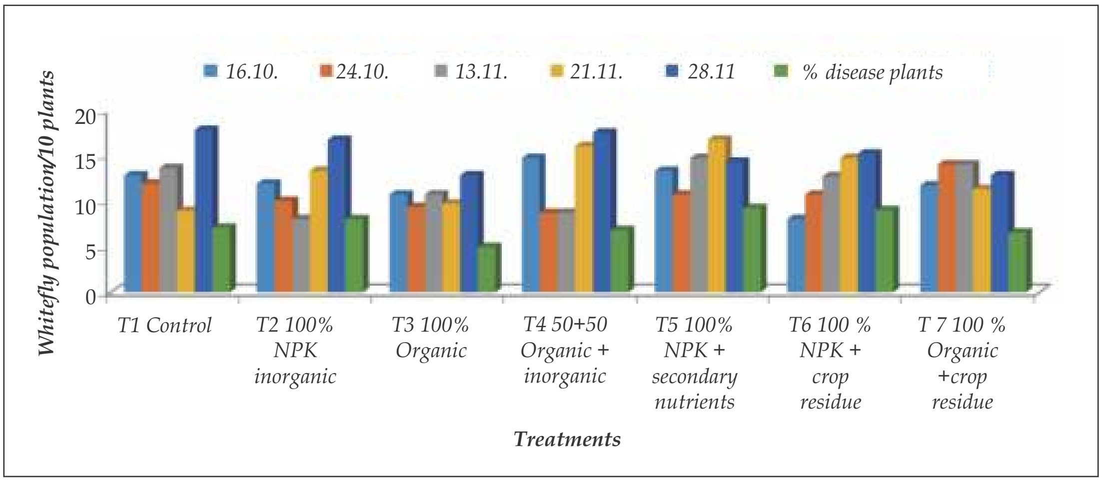


Fig. 27: Whitefly population in potato and % disease plants (potato-onion-maize)

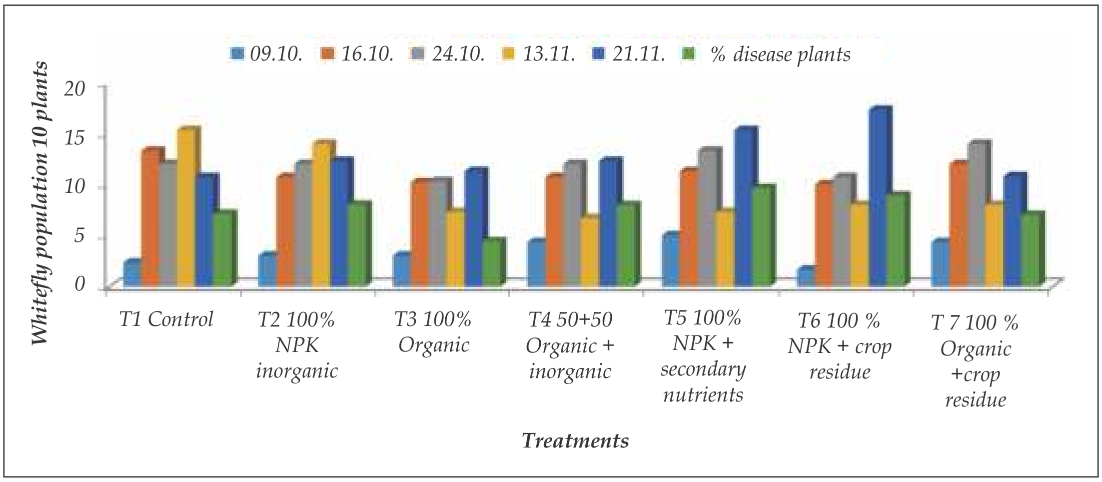


Fig. 28: Whitefly population in potato and % disease plants (potato-wheat-rice)

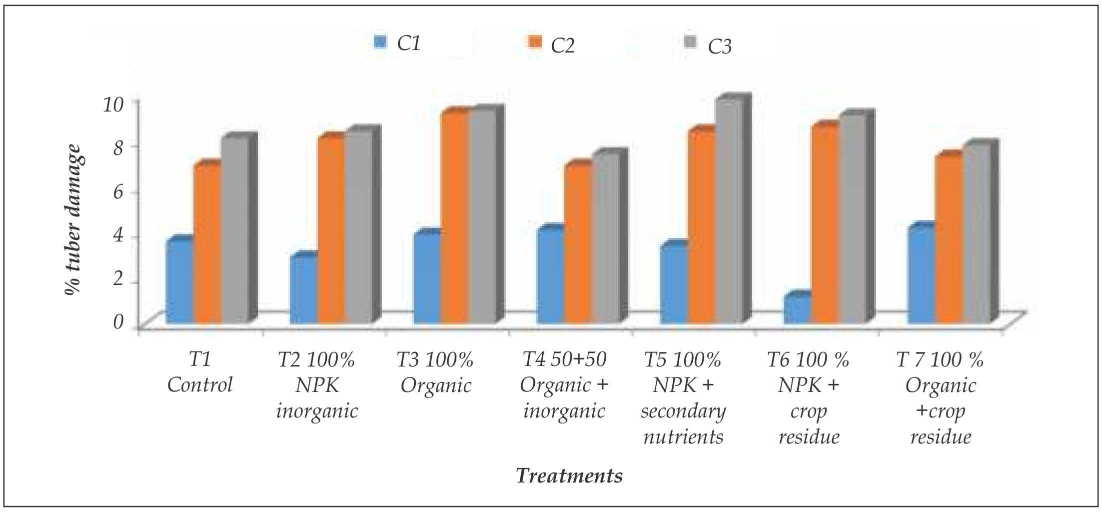


Fig. 29: Cutworm damage (%) in potato in different cropping systems

Development of agro-techniques for potato crop and popularization of new potato cultivars suitable for *kharif* season

Optimizing phosphorus requirement of potato cultivars suitable for *kharif* season: For optimizing phosphorus dose for three cultivars *viz*. Kufri Jyoti, Kufri Himalini and Kufri Surya a field experiment was conducted during 2019-20 at Hassan, Karnataka with five levels of P_2O_5 (0, 40, 80, 120 and 160 kg/ha). Nitrogen and potassium were applied uniformly at the rate of 150 and 125 kg/ha, respectively in all the plots. Variety Kufri Surya produced highest tuber yield (22.6 t/ha) when P_2O_5 was applied at 40 kg/ha, whereas, maximum yield in Kufri Jyoti (10.8 t/ha) and Kufri Himalini (24.0 t/ha) was observed at 120 kg P_2O_5 /ha **(Fig. 30)**. Amongst varieties, yield of Kufri Jyoti was lowest yield (8.24 t/ha).

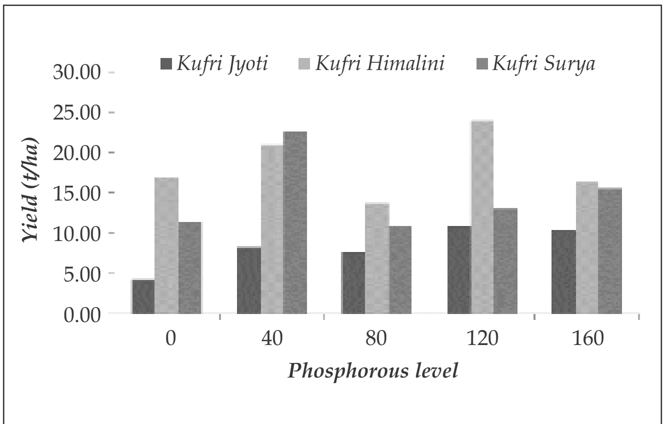


Fig. 30: Response of potato varieties to different levels of phosphorus at Hassan

Optimizing potassium requirement of potato cultivars suitable for *kharif* season: Field study was conducted at Hassan, Karnataka for optimizing potassium doses of three cultivars *viz*. Kufri Jyoti, Kufri Himalini and K. Surya with five levels of K_2O (0, 50, 100,150 and 200 kg/ha). Nitrogen and phosphorous were applied uniformly at the rate of 150 and 100 kg/ha, respectively in all the plots. Cultivar K. Surya recorded highest tuber yield (17.8 t/ha) when K was applied at 150 kg/ha, whereas maximum tuber yield was observed in Kufri Jyoti (13.5 t/ha) and Kufri Himalini (26.6 t/ha) at 200 kg /ha level **(Fig. 31)**. Variety K. Himalini had highest mean tuber yield (23.8 t/ha), whereas Kufri Jyoti attained the lowest yield (10.9 t/ha)

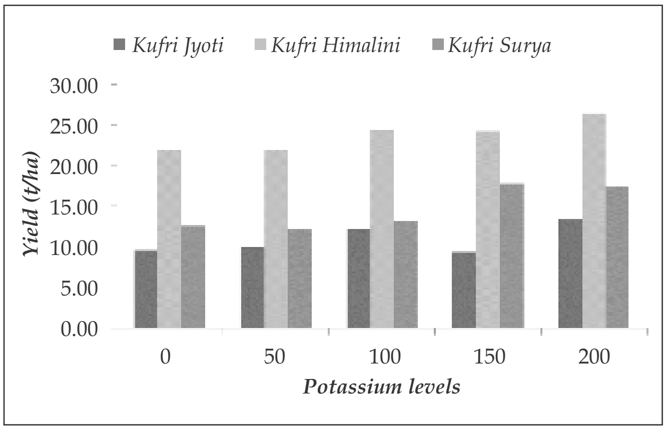


Fig. 31: Response of potato varieties to different potassium levels at Hassan

Mechanical technologies for potato cultivation

Assessment of potato damage during harvesting and post-harvest handling: A tractor operated two row potato elevator digger was tested at three forward speeds for assessment of damage to tubers. Samples were collected, and categorized as undamaged, scuffed, slight and severe **(Fig. 32)**. Similarly, bruising assessment of potato tubers at optimum speed of digger was done **(Fig. 33)**. One of the most common causes of mechanical damage to tubers is shock and impact during mechanical handling. A test was also performed in order to simulate the mechanical damage caused by all tumbling and dropping during harvest and handling operations. Tubers of Kufri Pukhraj were dropped from various heights (30, 60, 90 and 120 cm) onto a hard surface in order to perform damage to tubers. External damages (40%) were maximum when dropped from a height of 120 cm. Highest severity bruising (30%) was also observed when tubers were dropped from a height of 120 cm.

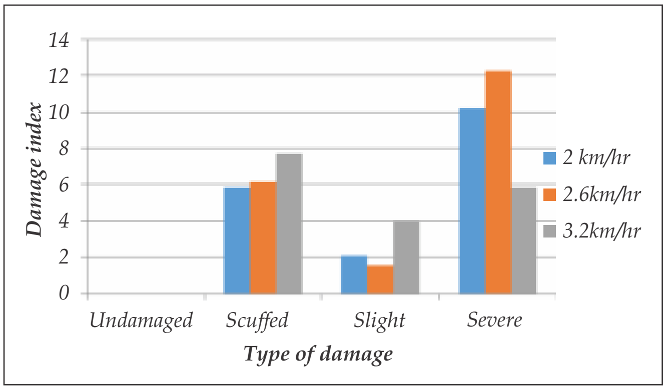


Fig. 32: Damage index of K. Pukhraj at three speeds of operation

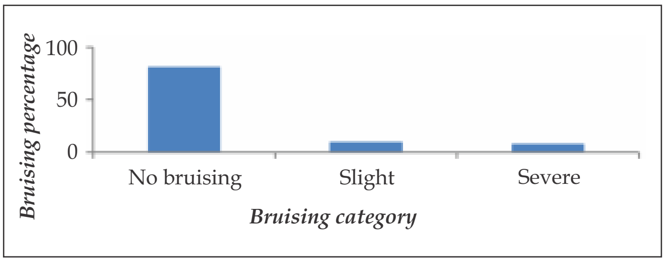


Fig. 33: Bruising assessment with potato elevator digger in K. Pukhraj

Solar drying unit: Drying of potato chips/ shreds/ sticks is very important component in potato processing. This operation consumes a lot of energy in the form of electricity or fossil fuel. Hence, solar energy is a potential source which can be harnessed for potato processing. Three solar drying units have been developed for drying of potato products having three different configurations of covering materials. These units have been fabricated with steel structure. Unit-I is covered with two layers of thick polycarbonate sheet (6.0 mm). Unit-II is covered with 200 micron single layer polythene sheet. Unit III has double layered polythene sheet and is equipped with a component for providing insulated air gap between two layers. Each of the units are provisioned with two exhaust fans with humidity sensors for flushing out the humid air, and also to maintain desired humidity level inside the drying unit. Air exhaust system is automatically controlled with humidity sensor. Three stage perforated SS racks are installed inside the drying units for keeping raw material for drying purpose. It was observed from preliminary trials that temperature inside all the drying units was approximately 15- 22 °C higher than the ambient temperature. These units have to be further tested for their performance and capacity.

Soilless seed potato production unit: A soilless crop growing structure has been developed for quality seed potato production **(Fig. 34)**. It includes insect proof net house, high density polyethylene troughs for crop raising, soilless media and steel structure for providing mechanical support to the troughs above ground level. In this system, 1.0 m wide, 6.0 m and 1.0 m high steel structure of 15 mm hollow square pipes have been fabricated. HDPE troughs of 1.0 m width are installed on the steel structure to keep crop above ground level. In this system, coco peat and rice husk was used as soilless media for crop raising. Developed units were installed inside the 40 mesh net house to provide vector free environment to the plants. This system was designed to take two potato crops from tissue culture plants and three potato crops from minitubers in one season.

Fig. 34: Soilless system, media, crop and produce

Hand tools for potato cultivation: A number of innovative designs of hand tools have been developed at Jalandhar for the use in potato and other horticultural crops. Most of the tools are used for weeding and intercultural operations. However, some of them can be used for multipurpose operation for different crops. These tools are light in weight, which can be operated easily with less amount of drudgery and higher work output as compared to traditional tools. Three developed designs were tested in field and were finalized for upscaling and commercialization with the local manufacturers.

Refinement in potato cleaning, treatment, grading and drying line: A potato treatment and grading line has been developed to perform the post-harvest operations such as cleaning, sorting, treatment, drying, grading, packaging etc. It comprises of an inclined conveyor, brush type potato cleaning unit, liquid spraying system with closed canopy for seed treatment, hot air dryers, sorting platform, tuber grading unit etc. Several electric motors are installed with the system to power and control the operation of various systems. The machine can grade and treat about 10 ton of potatoes per hour. In first step testing, some shortcoming in drying and cleaning system were identified, which are to be improved in coming season **(Fig. 35)**.

Development of potato starch extraction machine: A starch extraction machine has been designed for potato processing. It is a small scale starch extraction unit. In this design very fine blade is installed at the center of machine which rotates and remove the material from whole potato and further separates starch and other dry matter. This system is under fabrication in the engineering section of the station.

Development of transparent aeroponic system: A transparent aeroponics system (150 x 60 x 120 cm) was developed and tested successfully for study, display and experimental purpose. Unit consists of a transparent grow box, culture panel, hydraulically movable canopy management system, LED lights, inbuilt power back up, twin pumps, electrical control panel and nutrient solution chilling unit **(Fig. 36)**.

Fig. 35: Testing of cleaning, sorting, grading and drying line at Modipuram

Fig. 36: Portable complete unit of aeroponics

DIVISION OF PLANT PROTECTION

PROGRAMME: RE-DEFINING EPIDEMIOLOGICAL PARAMETERS AND MANAGEMENT APPROACHES FOR POTATO PATHOGENS

Disease Monitoring and Pathogens Profile

This was blight year and late blight appeared in almost all potato growing areas with varying intensity due to untimely rains during the cropping season. In Himachal Pradesh, appearance of late blight was delayed by 5 days as compared to last year. This year blight appeared on 11th July, 2019 on cv. Kufri Jyoti in Shimla hills and its overall severity ranged from 30-100% depending upon the cultivar raised and plant protection measures adopted. Late blight was observed in Alipur, Meerut, western UP on 14th December, 2019 on cv. Kufri Bahar and disease severity was observed up to 60%. Late blight survey was carried out in the Meerut and Hapur districts where its severity was 60% and 40%, respectively. In Punjab, blight appeared during third week of November (21.11.2019) while in West Bengal it appeared during last week of December. This year blight was also appeared in Odisha. Due to early appearance of late blight in most of the major potato growing regions, 15-20% yield losses are expected **(Fig. 1).**

Fig. 1: Late blight infected fields

Dry rot (*Fusarium* spp) incidence of 26.67% and severity of 5.33% was observed in potato variety "Kufri Frysona" (untreated) at 15 days of harvest (harvested on 08.03.2019 at Himmatnagar, Gujarat) i.e. just before storage at 10-12°C at Himmatnagar (Gujarat), Jalandhar (Punjab), Mandi Govindgarh (Punjab) and Shimla (Himachal Pradesh). After six months of storage at this temperature, the average incidence and severity of dry rot increased to 63.3 and 26.0% at Shimla, 20.0 and 6.7% at Jalandhar, 51.09 and 19.11% at Mandi Govindgarh, and 45.5 and 16.36% at Himmatnagar, respectively. Isolations from diseased tissues yielded 85% *Fusarium sambucinum* and 15% other *Fusaria* isolates.

Comparative Genomics of Potato Pathogens

Characterization of Phytophthora infestans

It is essential to understand the pathogen variability to devise suitable management strategies. Since last four years, population of *P. infestans* is being monitored for sensitivity to cymoxanil, dimetho-morph and fenamidone fungicides and this year also all the tested isolates were observed to be sensitive to these new fungicides.

Complete genome sequencing of Groundnut bud necrosis virus (GBNV) infecting potato

Groundnut bud necrosis virus (GBNV) of potato is belong to genus *Tospovirus* and family *Bunyaviridae* **(Fig. 2A & C)**. Tospovirus is divided into four serogroups based on serological relationships and nucleocapsid protein sequence homology with *Tomato spotted wilt virus* (TSWV), the type member of this genus. The virions are enveloped, quasi-spherical particles of 80–120 nm in diameter that encapsidate three negative stranded RNA genomes **(Fig. 2B)**. The Large (L), Medium (M) and Small (S) RNA encode essential proteins for viral survival (B). Since isolates of GBNV infecting potato were not available in the database, more than 20 different accessions of complete genomic RNA representing L, M and S RNAs of GBNV from various hosts were downloaded from NCBI **(Fig. 2D)**. These accessions were aligned with the reference sequences NC_003614.1, NC_003620.1 and NC_003619.1 available in the database. Further, the multiple sequence alignment was performed with Clustal X to find out conserved regions to develop primers to clone overlapping regions within the L, M and S RNAs **(Fig. 2E)**. A total of 28 overlapping primers set were developed manually from the corres-ponding regions includes L (15), M (8) and S (5). The amplicon length was adjusted between 700- 800 bp maximum for cloning in pCR TOPO vector for sequencing.

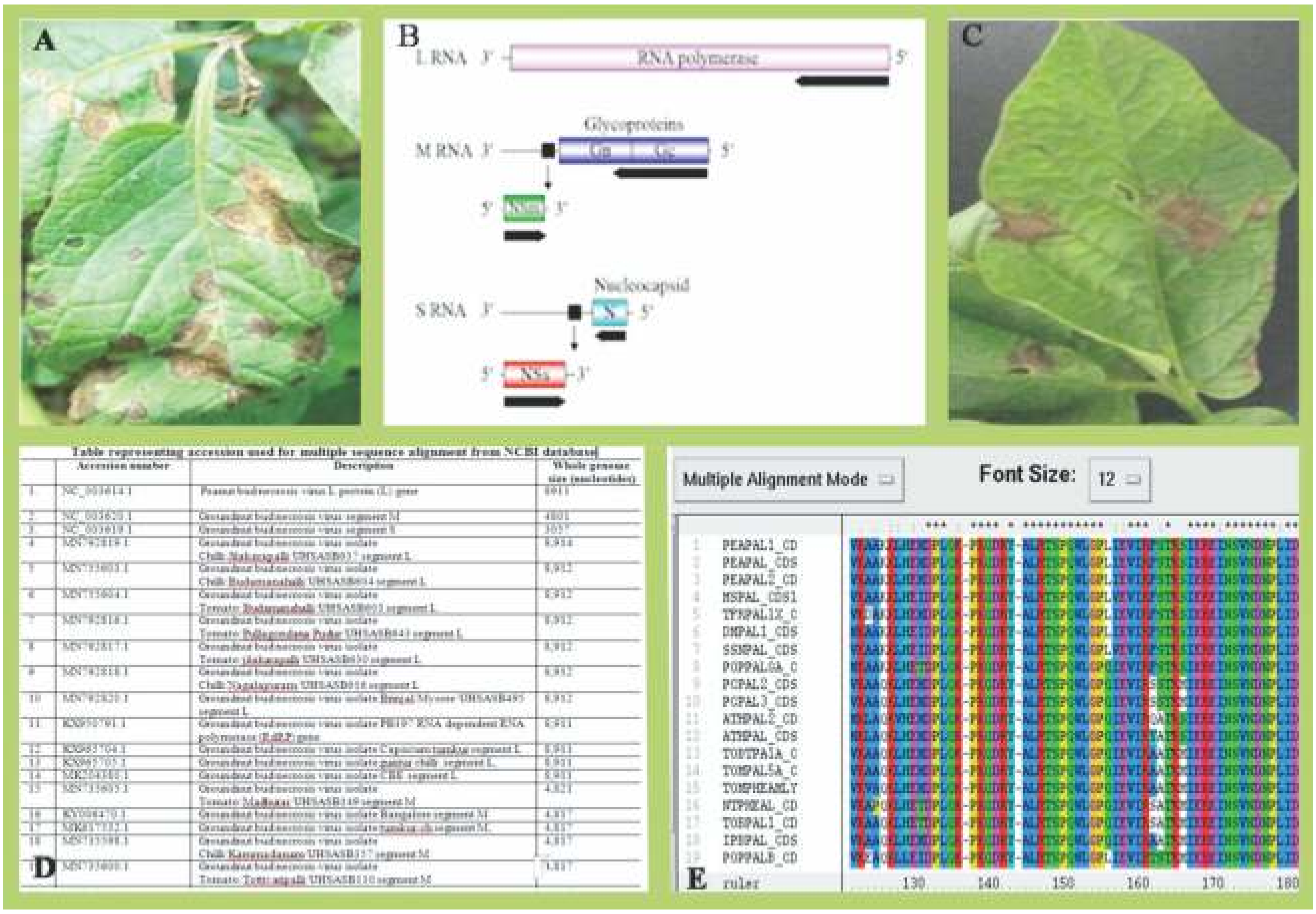


Fig. 2: Genome sequencing of Groundnut bud necrosis virus (GBNV)L, M & S RNA infecting potato.

Molecular Diagnostics and Detection of Potato Pathogens

Development of RT-LAMP assay for detection of Groundnut bud necrosis virus (GBNV)

Reverse transcription loop-mediated isothermal amplification (RT-LAMP) assay was developed for detection of *Groundnut bud necrosis virus* (GBNV) from potato. GBNV infected potato leaf sample was used as template (cDNA). Optimization of the LAMP assay was carried out with selection of primer, suitable temperature, incubation period, concentrations of $MgSO_4$, dNTP and *Bst* DNA polymerase. For visual detection of GBNV, SYBR gold nucleic acid staining dye was used where change in color from dark orange to fluorescent yellowish green indicated positive reaction. The developed LAMP assay was found specific as no cross reaction was observed with other potato viruses and healthy plant. The LAMP assay was 100 times more sensitive to that of RT-PCR assay **(Fig. 3)**. The assay was validated with 120 potato samples comprising tissue culture raised plants and randomly collected potato leaf samples from field.

Development of a visual detection method for PVM and PVS by reverse transcription loop-mediated isothermal amplification

A reverse transcription-loop mediated isothermal amplification (RT-LAMP) assay was developed for specific detection of PVS and PVM. Two sets of six novel primers that recognize the coat protein gene sequence of each PVS and PVM were designed and RT-LAMP assay was optimized using different concentrations of primers, $MgSO_4$, betaine, dNTPs, *Bst* DNA polymerase and temperature **(Fig. 4)**. The one step RT-LAMP was carried out using RNA for PVS under isothermal conditions using potato leaf samples infected with PVS, amplification at 65 ^{0}C for 60 min, and 80 ^{0}C for 5 min. The results were assessed by gel electrophoresis and visual observation of colour change using SYBR Green I dye. The sensitivity analysis showed an increased sensitivity (10^{-6}) i.e., up to 100 times more sensitive in comparison with RT-PCR (10^{-4}) assay. For PVM detection, the two steps RT-LAMP was carried out under isothermal conditions using cDNA from potato leaf infected with PVM, LAMP specific primers, amplification at 65 ^{0}C for 60 min, and 80 ^{0}C

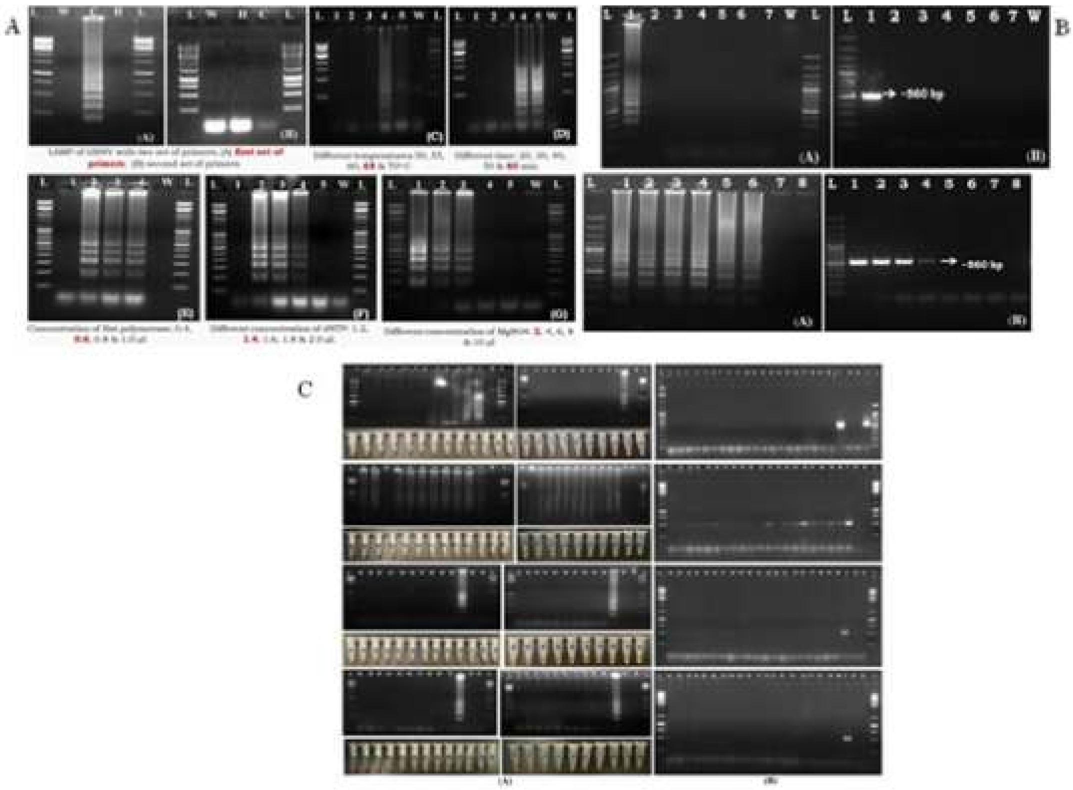


Fig. 3: Development of RT-LAMP assay for detection of GBNV from potato plants. (A) Optimization with respect to isothermal temperature, incubation period and its reaction mixture. (B) Cross-reactivity and sensitivity (C) Validation using potato leaf samples

for 5 min. RT-LAMP assays could successfully detect positive infected plant leaves and tubers samples, considering the time, safety, sensitivity and simplicity, whereas no cross-reactions were observed with healthy plants and other potato viruses.

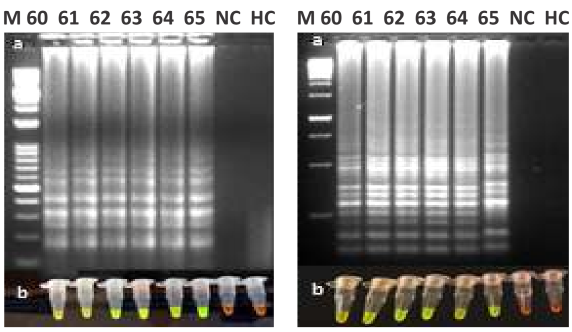


Fig. 4: Optimization of RT-LAMP for the detection of the PVS (left) and PVM (right). (a) Agarose gel electrophoresis of the RT-LAMP products. M-100bp ladder, lanes 1 to 6 (60, 61, 62, 63, 64 and 65^{0}C temperature, respectively), lane 7-water control and lane 8- healthy control. (b) Visualization of the RT-LAMP products under UV excitation at 365 nm. The tubes in (b) from left to right containing the RT-LAMP products and SYBR Green I are the same as those in lanes 1 to 8 in (a).

Recombinase polymerase amplification assay for rapid detection of a geminivirus associated with potato apical leaf curl disease

Recombinase polymerase amplification (RPA) assay was developed for specific detection of *Tomato leafcurl New Delhi virus*-potato (ToLCNDV-potato). The RPA assay was optimized with respect to its isothermal temperature, post-amplification treatment and its components of the reaction mix. The assay showed a clear and sharp expected amplicon at 40 °C for 30 min in the thermal cycle followed by post-amplification denaturation, i.e., heat treatment at 65 °C for 10 min. The target specificity of the developed assay was determined by sequencing the amplified product. The comparative sensitivity of the assay was ten times more than PCR **(Fig. 5)**. It was successfully applied for the detection of ToLCNDV-potato from tissue culture raised plants and also from tuber and sprouts **(Fig. 6)**.

Standardization and melt curve analysis of quantitative PCR method for detection of PSTVd

Presently the assay was developed to detect PSTVd in potato leaf samples. For standard curve

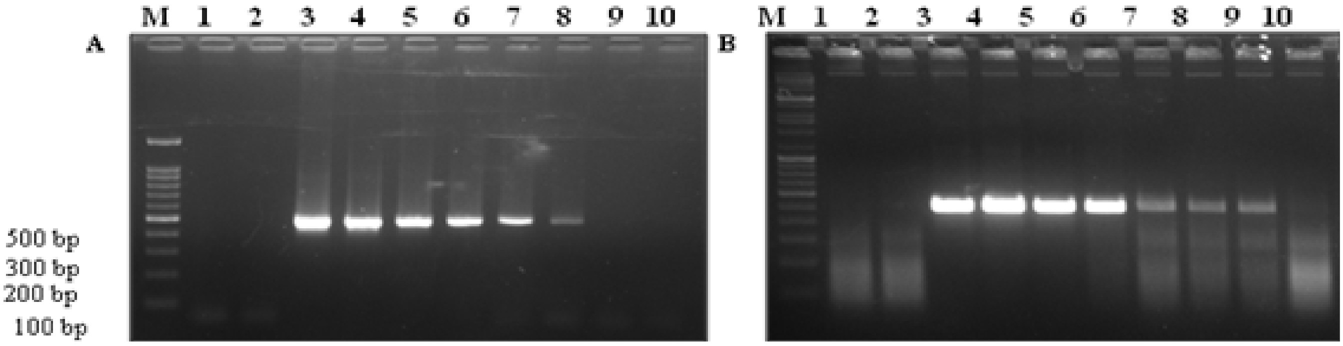


Fig. 5: Comparative sensitivity of RPA assay with PCR. (A) PCR based assay where, lane M DNA ladder, lane 1 no template control, lane 2 healthy control, lane 3 positive control and lanes 4-10 are dilution ranging from 10^{-1} to 10^{-7}. (B) RPA based assay where, lane M DNA ladder, lane 1 no template control, lane 2 healthy control, lane 3 positive control and lanes 4-10 are dilution ranging from 10^{-1} to 10^{-7}.

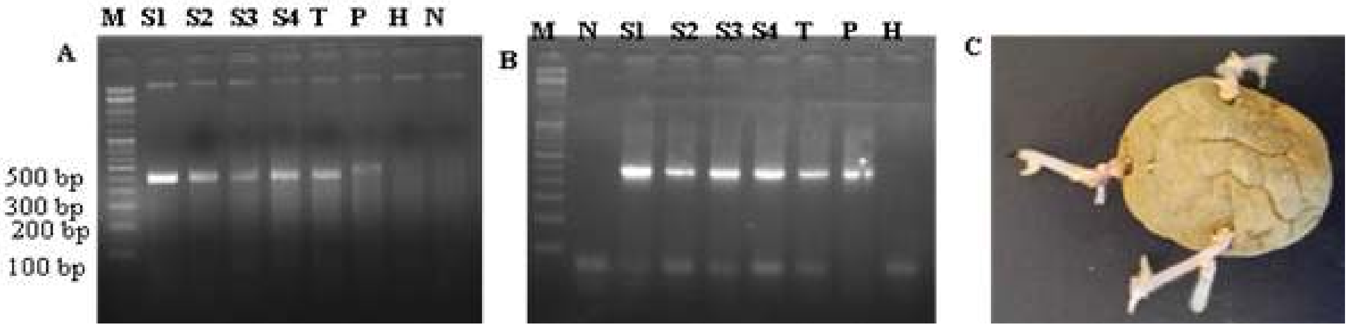


Fig. 6: Detection of ToLCNDV-potato from tubers and sprouts of potato by RPA assay where, (A) lane M DNA ladder, lane S1-S4 are sprouts, lane T is tuber, lane P-positive control, lane H-healthy control and lane W is No-template control. (B) The same samples were examined by PCR assay where the lanes are similar to that of A. (C) Sprouted tuber used in the study.

preparation, the cloned genomic RNA of PSTVd (pPSTVd::pCR4TOPO) is used as standard. The initial stock of plasmid DNA was 10 fold serially diluted and used as template in the reactions. The initial template concentration of the plasmid DNA was normalized with spectrophotometer and is estimated ~ 46.5 ng/µl, which corresponds to 2 x 10^{10} copies of PSTVd cloned genomic fragment. The estimated copy number of PSTVd genome in the dilution series from 2 x 10^{8} to 2x10^{2} copies/µl was determined for standard curve preparation. The average Cq values (triplicates) of each dilution in a real-time PCR reactions yielding 11.17 ± 0.02 - 30.57 ± 0.20 and in negative control which is de-voiding of template, the Cq remains undetermined. The amplification curves shifted to the right as the initial amount of the plasmid was reduced **(Fig. 7A & B)**. The correlation between the Cq and the amount of target template showed excellent linearity with an high coefficient of determination (y = -3.294x + 35.377, R^2=0.998) demonstrating that the assay has a dynamic range of at least 7 logs and is capable of detecting as few copies in the PCR reaction **(Fig. 7C)**. The results of the assay were analyzed by plotting the log of the template concentration against cycle threshold (Cq) values, using the formula E= [10 (−1/slope)−1] × 100 to calculate the PCR efficiency, where E is the amplification efficiency and the slope is derived from the plot of log of the template concentration against Cq. In qPCR experiments, the amplification efficiency of 95-110% is determined as good which generally corresponds as in every cycle the product is getting doubled. We observed a PCR efficiency of 101.18 % which is an indication of good qPCR assay. In order to analyze specificity of qPCR assays, the use of SYBR green chemistry provides this opportunity to generate a melt curve which revealed specific product amplification during real time PCR. We observed a single melt peak of each dilution (triplicates) with a Tm value of ~ 80.51°C **(Fig. 7D)**.

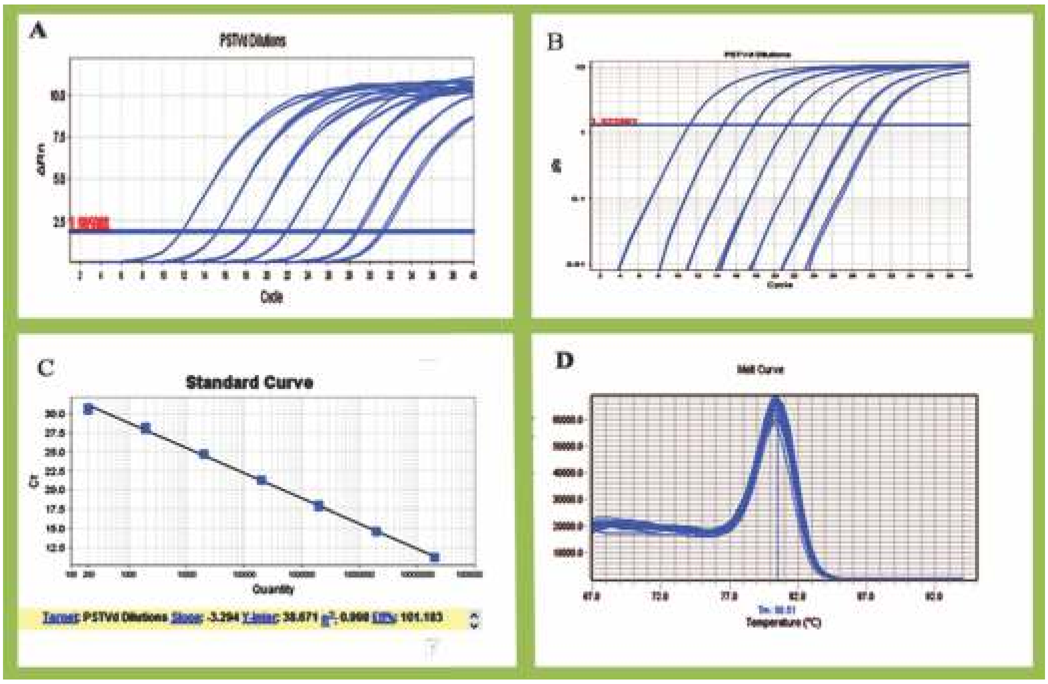


Fig. 7: Standardization and melt curve analysis of qPCR method for PSTVd

Application of RT-LAMP assay for detection of PSTVd in field samples

The specificity of the designed RT-LAMP for PSTVd was evaluated with other potato viruses and cross reaction was not observed with any of the tested potato viruses **(Fig. 8A & B)**. In addition, we performed a restriction digestion assay of the amplified products, in which, we identified *in silico* a single enzyme cut site within the targeted sequence. After digestion with *BamHI-HF* enzyme we were clearly able to see, two distinguished bands on an agarose gel of different sizes generated by enzymatic activity in the reaction. The major advantage of this method is to confirm target specificity of the reaction without undergoing sequencing of the products and moreover it is simpler to achieve in any low cost diagnostic laboratories. A total of 63 potato leaf samples with unknown etiology were evaluated by RT-LAMP assay in comparison to qPCR and RT-PCR assay for detection of PSTVd. RT-LAMP allowed detection of 23 samples **(Fig. 8C)** with PSTVd in agreement with

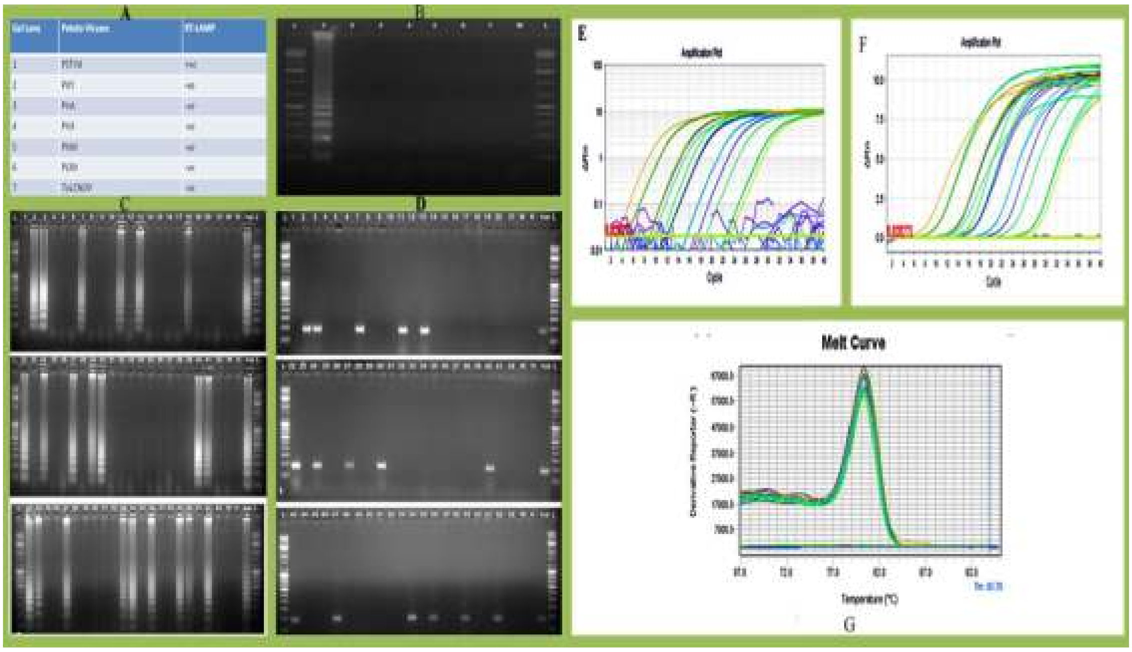


Fig. 8: Validation of PSTVd RT-LAMP assay

qPCR **(Fig. 8D)**. In addition, in qPCR assay we observed positive signal in total of 27 samples with Cq values ranging from 8.52 to 28.95. However, out of 63 potato samples, 16 were positive in RT-PCR assay **(Fig. 8E-G)** suggesting higher sensitivity of RT-LAMP and qPCR assay with respect to RT-PCR. The RT-LAMP assay provides the negative results in 40 samples in agreement with qPCR results. These results suggest RT-LAMP assay for detection of PSTVd in potato leaf samples is sensitive than conventional PCR as a gold standard.

Immunosorbent electron microscopic (ISEM) technique for detection of Potato aucuba mosaic virus

An Immunosorbent electron microscopic (ISEM) technique was developed for specific detection of *Potato aucuba mosaic virus* (PAMV) in potato. The virus is a single stranded RNA belonging to the genus *Potexvirus* and family *Alphaflexiviridae.* Upon infection, the potato plant shows bright yellow spots on the lower leaves, yellow necrotic spots, often leading to systemic or top necrosis. To examine the presence of virus particles, the potato leaves were crushed in phosphate buffer and a carbon coated copper grid was floated on to the extracted sap. Incubated at 37°C for 30 min followed by washing with double distilled water and stained with 2% freshly prepared uranyl acetate (UA). The excess stain was drained, air dried and examined under Transmission Electron microscope (120 kV-FEI make). The images were acquired where, we found elongated flexuous particles. Since, majority of the viruses infecting potato plants fall under the category of elongated flexuous, ISEM technique was adopted. A carbon coated copper grid was floated over a drop (10µl) of diluted IgG of PAMV (1:1000) which was placed on a piece of parafilm fixed on a glass slide and incubated for 30 min at 37°C. The grid was washed with 10-15 drops of double distilled water and excess water was drained using Whatman filter paper. The antigen or the virus was isolated from the potato leaves in phosphate buffer (1:2 v/w) and 10µl of the extract was placed on a parafilm fixed on a glass slide. The antibody coated grid was floated on leaf extract and incubated at 37°C for 10 min followed by draining of excess water. Finally the grid was stained with 2-4 drops of 2% freshly prepared UA. The excess stain was drained again, air dried and examined under TEM where the images showed flexuous particles measuring about 560 x 12 nm (**Fig. 9)**. This indicates that the potato plants were infected with PAMV. The ISEM can trap increased number of virus particles and reduced amount of host debris on the grid by making use of antigen and antibody trapping mechanism. The assay has advantage over traditional leaf dip method where it can specifically detect PAMV even in mixed infection of viruses with similar morphology.

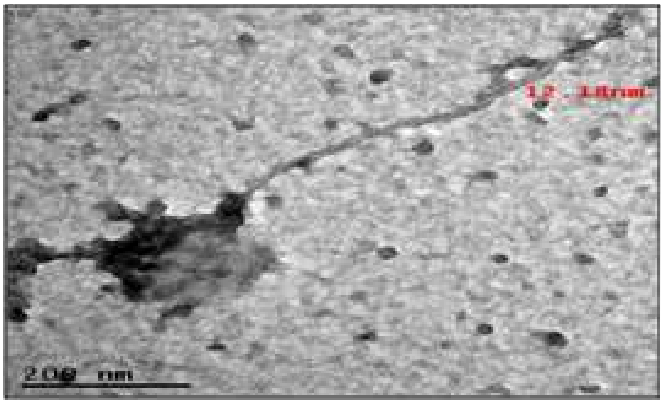


Fig. 9: Detection of Potato aucuba mosaic virus (PAMV) by immunosorbent electron microscopy (ISEM)

Epidemiology and Forecasting of Potato Pathogens

Whitefly mediated ToLCNDV-[potato] transmission

Whitefly, *Bemisia tabaci* (Gennadius) is a species complex; consist of 29 putative genetic groups across the world. Apical leaf curl disease in potato is caused by a strain of *Tomato leafcurl New Delhi Virus* (*ToLCNDV*). The *B. tabaci* is responsible for transmission of *ToLCNDV-potato* in circulative and persistence manner. A method was standardized to quantify the absolute load of *ToLCNDV- potato* in the whitefly using standard curve generation **(Fig. 10)**. A linearized plasmid containing coat protein gene of *ToLCNDV –Potato* (771 bp) was used to generate the standard curve. The standard curved was prepared by making six serial dilutions (tenfold) starting with 1.1×10^{-6} copies of the plasmid. Number of copies per ng of plasmid carrying CP gene was calculated using a dsDNA copy number calculator (https://cels.uri.edu/gsc/cndna.html). Virus-specific primer ToLCNDV-CP-Q 5' TAAGGTGCAGTCCTTTGAATCT3' and 5'CTCCTCGGGTAACATCACTAAC3' targeting coat protein gene was used for qPCR. To check the virus titre in whitefly, adults were allowed to acquire the virus from ToLCNDV positive potato plant at different acquisition access periods (6, 12, 24 and 48 hrs). The qPCR reaction was carried out with a activation cycle of 95°C for 10 min to begin amplification, followed by 40 cycles of 95°C for 15s and 60°C for 30s. qPCR reactions (20 µl volume) included 1µl of the template (30 ng), 10µl of Power SYBR Green Master Mix (ABI), 0.1 µM forward and reverse primer each, final volume of 20 µl was made with nuclease free water. The virus load was successfully carried out in whitefly; it acquired a 15658.4 ± 2963.0, 55730.9 ± 14012.9, 131870.1 ± 37144.1, 547158.7 ± 149184.5, numbers of virus copies in per 30 ng of DNA sample at 6, 12, 24, and 48 hrs of acquisition periods respectively. The outlined protocols are potentially suitable for various applications, such as plant breeding for resistance, testing response of various chemicals on virus replication and virus-vector interaction studies.

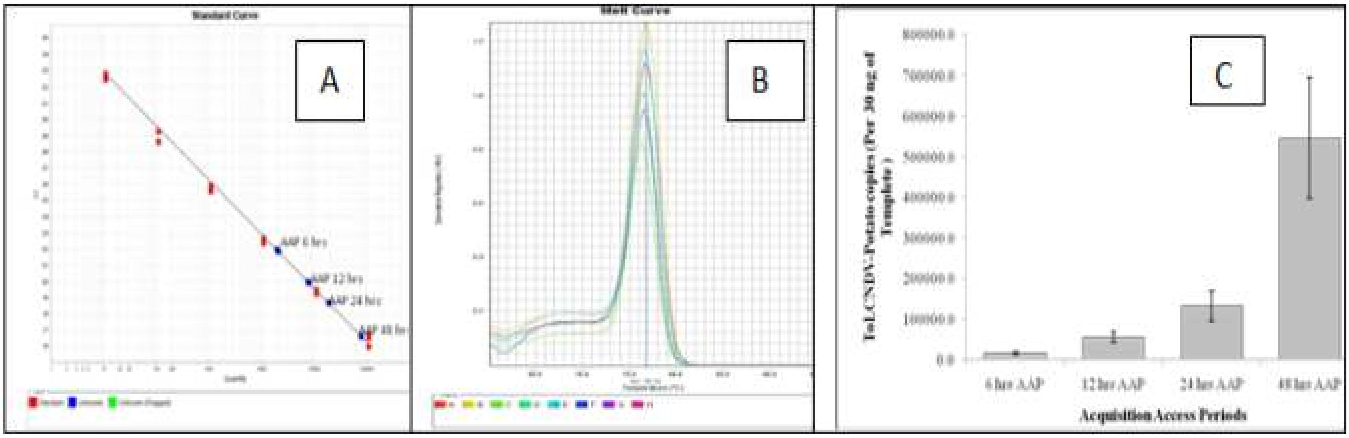


Fig. 10: A- Standard curve with unknown whitefly samples; B- Melt curve of standard dilutions; C- Viral copies in whitefly with different Acquisition Access Periods.

Performance of Indo-Blightcast and issue of agro-advisories

The model was used to predict appearance of late blight across the agro-ecologies in India during *kharif* and *rabi* seasons of 2019-20 and it predicted late blight accurately at each location **(Table 1)**. Accordingly the advisories were issued to respective regions to protect the crop from late blight onslought.

Besides, the model developed for prediction of early blight was also validated at Shimla. The model predicts early blight after accumulation of P-days values above 300 units which were accrued on 04.06.2019 and flashed a message 'watch out for early blight symptoms'. The symptoms of early blight were observed on 20.06.2019 thereby indicating the efficacy and accuracy of the model.

Table 1: Performance of Indo-Blightcast model during 2019-20

Location	Prediction date of late blight	Actual date of late blight appearance
Shimla (HP)	15.07.2019	19.07.2018
Jalandhar (Punjab)	15.11.2019	21.11.2019
Jalpaiguri(WB)	20.12.2019	23.12.2019
West Midnapur (WB)	30.12.2019	31.12.2019
Bankura (WB)	25.12.2019	02.01.2020
Burdwan (WB)	30.12.2019	01.01.2020
Kalyani (WB)	25.12.2019	28.12.2019
Hooghly (WB)	30.12.2019	08.01.2020
Kanpur	08.12.2019	12.12.2019

Management of Potato Pathogens

Chemical management

It is well known that *P. infestans* adapts to fungicides very quickly after its regular applications hence, there is need to test new molecules against this pathogen regularly for their inclusion in spray schedules for proper management of the disease. In this context experiments were conducted. At Shimla, out of six treatments tested, application of chlorothalonil (0.25%) and famoxadone + cymoxanil @ 0.1% resulted in 56.67 and 58.33% disease severity respectively as against of 100 % in control **(Fig. 11)**.

In earlier studies, we have found efficacy of phosphorous acid (0.2%) against late blight. This year phosphorous acid was rotated with other fungicides to develop spray schedule. Though all the combinations were found effective over control but least disease severity (58.33%) was observed when phosphorous acid (@0.2%) was sprayed at weekly interval followed by chlorothalonil (0.25%, 60%) and mancozeb (0.25%, 61.67%) at weekly interval as against of 100% in control **(Fig. 12)**. When phosphorous acid was rotated with either chlorothalonil or mancozeb, terminal disease severity was 68.33%.

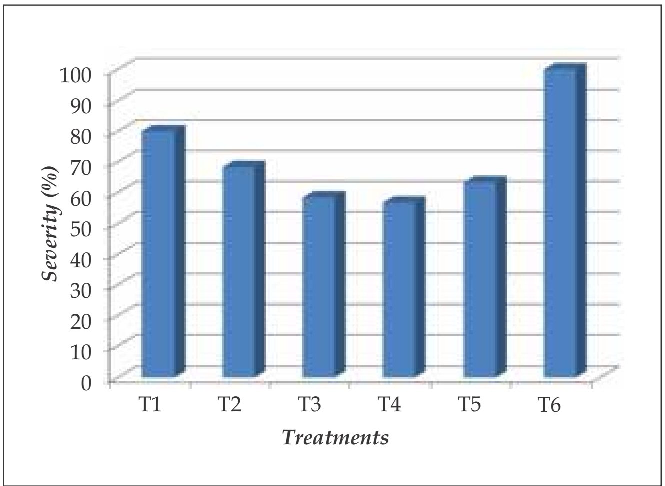


Fig. 11: Efficacy of different fungicides on development of late blight. T1: Mancozeb @0.25%, T2: Dimethomorph @0.1%, T3: Famoxadone + cymoxanil @0.1%, T4: Chlorothalonil @0.25%, T5: Cymoxanil+mancozeb @0.3% , T6: control

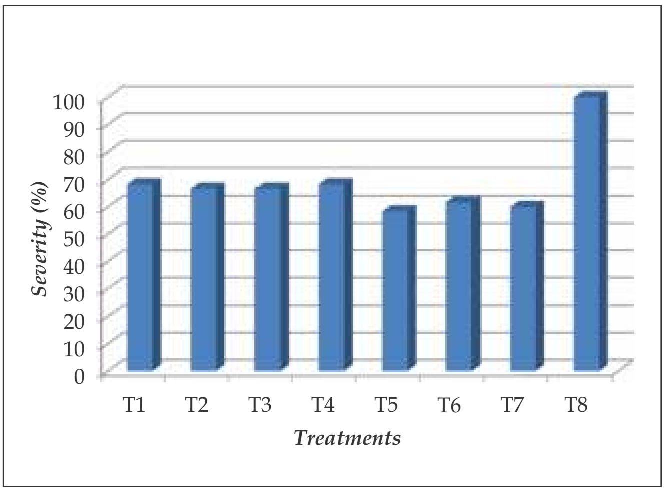


Fig.12: Efficacy of different spray schedules on development of late blight. T1: Phosphorous acid (PA, @0.2% Mancozeb (MZ, @0.25%)-PA , T2: PA-Chlorothalonil (Ch@0.25%)-PA, T3: PA-MZ-MZ, T4: PA-Ch-Ch, T5: PA-PA-PA, T6: MZ-MZ-Mz, T7: Ch-Ch-Ch, T8: control

Experiment conducted at Ooty in *kharif* season revealed that prophylactic spray with mancozeb @0.20% followed by cymoxanil + mancozeb @ 0.3% at onset of the disease and alternate sprays at 6-12 days intervals recorded lower AUDPC (34) as compared to control (298). The next best treatment was prophylactic spray of chlorothalonil @ 0.25% followed by famoxadone + cymoxanil @ 0.1% and alternate sprays at 6-12 days **(Fig. 13)**.

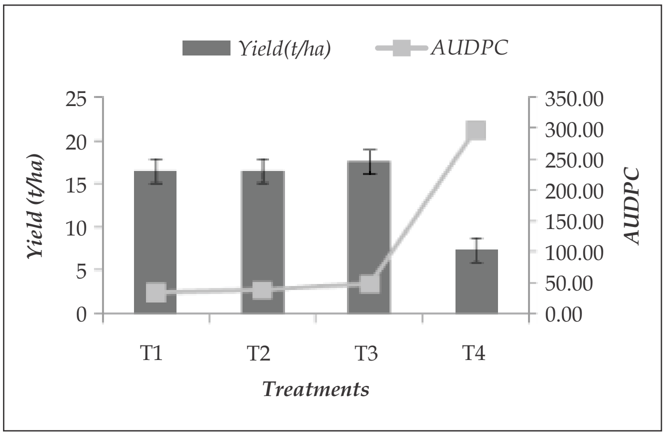


Fig. 13: Effect of different fungicides spray schedule on management of late blight

Scheduling fungicides application for management of late blight using Indo-Blightcast

Experiments, with three sub-sets of treatments, were laid out at ICAR-CPRI, Shimla for scheduling fungicides application for management of late blight using Indo-Blightcast model during 2017-2019 crop seasons. In first set of treatments, spraying of fungicides was initiated after 50 days of planting i.e. at the time of canopy closure and thereafter at weekly interval (calendar based). In another set of treatments, fungicides were sprayed as per prediction by Indo-Blightcast. Third set of treatments was maintained as control i.e. unsprayed. Mancozeb was sprayed prophylactically and at onset of disease, translaminar/systemic fungicides were applied. Results revealed that there were saving of two to four sprays on account of fungicide usage in Indo-Blightcast based sprays. No differences in terminal disease severity were observed between the calendar based and Indo-Blightcast based fungicide scheduling. However, Indo-Blightcast decision support system reduced fungicide use by 22.2%, 28.5% and 44.4% during 2017, 2018 and 2019 crop seasons, respectively over calendar based fungicide scheduling; thereby saved money (Rs.2250 - Rs.5325/ha) and environment.

Screening of selected clones of potato variety "Phulbani Local" (from Odisha) for resistance to Ralstonia solanacearum

Among the 22 selected clones of potato variety "Phulbani Local" tested for their resistance to *R. solanacearum* under glasshouse condition, only 05 clones found resistant and 03 as moderately resistant to *R. solanacearum* in initial screening test.

Evaluation of disinfectant, Huwa San TR 25 and chlorine dioxide (ClO_2) for the management of soil and tuber borne diseases of potato

The effect of pre-storage tuber dip and tuber spray treatments of two disinfectants namely Huwa San TR 25 and chlorine dioxide for managing common scab and black scurf diseases of potato was evaluated at ICAR-CPRS, Jalandhar during 2019-20. The tuber treatments with either of two disinfectants (spray or dip) had no effect on the storage behaviour, germination percentage and yield of potato tubers. The tuber treatment with Huwa San TR 25 did not result in any significant reduction of common scab and black scurf incidence and severity compared to control. However, tuber spray treatment with chlorine dioxide (0.03%) resulted in significant reduction in common scab severity (13.96 and 12.16% as compared to 19.13 and 23.42% in control, respectively, in two separate experiments on healthy and diseased tubers treatments) and black scurf severity (1.59 and 1.71% as compared to 7.14 and 10.53% in control, respectively, in two separate experiments on healthy and diseased tubers treatments). Thus, ClO_2 can effectively disinfect the tubers and reduce the soil-borne infection of common scab and black scurf diseases.

In-vitro evaluation of fungicides/ chemicals against *Streptomyces scabies*

Among the 34 fungicides/ bactericides/ insecticides/ chemicals evaluated, 09 fungicides/ bactericide/ chemicals namely, mancozeb 72WP, Curzate 72 WP (cymoxanil 8%+ mancozeb 64%), benalaxyl+ mancozeb, Sectin 60WP (fenamidon10%+ mancozeb 50%), copper oxychloride 50WP, copper hydroxide 53.8W/W, Zineb 75WP (all at 1500 ppm), streptomycin (at 100 ppm) and $ZnSO_4$ (at 1000 ppm), were found effective in inhibiting the growth of *Streptomyces scabies in-vitro*.

Field evaluation of fungicides/ chemicals/ endophytic bacteria for management of common scab and black scurf diseases

A field experiment was conducted at ICAR-CPRS, Jalandhar in November 2019 for the management of common scab and black scurf disease comprising tuber treatment with mancozeb (0.3%), copper oxychloride (0.3%), streptocycline (200 ppm), four endophytic bacterial strains (E-18, E-23, E-41, E-49) each at concentration of $1x10^8$ CFUs), soil application of $ZnSO_4$ (50.0 kg ha^{-1}), herbal powder (62.5 kg ha^{-1}) and a control. Among these, tuber treatment as spray with endophytic bacterial strain E-23 resulted in significant reduction in common scab (9.59%) and black scurf (0.35%) severity compared to 19.65% common scab and 6.40% black scurf severity in control. Other treatments were at par with control.

Biotechnological Approaches

RNAi mediated dsRNA formulation against tomato Phytophthora infestans

In earlier studies, we have demonstrated the efficacy of dsRNA against potato late blight. Further, to know its versatile action against tomato

P.infestans isolate, *in vitro* and detached leaf assays were performed. Results of *in vitro* studies revealed varied response in mycelial growth. When dsRNA was assessed at 6 mg/ml, there was only 20% mycelium growth as compared to control; whereas at 500 µg/ml and 15 mg/ml dsRNA concentration, mycelial growth was on par with control. When assessed through detached leaf assay, least lesion area (0.2 cm^2) was observed at 8 mg/ml dsRNA compared to control (2.5 cm^2). The other two concentrations (5 mg/ml and 10mg/ml) exhibited 1.5 cm^2 and 1.8 cm^2 lesion area, respectively. Since dsRNA efficacy depends on accumulation of siRNA in the cell **(Fig. 14),** it indicates that higher concentration of dsRNA leads to sequestering of siRNA and unwinding of secondary structure, which might have resulted in reduced expression of siRNA. This needs to be validated under whole plant assay to develop as novel versatile protection strategy for the management of late blight in potato and tomato crop.

Fig. 14: Potato Phytophthora infestans isolate dsRNA assay against tomato isolate on mycelium growth and lesion area development in tomato detached leaf assay.

Alternative approach for management of Ralstonia solanacearum in potato by silencing host susceptible gene

Based on proof of concept that PAP2 gene is responsible for wilting via degradation of accumulation of reactive oxygen species/ hypersensitive response, RNAi transgenic lines were developed and subjected to bacterial wilt assay. Results of third clonal generation screeing revealed that three transgenic lines possess high degree of resistance to bacterial wilt. The quantitative expression analysis revealed reduced expression of PAP2 and increased expression of jasmonic acid marker gene PR-4 in RNAi lines, thereby indicating the role of jasmonic acid pathway in inducing resistance. Further, to validate the role of jasmonic acid pathway in inducing resistance, the expression of salicylic acid marker gene PR1 was studied. The expression of this gene (PR1) was reduced in RNAi transgenic lines. Authentication of wilt resistance in resistant transgenic lines was further confirmed by bacterial load count. Among the 04 RNAi PAP2 transformant lines screened under glasshouse condition, 01 line was highly resistant to *R. solanacearum* (r3bv2), while 03 were moderately resistant. The CFUs count in 1ml extract from 2 cm stem was lowest for highly resistant line (0.00004 x 10^6) and yielded only avirulent colonies of *R. solanacearum* compared to other 03 moderately resistant line (6.76 – 449 x 10^6) and control (506 x 10^6) which yielded virulent colonies on SMSA medium **(Fig. 15)**.

Genome editing for development of late blight resistant potato

CRISPR cas mediated resistance to late blight disease by targeting susceptible genes. Last year we developed multi sgRNA cassette encoding three late blight susceptible genes for enhancing late blight resistance. The positive clone was mobilised into Agrobacterium cell (GV3101 strain) and the construct was used for genetic transformation of potato variety "Kufri Jyoti (KJ)" and "Lady Rosetta" using inter nodal stem cuttings for editing all the 03 genes simultaneously. Agrobacterium transformation is under progress to get enough number of transformants followed by their

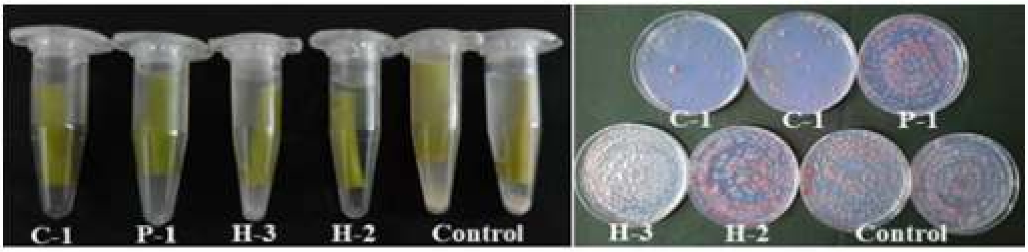


Fig. 15: Extract from 2.0 cm stems of trans-formant lines in 1.0 ml water after 21 days of R. solanacearum inoculation (left) and isolation on SMSA medium (right). Note afluidal/ avirulent colonies from resistant line (C-1) and fluidal/ virulent colonies from moderately susceptible line (P1, H-3, H-2) and control.

confirmation. Meanwhile, we attempted *in planta* method of transformation to get sufficient number of lines (50) for desired mutants and presentaly these plants are in CT_0 stage, designated as clonally propagated plants in initital stage. Though chimeric transformants are in initial generation of *in-planta* transformation method, we sprayed 0.01% BASTA on all 50 lines of KJ for selection of positive lines using CRISPR construct harbouring *Bar* gene, a plant selection marker for selection of positive lines, and observed chlorotic symptoms in control and in some of the transformants **(Fig. 16)**. This is just an initiative in developing CRISPR mediated lines of popular potato cultivars against late blight.

Fig. 16: BASTA selection of putative transformants of CRISPR CT_0 lines (out of 50 transformants).

Novel dsRNA based protection strategy against ToLCNDV in potato

Potato viruses are difficult to control as no resistance source and chemicals are available for their management. A new approach that uses topical application of double-stranded RNA (dsRNA) to induce antiviral RNA-interference has shown some promise to prevent virus infection in a range of plants. Though, we have demonstrated RNAi transgenic approach for the management of ToLCNDV in potato, synthesised dsRNA molecule as alternative to transgenic approaches for development of virus free plants seems to another viable option. The benefit of dsRNA based management approach is that both virus and vector can be targeted from single construct at the same time. We targeted coat protein, replicase and pathogenicity factor of the DNA A component of the virus and three genes of whitefly for simultaneously silencing. The *in silico* analysis was performed and selected effective siRNA region to develop a single synthetic construct having all stacked siRNA using siRNA prediction tools **(Fig. 17)** driven by T7 promoter on both 5' and 3' end. The synthetic construct was sub cloned into L4404 vector and the positive clone was confirmed through restriction analysis and same has been subjected to *in vitro* dsRNA synthesis using T7 polymerase enzyme. However, this needs to be validated through *in vitro* bioassay.

Fig. 17: Multi siRNA vector driven T7 promoter harbouring ToLCNDV genes.

Identification of host susceptibility genes in potato against ToLCNDV-potato

Two popular varieties of potato i.e. Kufri Bahar (moderately resistant to ToLCNDV-potato) and Kufri Pukhraj (susceptible to ToLCNDV-potato) were planted in glasshouse and challenge inoculated with infectious clones of virus. After 10 days of inoculation, samples were taken for RNA isolation and real time PCR analysis. To identify the susceptibility genes, 06 primers were designed **(Table 2)** based on available microarray transcriptome data. The targeted genes were mainly associated with cell cycle regulation, defence related activity, heat sock protein/F-Box protein, translation initiation factors and protein kinases. The real time PCR analysis revealed up regulation of few genes in Kufri Pukhraj and out of which up-regulation of AP2 gene was manifolds **(Fig. 18)**. The generated data will be useful for silencing the identified susceptibility gene using CRISPR-cas9 technique for effective management of ToLCNDV in potato.

Table 2: Selected genes and their respective primers

Predicted host susceptibility Genes	Primers for Real-time PCR
D6-type cyclin	D6TC-Fp: AGCCATGGATCTTGAAGCTAAT D6TC-Rp: ACCACCATCTTGCTGAATGT
S-locus F-box b	SLFB-FP: GTTTGGGTGATTGTGCCATTTA SLFB-FP: AACTCCCATTTCATTATTCATCACC
Translational initiation factor eIF1	EIF1-FP: GAAAGAGTTCTGCTGCAATGG EIF1-RP: AGCCTGGACAAGAAATGTAGAA
AP2/ERF domain containing transcription Factor	AP2-FP: TCGACAGAGGAATGGGAAATG AP2-RP: CCAAAGCTGCAACGTCATAAG
ETIP5	ETIF5-FP:TACGGCCAGCCAATTTCTATC ETIF5-RP: CTTTCTCCACACCATCCAAGAG
PTBR	PTBR FP: TCCCACGTTTATGGGCTTTAC PTBR-RP: GACGATGAAACCCACCTTCA

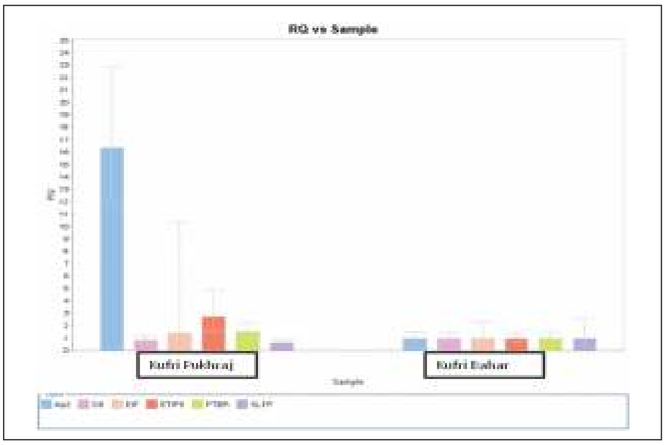


Fig. 18. The q-PCR data indicating the upregulation of AP2 gene.

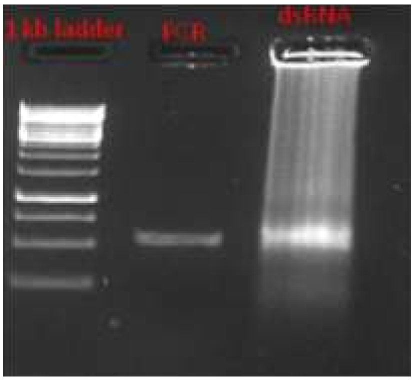


Fig. 19. Gel picture for dsRNA

Designing of dsRNA construct targeting pathogenicity genes of PLRV and its aphid vector

Based on available literature, previously reported genes having role in pathogenicity were taken into consideration. Two genes, encoding coat protein and movement protein, from the whole genome of PLRV were selected. Similarly, three genes encoding P1 protein, ephiryn receptor and cytochrome p450 were selected for targeting aphid vector (*Myzus persicae*). The siRNA target region (410 bp) was identified within these genes using siRNA selection finder such as siDirect 2.0, Noble foundation psiRNA target finder tool and cloned in a suitable vector carrying T7 promoter. Further, the selection of positive clones was done by PCR, restriction digestion and sequencing. Synthesis of dsRNA was carried out using DNA polymerase enzyme and dsRNA was purified **(Fig. 19)**. The developed dsRNA will be used for pathogenicity assay against PLRV.

Sequence of Multi siRNA construct

ATGGAATACTCAAGGCCTACCATGAGTACACAAGCATCTTAC
TTCAGTTCGTCAGCTCCAAAATGCGGCTGGATTGTCAAACGGT
TCCTCAAAGCGGCCTCCGTGACCTTATGGGCAGGGAAGGTCT
ACTATCAGTCAAAGGAGGGAGAAGAAGGATGTTAGGCAACC
GAATAGCAAAAGTCGTATACCAAGCATACGAAAACGGGAAG
CAAGAACGATGTGAATTCAAAGTCAAGTTTACCATCCGAGAT
TGTTCGACGAAGTGGTGATCAATACTGAGACAAACAGAAGCT
TCCGTTAAGTCTGCGTCCGTCTGAAGACCATGCTAAACAGAA
AGAACGGGAAGCATTATACCAACAGGTGTTAAAGAGAAGCT
GAACAAGCGGCTAAAGACAG

Multiplication and screening of selected transgenic lines resistant to ToLCNDV-potato under controlled conditions

Twenty five tubers each of two promising transgenic lines (GTLC2-127 and KPLC2-53) were planted in containment facility for phenotypic observations. The tubers from these plants were harvested for further multiplication and studied tuber characters. GTLC2-90, GTLC2-127, KPLC2-13, KPLC2-37, KPLC2-53 and KPLC2-54 transgenic resistance lines were also multiplied under tissue culture. Out of these, two promising transgenic lines GTLC2-127 and KPLC2-53 were screened through agro inoculation technique and the result showed that transgenic lines did not show ToLCNDV- potato symptoms as against non transgenic (control plants).

Biological Approaches

Field evaluation of endophytes against bacterial wilt (R solanacearum)

Eight endophytic bacteria, which proved effective *in-vitro* against *R. solanacearum*, did not prove effective against bacterial wilt disease in field experiment when applied as tuber treatment just before planting.

Management of virus by eco-friendly approach: Identification of new potential source of antiviral proteins to manage Potato virus Y

Study was conducted to identify plants which can produce antiviral proteins (AVPs) having the property of inhibiting viral protein synthesis. Initially, seven botanicals were collected from different parts of Himachal Pradesh and evaluated under glass house conditions against PVY. Healthy potato plants were raised and at 3-4 leaf stage treated with AVPs followed by (after 24 hr) challenge inoculation (mechanical inoculation) with *Potato virus Y*.

Ten days after the inoculation, non-enzymatic and enzymatic antioxidants were analyzed which are reported to be involved in defense related pathways and play core role in response to wide range of pathogens. The results of peroxidase and proline have shown significant increase as compared to the positive control (inoculated with virus only, **Fig. 20**) indicating that the proteins isolated from *Solanum chacoense, Bougainvillea, Valeriana jatamansi* and *Ricinus* sources activated the plant defense response; whereas, increase in chlorogenic acid was observed only in *Ricinus* and *Bougainvillea* treated plants. In addition, the plants were also screened by serological based assay (ELISA) against PVY, where

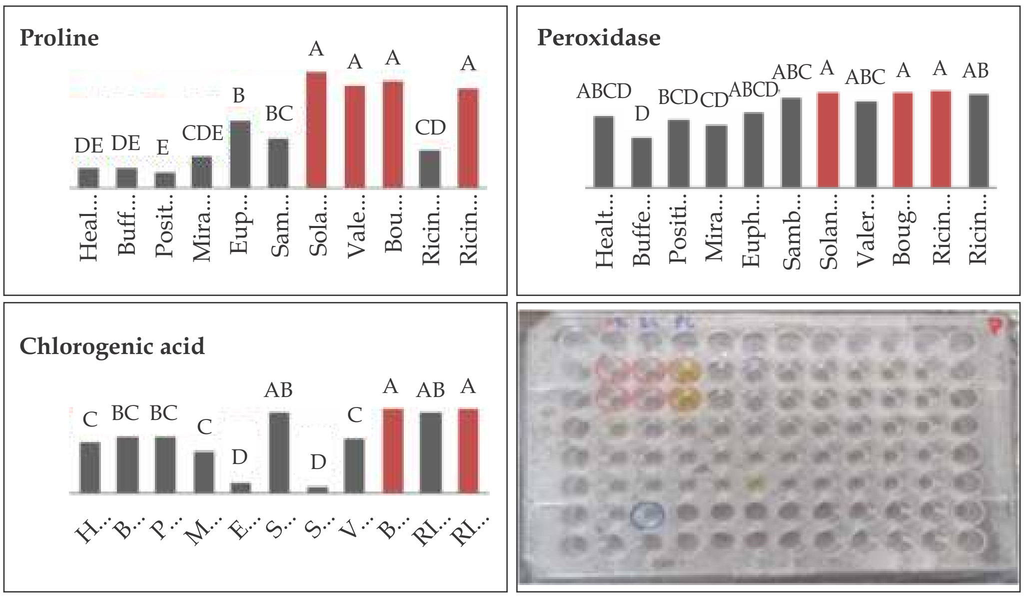


Fig. 20: Extraction of total Proteins from collected plants suspetec to contain antiviral proteins (A) and its biochemical and serological (DAS-ELISA) based evaluation (B).

the plants treated with proteins isolated from *Solanum chacoense, Bougainvillea, Valeriana jatamansi* and *Ricinus* were found free from PVY. This study indicates that the AVPs can be effectively used as an eco-friendly measure in managing PVY.

Screening of novel non-toxic bimolecules against PLRV under controlled conditions

Production and maintenance of virus-free planting materials is pivotal for the control of viral diseases in potato. Melatonin (N-acetyl-5-methoxytryptamine), an indole-amine molecule, is an antioxidant and has proven to have multiple functions in fortifying plants against abiotic and biotic stresses. Melatonin has been found effective in mitigating plant viruses in apple, tobacco, and Arabidopsis. Based on these observations the present study attempted to test exogenous application of melatonin for eradication of *Potato leaf roll virus* (PLRV) from virus-infected *in vitro* shoots of potato plants. Exogenous application of 10-15 uM melatonin to the shoot proliferation medium significantly increased the number of shoots and shoot length. Analyses of viral load using qRT-PCR showed that PLRV concentration decreased in shoot tips of the virus-infected shoots proliferating on the medium containing 15 uM melatonin for 4 weeks **(Fig. 21)**. Exogenous application of melatonin provides an alternative means for plant virus eradication and has the potential to produce virus-free plants. The results and observations clearly showed that there is a significant reduction in the virus titer in response to exogenous melatonin application and hence a healthy potato plantlet can be grown in tissue culture with addition of melatonin in culture media. The growth of the plants were completely normal and melatonin treated plants were either asymptomatic or having very mild symptoms. If the virus can be eliminated at this stage definitely there will be a huge reduction is the virus multiplication and spread in the field conditions. The key findings of this research will definitely give a way forward to melatonin based alternate approaches for managing viral diseases in potato.

Post entry quarantine testing of imported germplasm

A total of 136 *in-vitro* cultures of potato imported by Crop Improvement Division, ICAR-CPRI, Shimla (97 cultures), M/s TechnicoAgri Sciences Ltd (18 cultures), M/s McCain Foods India Pvt Ltd (06 cultures) and M/s Mahindra HZPC (15 cultures) were tested for post entry quarantined pathogens.

Testing of viruses under National certification system for tissue culture raised plants (NCS-TCP) through DAS- ELISA and PCR

Certification process of potato crop in recognised TCPU Four thousand seven hundred and eight samples of M/s Technico Agric Science Pvt Ltd. Baddi, Solan (HP), M/s Bhatti Tissue Tech. Jalandhar, M/s PepsiCo India Holdings Pvt. Ltd. Hoshiarpur (Punjab), M/s Mahindra HZPC Pvt. Ltd., Mohali, M/s Gugle Biotech Pvt. Ltd., Bangalore and M/s Jain Irrigation Systems Pvt. Ltd., Maharashtra were tested for PVX, PVS, PVY, PVA, PVM, and PLRV by DAS- ELISA and GBNV, PSTVd and ToLCNDV-potato by PCR/RT-PCR and the total plants for batch certification were 12.09 lakh. Besides, three hundred fifty samples of apple from M/s Nishant Biotech, Bilaspur, HP were tested for apple viruses namely ACLSV, AMV, ASGV, ASPV, PNRSV, ASSVd through RT-PCR to certify the total batch size of 3, 50,000 plants under NCS-TCP **(Fig. 22)**.

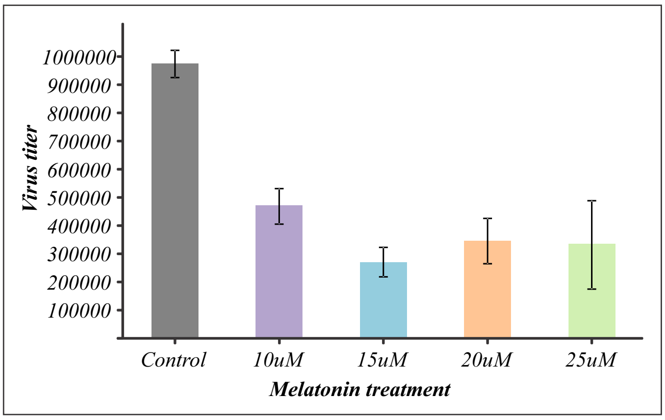


Fig. 21: Real time PCR based quantification of PLRV shows a reduction in virus titer with melatonin treatment

Fig. 22: Certification process of potato crop in recognised TCPU

PROGRAMME: BIOLOGY, EPIDEMIOLOGY, MODELING AND MANAGEMENT OF INSECT PESTS, VECTORS AND CYST NEMATODES OF POTATO

Monitoring of Various Potato Vectors/Pests

Aphids

The population of aphids was monitored at Modipuram, Jalandhar and Gwalior in unsprayed potato fields during October-December, 2019. At Jalandhar, *M. persicae* first appeared on the potato in the 1st week of November and did not cross the critical limit of 20 aphids per 100 compound leaves till last week of December **(Fig. 1)**.

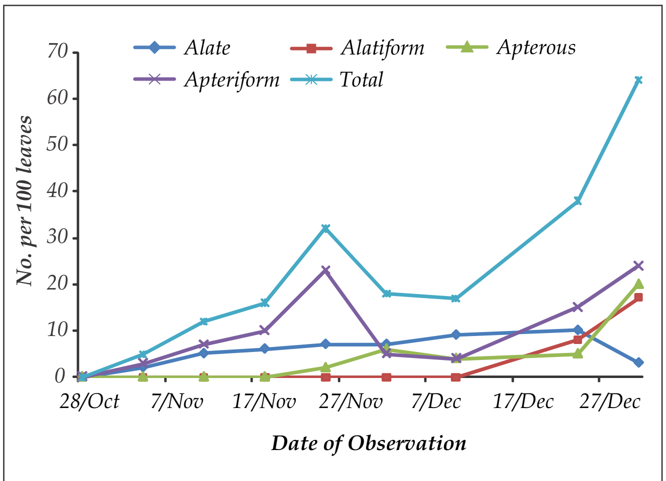


Fig. 1: Population dynamics of Myzus persicae on potato at Jalandhar

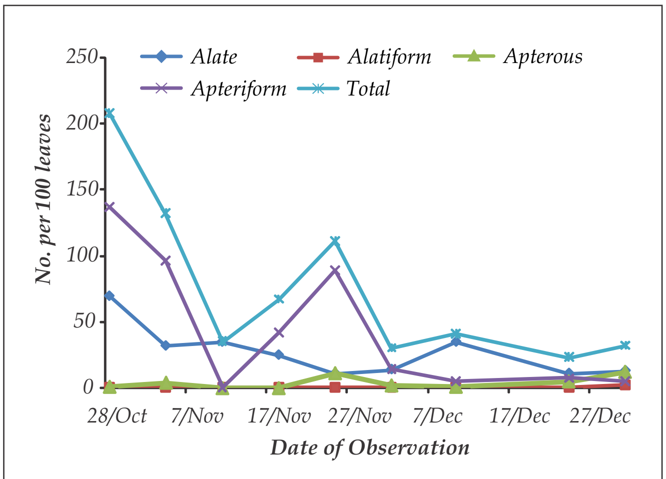


Fig. 2: Population dynamics of aphids (other than M. persicae) on potato Jalandhar

The population of the winged morphs of other aphids started out at 70 aphids per 100 compound leaves in the first week after emergence of the crop **(Fig. 2)**. *M. persicae* appeared on potato in 4th week of November at Gwalior. *M. persicae* did not cross the critical level till last week of December at Modipuram. *A. gossypii* was active on potato till last week of December in Western Uttar Pradesh. The flight activity of all the aphids followed a similar trend **(Fig. 3)**.

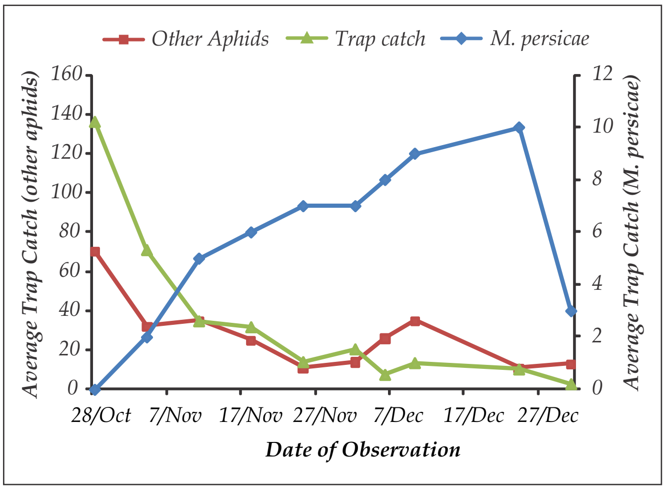
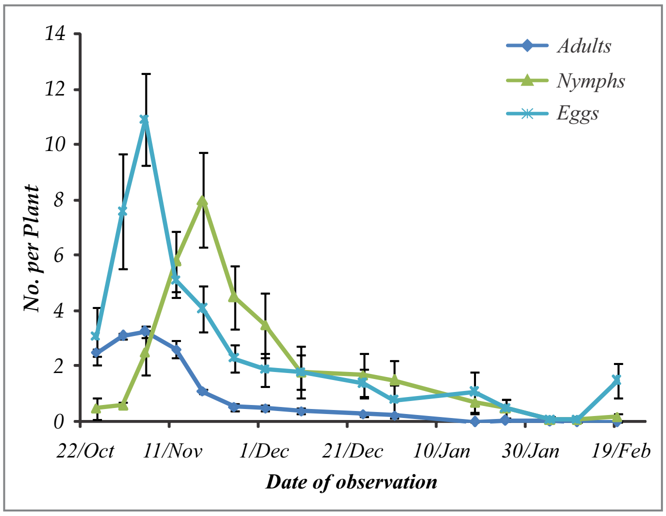
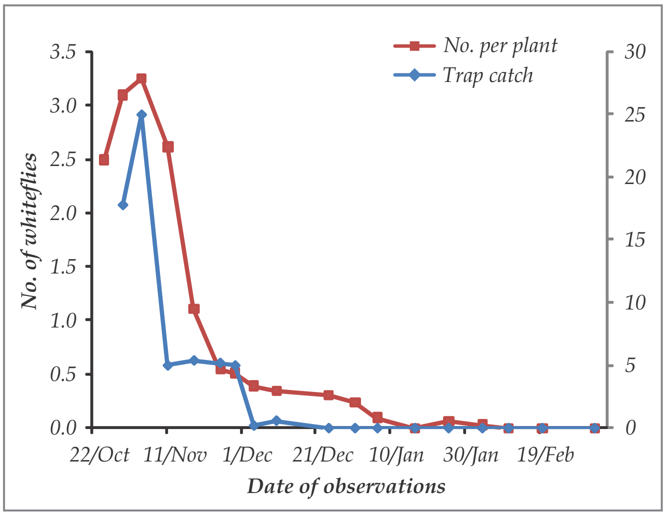


Fig 3: Comparison of the dynamics of winged morph of aphids and average YST catch on potato at Jalandhar

Whitefly

The population of whitefly, *Bemisia tabaci* at Jalandhar was monitored from October to December by leaf count method and yellow sticky traps (YST). The population remained above economic threshold till the 2nd week of November. The number of eggs laid per plant increased till first week of November and declined gradually afterwards **(Fig. 4a)**. Up to 28 whitefly adults were caught on YSTs on an average in the last week of October however, the trap catch showed a sudden drop by the 2nd week of November **(Fig. 4b)**. Whitefly appeared on the crop in 4th week at Gwalior with maximum catch on seed (06/10 plants) and ware crop (27whiteflies/10plant). At Modipuram the population of whitefly remained high 27/05 plants on early potato crop (Kufri Pukhraj) while it was 3.32/05 plants on main potato crop (Kufri Pukhraj). The yellow sticky traps data revealed that maximum whitefly (204/trap/week) recorded in 51st standard week of the year 2019.





(a) **(b)**

Fig. 4. Population dynamics of Bemisia tabaci sampled by (a) leaf count method and (b) YST catch in potato at Jalandhar

Thrips

High population of thrips was recorded on ware crop in comparison to seed potato crop at Gwalior. Maximum 42 thrips/10 plant was recorded in ware crop (unsprayed crop) while 16 thrips/10 plants on seed crop during crop growth.

Whitefly preference to potato cultivars under net house: choice experiment

Thirteen varieties including K. Neelkhant, K. Mohan, K.Ganga and K. Lima, and three genotypes (MS/7-645, MS/8-1148 and MS/0042) were grown under net house. The whiteflies were released in net house with open/free choice of settlement/ multiplication on potato varieties and genotypes. The data revealed that least preferred genotype was MS/0042 with a mean population of whitefly (0.42/plant) and the most preferred potato varieties were K. Mohan (1.76/plant) and K. Neelkhant (2.46/plant) during crop growth.

Management of vectors/pests by row covers, chemicals /safe chemicals /mineral oils

Effect of polypropylene (PP) Row Covers on the Incidence of Insect Vectors, Diseases and Tuber Yield in Potato

The effect of PP row covers (25 GSM), either free floating or hoop supported was studied on the incidence of insect vectors, viral and fungal diseases, and tuber yield in potato crop **(Fig. 5)**. Aphids and whiteflies were completely excluded from the covered plots with low incidence of virus diseases till the last week of December. The terminal intensity of late blight was higher, and the total tuber yield was lower, in the covered plots as compared to the uncovered control (21.64 to 36.75% reduction in yield as compared to control). Therefore, it's concluded that spunbonded row covers can provide effective protection to potato crops from virus and their vectors, with minor compromise in yield.

Fig. 5: Potato crop covered with PP row covers; hoop supported and frees floating in comparison to control

Bio-efficacy of IGR and knockdown insecticides against cotton whitefly, B. tabaci, leafhoppers, thrips and peach-potato aphid, M. persicae in potato

Field experiment were carried out at Modipuram, Gwalior and Jalandhar to assess the bio-efficacy of knock down insecticides against whitefly, aphids and leaf hopper on potato crop with two insecticides Pymetrozine 50 WG @ 0.04 % (4, 6 and 8g/10l), Buprofezine 25% SC (8, 12 and 16 ml/10l) and Imidacloprid 17.8 SL @ 0.04 % (4ml/10l) along with control. Data revealed that Pymetrozine 50 WG @ 0.04 % (8 g/10l) was effectively reduced the population buildup of whitefly and leafhopper, which is almost at par with Imidacloprid at Modipuram **(Fig. 6 & 7)**. Pymetrozine 50 WG@ 0.08% and Buprofezine 25% SC@ 0.16% were found effective with maximum per cent reduction of insect-pests over remaining treatments for managing whitefly, thrips and aphids at Gwalior.

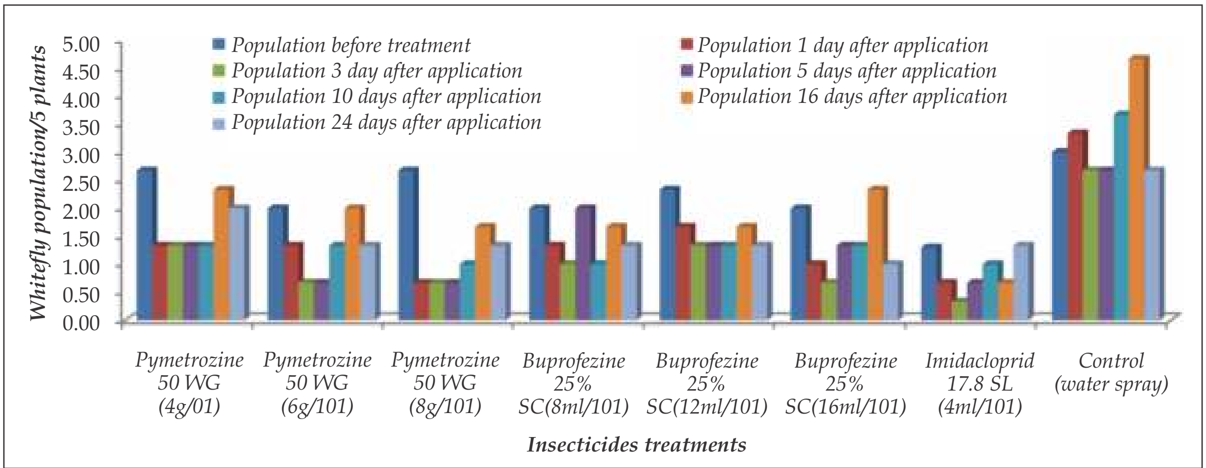


Fig. 6: Bio-efficacy of knockdown insecticides against whitefly (Modipuram)

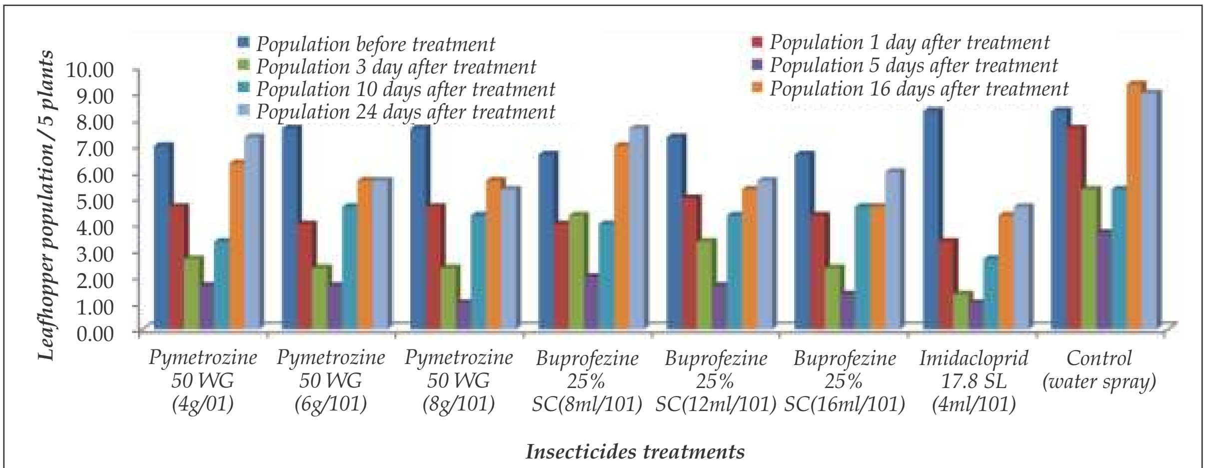


Fig. 7: Bio-efficacy of knockdown insecticides against leafhoppers (Modipuram)

Similarly at Jalandhar, Pymetrozine 50 WG @ 0.06% and Diafenthiuron 50 WP @ 0.1% performed at par with 67.7%, 68.3% and 60.3% population reduction, respectively. No significant variation in virus incidence was noted among the treatments. Thus, it's concluded that no significant immediate knockdown was noted for the tested insecticides but Imidacloprid 17.8 SL @ 0.04 % and Pymetrozine 50 WG @ 0.06% could provide significant control of adult whiteflies and aphids up to 2 weeks.

Bio-efficacy of soil incorporated insecticides against cotton whitefly, B. tabaci, leafhoppers, thrips and Aphis spp. in potato

Field experiments were carried at Modipuram, Gwalior and Jalandhar to assess the bio-efficacy of soil incorporated insecticides against whitefly, aphids, thrips and leaf hopper on potato crop with two insecticides Cartap Hydrochloride (15, 20 and 25 kg/ha), Fipronil 0.3 G (15, 20 and 25 kg/ha) and Phorate 10 G (15 kg/ha) along with control. Data revealed that Cartap Hydrochloride 4G at (20 kg/ha) was effective against whitefly and leafhopper, which is at par with Phorate 10 G (15kg/ha) (Fig 8 & 9). Fipronil 0.3G @ 20 Kg/ha and 25 Kg/ha and Cartap hydrochloride 4G @ 25 Kg/ha and 20 Kg/ha performed at par and reduced the whitefly and aphid population as compared to control. Both the insecticides performed better Phorate 10 G @ 15 Kg/ha against sucking insects as soil incorporated insecticides. Fipronil 0.3 G @ 25 Kg/ha followed by cartap hydrochloride 4G@ 25 Kg/ha was found effective over remaining treatments in per cent reduction of insect-pests and managing whitefly and thrips.

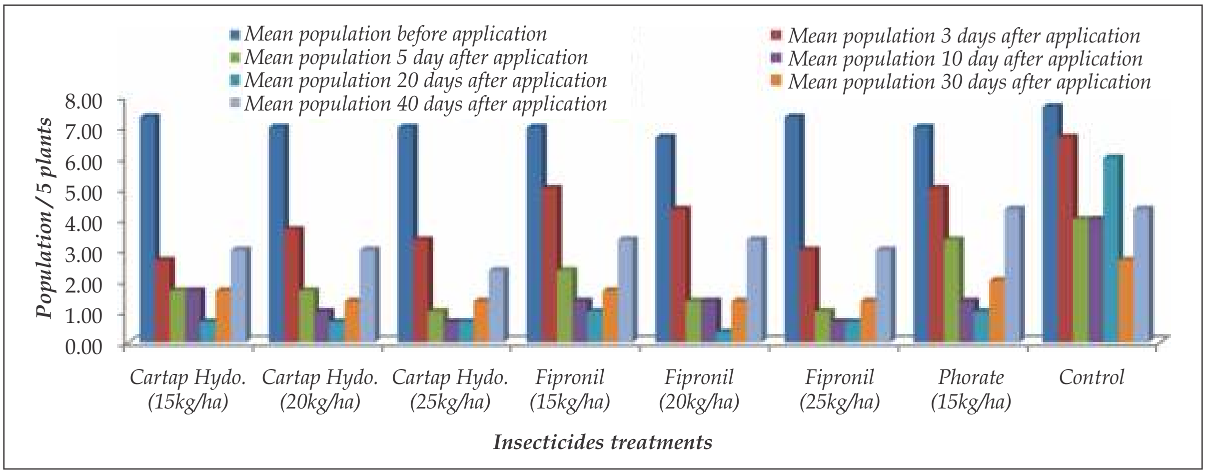


Fig. 8: Bio-efficacy of soil incorporated insecticides against leafhoppers (Modipuram)

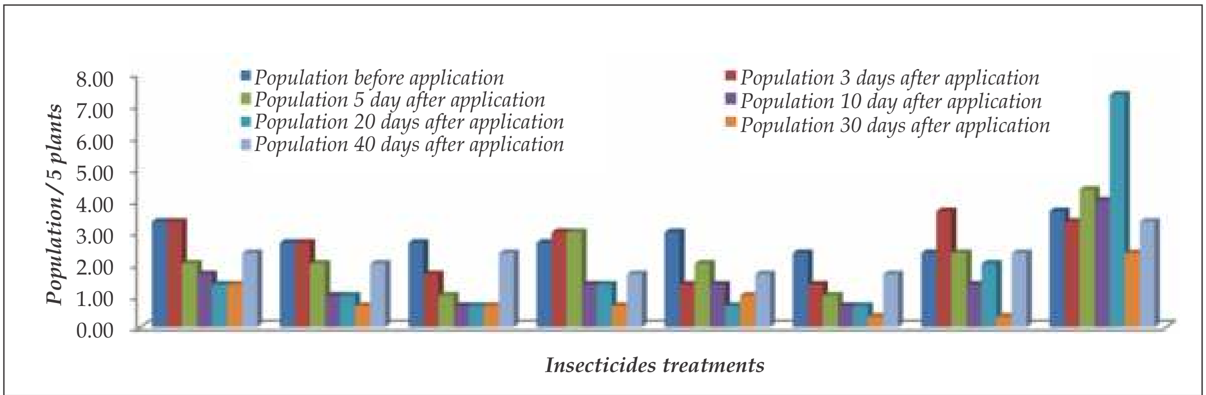


Fig. 9: Bio-efficacy of soil incorporated insecticides against Whitefly (Modipuram)

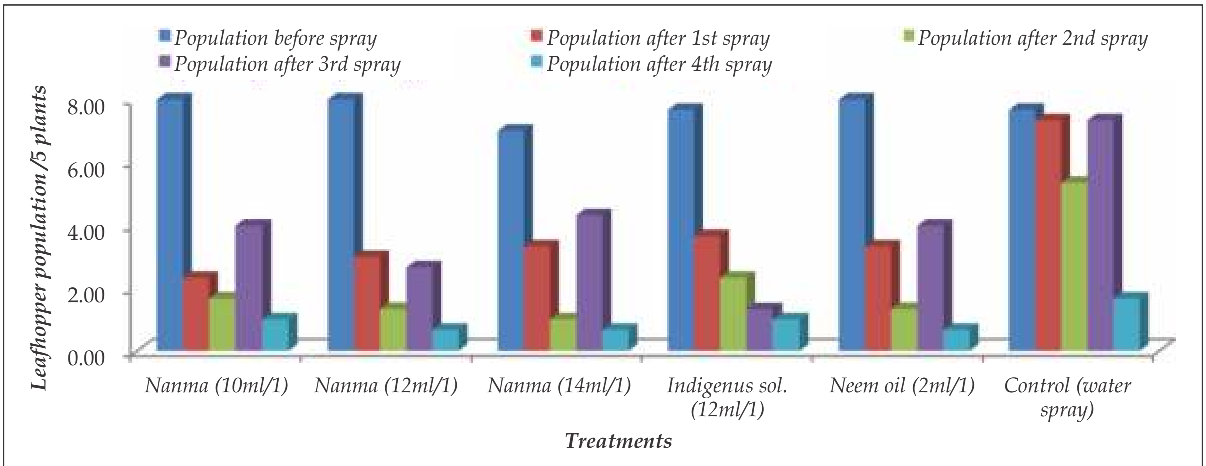


Fig. 10: Bio-efficacy of plant products against leafhoppers on potato (Modipuram)

Bio-efficacy of botanical insecticides against cotton whitefly, B. tabaci, leafhoppers, thrips and peach-potato aphid, M. persicae

At Jalandhar, Nanma @ 1.0%, mineral oil @ 0.5%, and Imidacloprid 17.8 SL @ 0.04 % provided some degree of whitefly & aphids control over the first 3 days, Nanma @ 1.0% and Imidacloprid 17.8 SL @ 0.04 % could provide sustained reduction of whitefly up to 9 days after treatment. Similarly, Nanma @10ml/l was found effective over remaining treatments with percent reduction of whitefly and thrips 81.55%, 72.59% respectively for the management of these pests at Gwalior. Nanma (10 ml/l) was effective against whitefly, plant hopper and aphids and lost their effectiveness within 2-3 days at Modipuram. Therefore, frequent spraying will be required to bring down the population of sucking pests.

Effects of insecticides on resurgence of whitefly & leafhoppers in early potato cv. K. Pukhraj

Data revealed that oxy-demeton methyl was almost not effective against sucking pests, while slightly higher doses of imidacloprid (8ml/10 L) and thimethoxam (8 g/10 L) significantly reduced the whitefly and leafhopper population with maximum increase in tuber yield of 8.85% and 8.53%, respectively **(Fig. 12 & 13)**. Similarly, highest tuber yields 20.66 and 20.60 t was recorded in the respective treatments with a C: B ratio of 1:3.38 and 1:3.0.

Identification of virulence genes in the foxglove aphid, *Aulacorthum solani*

Annotated genes were used for identification of putative functional virulence genes in the foxglove aphid or glasshouse potato aphid *Aulacorthum solani* draft genome. Several genes with putative functions were identified such as defensive and detoxification genes (53 cytochrome P450s (CYP), 11 glutathione S-transferases, 17 ATP binding cassette (ABC) transporters (F and G families), 17 carboxyl/cholinesterases, 1 uridine diphosphate (UDP)-glucosyltransferase and 37 cuticle proteins

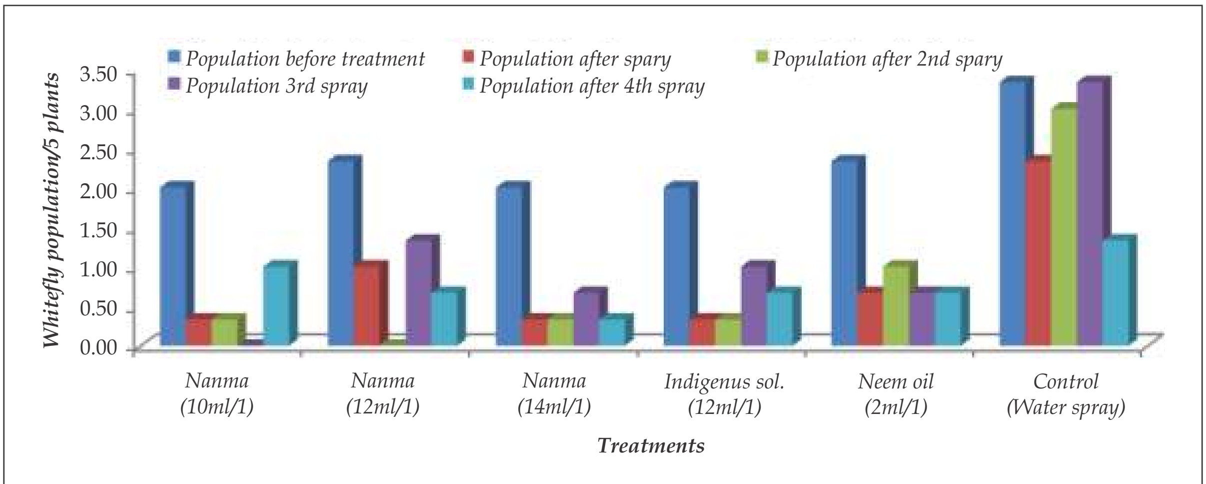


Fig. 11: Bio-efficacy of plant products against whitefly on potato (Modipuram)

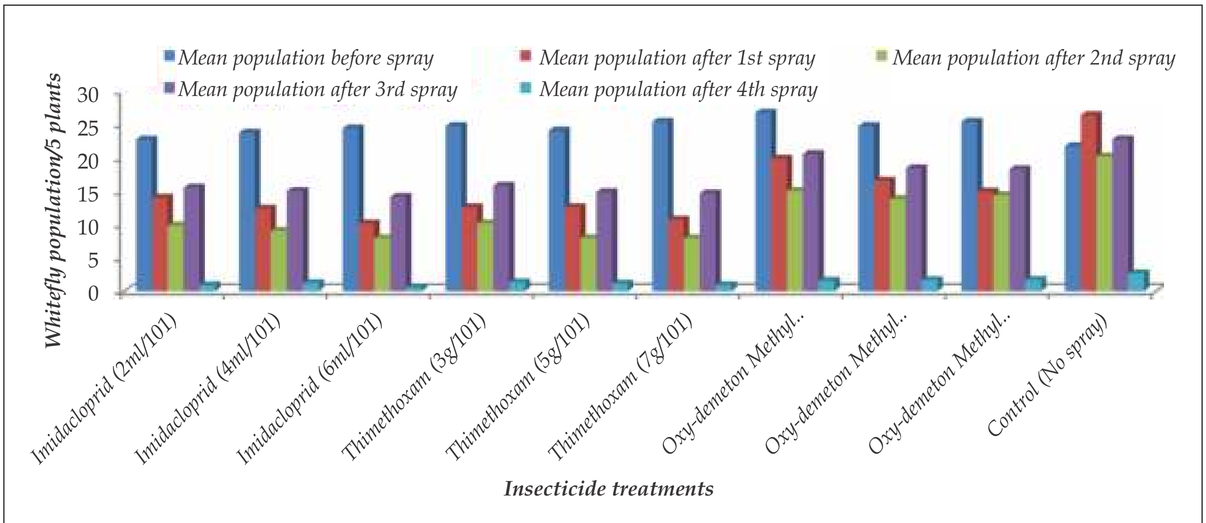


Fig. 12: Resurgence of whitefly population on potato (Modipuram)

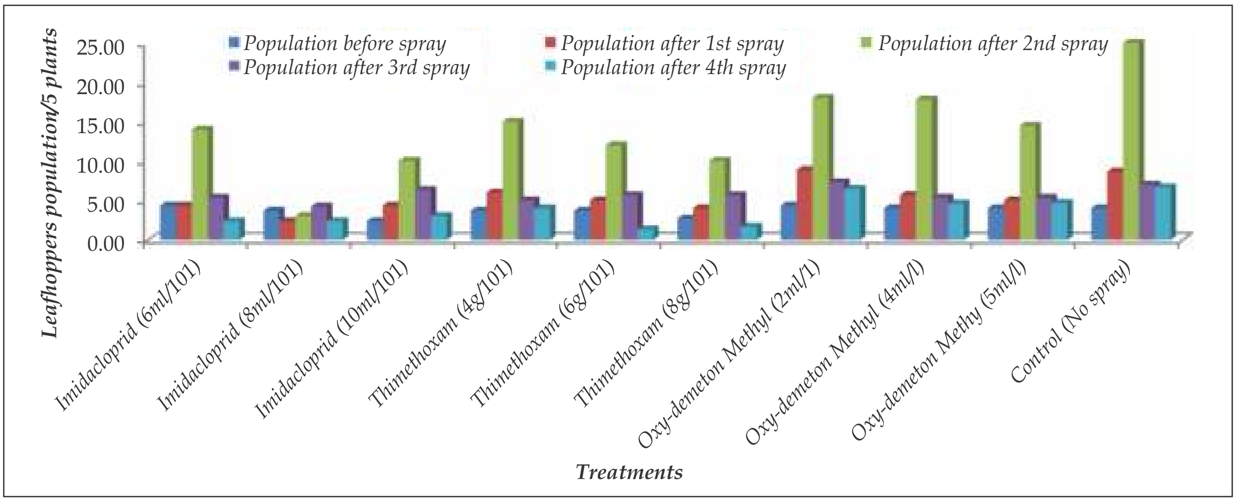


Fig. 13: Resurgence of Leafhoppers population on potato (Modipuram)

(Fig. 14). Under salivary genes and chemoreceptors, 39 glucose dehydrogenases, 24 sugar/glucose /inositol transporters, 1 apolipophorin, 4 salivary glands/proteins, 6 secretory proteins, 9 gustatory receptors and 20 odorant receptors/proteins. In addition, insecticide resistance genes were also observed, which includes 26 acetylcholine receptors/esterases, 91 sodium exchangers/ channels/transporters and 5 GABA transporters. In virus transmission genes category, 11 dynamin, 3 serine protease inhibitors and 7 vesicle transport/ trafficking proteins genes were observed in *A. solani* genome. Analysis of 53 CYP genes indicated the association of 23 CYP families, of which *CYP4C1-like* (15) was predominant followed by *CYP6a13* (6), *CYP6a14* (5)/*CYP6k1-like* (5) etc in *A. solani* genome. These 53 CYP genes were annotated from four insect species namely *Myzus persicae* (39) followed by *Acyrthosiphon pisum* (7) and *Diuraphis noxia* (5).

Studies on Phyto-semiochemicals involved in interaction of major pests of potato with *Solanum tuberosum* L

Natural plant secondary metabolic compounds play an important role in the host selection behavior of insect pest species. The objective of present study was to evaluate attractiveness of host plant volatiles of *S. tuberosum* to *T. absoluta* against gravid females and adult *B. tabaci*.

1. Attractiveness of *T. absoluta* to *S. tuberosum* volatiles

A total of 27 plant volatile organic compounds were identified from the GC-MS analysis of potato volatiles. Coupled GC-EAD response with *T. absoluta* gravid females to *S. tuberosum* plant volatiles revealed seven biologically active volatile organic compounds such as 4-Methyloctane, α-Thujene, Undecane, 2,4,6-Trimethyldecane, 4-Ethyl-5-methylnonane, 2,3,5,8-Tetramethyldecane, Pentadecane that could elicit an EAD response **(Fig. 14)**. This will make possible future studies where a lure for adult *T. absoluta* may be developed for monitoring and mass trapping applications.

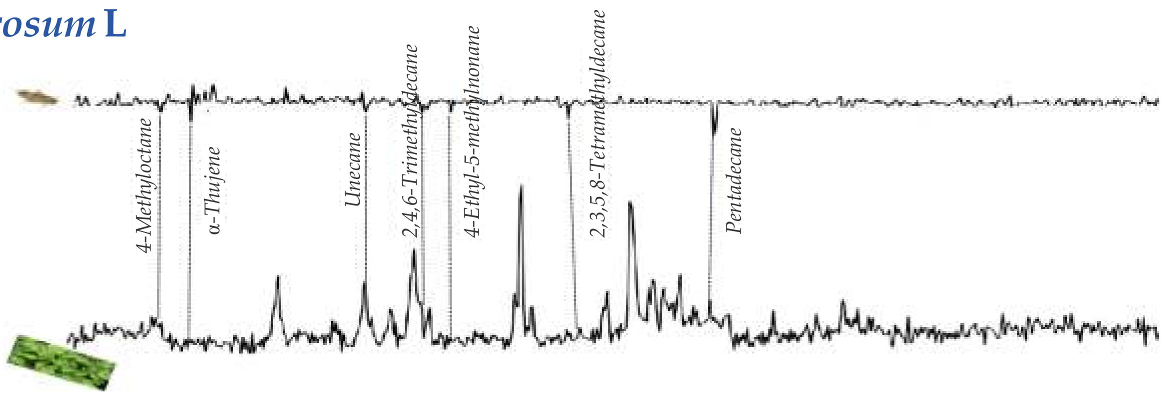


Fig. 14: GC-EAD traces showing the response of T. absoluta gravid female to S. tuberosum plant volatiles

2. Differential response of *B. tabaci* to healthy and herbivore induced plant volatiles of *S. tuberosum*

In dual choice assay, whiteflies spent significantly more time (F = 11.29; df = 3, 36; P < 0.0001) in the infested potato plant volatile treated region of the olfactometer (3.48 ± 0.24 min; mean time spent ± S.E.) than in the healthy plant volatile treated region (3.0 ± 0.29 min) and solvent controls in the olfactometer (1.86 ± 0.29 and 1.67 ± 0.22 min), respectively. GC-MS analysis of potato volatiles collected from both healthy and infested plant shows that there was a change in the volatile profile in terms of abundance and compounds. Coupled GC-EAD with *B. tabaci* to *S. tuberosum* healthy plant volatiles revealed four biologically active volatile organic compounds such as α-Thujene, 2,4, 6-Trimethyldecane, Ethyl-benzaldehyde, 2-Butyloctanol that could elicit an EAD response **(Fig. 15)** whereas Coupled GC-EAD with infested *S. tuberosum* plant volatiles revealed that three compounds found to be biologically active namely 2,4-Dimethylheptane, 2-Butyloctanol, Farnesane that elicited an EAD response **(Fig. 16)**.

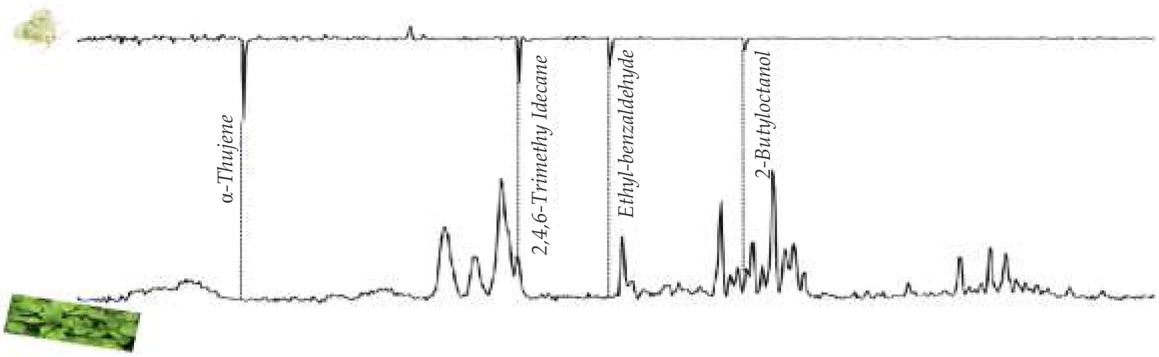


Fig. 15: GC-EAD traces showing the response of B. tabaci to healthy S. tuberosum plant volatiles

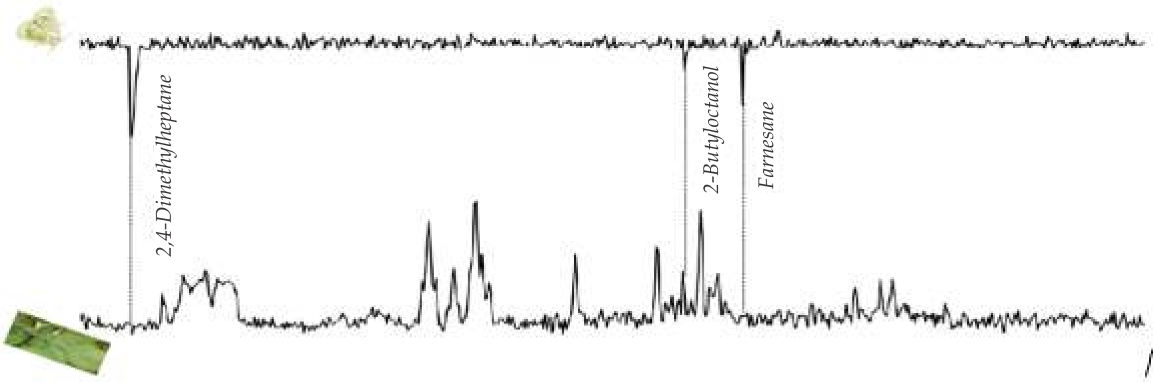


Fig. 16: GC-EAD traces showing the response of B. tabaci to S. tuberosum herbivore induced plant volatiles

RNAi approach for the management of *Myzus persicae* (Sulzer)

RNA-interference (RNAi) is a homology-dependent innate immune response in eukaryotes, including insects, which results in degradation of the corresponding transcript following its recognition by a double-stranded RNA (dsRNA) that shares 100% sequence homology. In this study, five aphid genes were selected from an *in silico*-annotated transcriptome library constructed from the aphid, *M. persicae*. Candidate genes were: Acetylcholinesterase, Macrophage migration inhibitory factor, Stylin-001, V-type proton ATPase subunit E and Uncharacterized LOC111031105. GenScript siRNA Target Finder tool was used to design siRNA multiconstruct with 401 bp from the selected five genes. The designed gene construct was synthesized by Eurofins Genomics India. Further, Gene cloning was carried out to insert the synthesized target gene construct to desired vector. dsRNA synthesis was carried out using Mega script RNAi kit and it was confirmed by Gel electrophoresis. Further, we are attempting to standardize different methods for delivery of dsRNA into the aphids to evaluate knockdown efficacy and mortality of the synthesized dsRNA. This study offers a viable approach for the discovery of prospective dsRNA biopesticide.

M. persicae siRNA construct

GATATGTTTGCCCAAGAGCCAGAATACACAGAGAAGCGAAACCTTAATCATAGACGGAGGTCCGAATTTAGTGGAAACCAGGATAATGATTTCGAATCTTCTCCTAAAGTACTCGTATCGGAAGAAAATTGGAAAACCAGAATCGTATGTAGTTGTGACTATTAAGAAACATGCCGCCGTCTTGTATCCTCAACTTCCAAACCGATAACGGAATCAAACAAGAAGAAGTCAGGTACTTGAAGTCCAAGGAGCAGTGTCTTACGTGGCCCCAATTAATGATCAGGAAGGATATTACGAAAGAAGCCAATGAGAAAGCCGAGGAAATCGACGCCAAAGCCGAAAAGGAAGCGTCTGGTCAAAGTGACAAATA

Endosymbiont profiling of laboratory cultured aphid, *Myzus persicae* (Sulzer)

Aphids enter a symbiotic relationship with bacteria which holds influence on their ecological characteristics. In this study, *M. persicae* cultured on Chinese cabbage was used to profile the endosymbionts. 16s rRNA universal primer PCR reaction was set up with DNA extracted from three bacterial colonies for amplification and it was confirmed with gel electrophoresis. The gel eluted product was used for setting up of Sequencing PCR and the PCR product was purified using Qiagen PCR purification kit following the manufacturer's instructions. The sequencing reactions were run on an automatic sequencer (ABI 377; Applied Biosystems) and the sequence was determined using universal primer. The sequences generated were compared to sequences available in GenBank using a BLASTn search. The bacterial endo-symbionts were identified as *Staphylococcus sciuri* and *Bacillus* species from the cultured aphids **(Fig. 17)**.

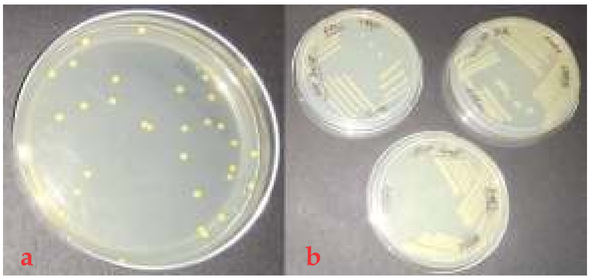


Fig. 17: a) Bacterial colonies grown on nutrient Agar; b) Pure culture of individual bacterial colonies grown on nutrient Agar

Viral load in whitefly population

Whitefly acquires and transmits *ToLCNDV*-potato which is responsible for Potato Apical Leaf Curl Disease. The circulative transmission of virus in vector is affected by various facultative endosy-mbionts harbored by insect vectors. A significant difference was also observed in their ability to acquire the *ToLCNDV-potato*. This study revealed that the rearing of whiteflies on brinjal and potato can significantly affect virus acquisition ability however, endosymbionts frequencies may remain unaffected **(Fig. 18)**.

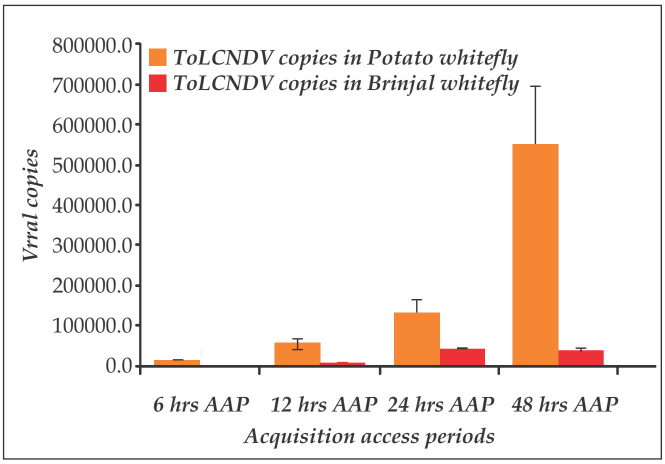


Fig. 18: Viral load in whitefly population reared on two separate host i.e. potato and brinjal

Nematology

1. Validation of LAMP assay for the identification of *Globodera pallida*

A loop-mediated isothermal amplification (LAMP) assay was developed to detect *G. pallida* directly from soil by developing the mitochondrial cytochrome c oxidase I (COI) gene specific primer **(Fig. 19)** In analytical sensitivity tests, the Gp-LAMP assay was able to detect *G. pallida* up to 10fg/µl of DNA visually with SYBR Gold nucleic acid stain whereas; it was 10 pg/µl for conventional PCR.

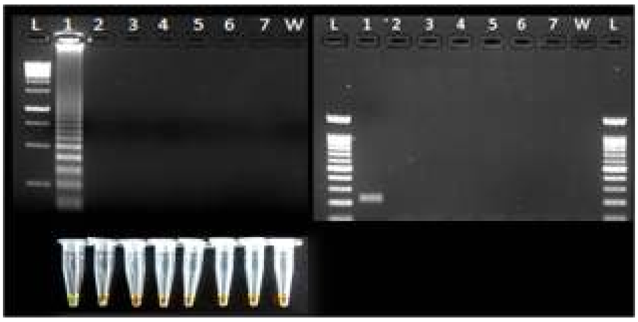


Fig. 19: Specificity test of a. Gp-LAMP assay compared with b. conventional PCR and c. SYBR Gold nucleic acid dye using different species genomic DNA. (L: Ladder (100 bp) 1. G. pallida, 2. G. rostochinensis, 3. M. incognita, 4. M. javanica, 5. H. avenae, 6. H. carotae 7. Cactodera and W: control)

2. Validation of LAMP assay for the identification of *Globodera rostochiensis*

A LAMP assay was developed to detect *G. rostochiensis* directly from soil by developing the

Gr-Ex (225bp) (Exapansins) gene specific primer **(Fig. 20)**. In analytical sensitivity tests, the Gr-LAMP assay was able to detect *G. rostochinensis* up to 1pg/µl of DNA visually with SYBR Gold nucleic acid stain whereas; it was 10 ng/µl for conventional PCR.

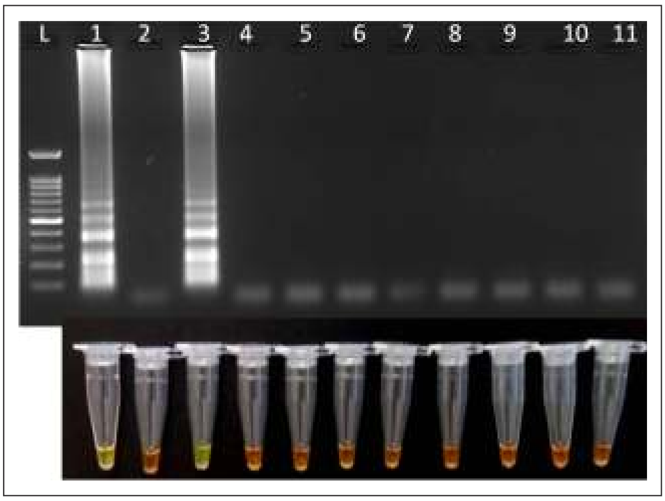


Fig. 20: Specificity test of Gr-LAMP assay with SYBR Gold nucleic acid dye using different species genomic DNA (L: Ladder (100 bp) 1.G. rostochinensis (Kufri), 2. G. pallida (Kufri), 3. Mixed Globodera population (Kufri), 4. G. pallida (Ooty), 5. M. incognita, 6. M. javanica, 7. H. avenae, 8. H. carotae 9. Cactodera 10 and 11 Water control)

3. Effect of bleaching powder [calcium hypo-chlorite (Ca(ClO) 2)] on PCN at Shimla

A study was carried out with different concentrations of bleaching powder [calcium hypochlorite ($Ca(ClO)_2$)] and the results revealed that under *in vitro* condition cent-percent cyst disintegration was recorded in 2.0% bleaching powder solution after 24 h **(Fig. 21)**. In addition to this application of bleaching powder resulted enhancement of soil pH as well as calcium content and reduced the electrical conductivity. Under field condition, different doses of bleaching powder (20-200 gm/m^{-2}) reduced the PCN population without affecting the germination **(Fig. 22)**.

Fig. 21: Effect of bleaching powder solution on PCN.

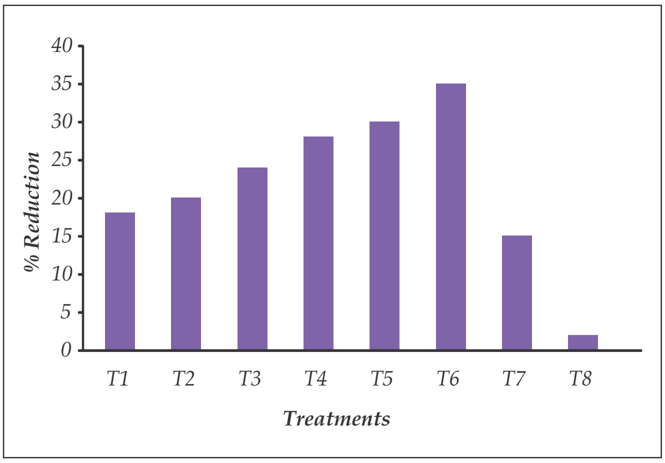


Fig. 22: Effect of bleaching powder on PCN population under field condition. T_1- BP@20 g/m^2; T_2- BP@30 g/m^2 ; T_3- BP@40 g/m^2 ; T_4- BP@50 g/m^2; T_5- BP@100 g/m^2; T_6- BP@200 g/m^2 ; T_7-Carbofuran3G@6.5g/m^2 ; T_8- Untreated control

4. Effect of different doses of Fluensulfone 2G on root-knot nematode of potato at Modipuram

Experiment on effect of different doses of Fluensulfone 2G on root-knot nematode (RKN) was carried out with different combination treatments of doses, time of application along with untreated control. Different doses of Fluensulfone 2G had significant effect only on root-knot index (RKI). However, there was no significant effect on different plant and yield parameters. Root knot nematode index was significantly affected by different doses as well as time of application of Fluensulfone 2G but there was no significant effect due to the application of Carbofuran 3G @65 kg/ha as compared to control **(Fig. 23)**.

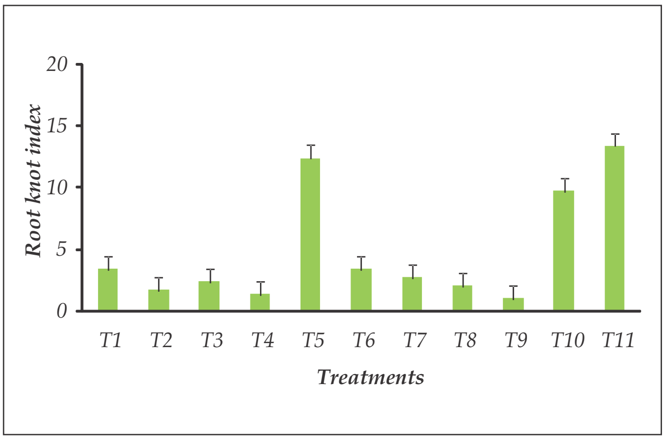


Fig. 23: Effect of different doses of Fluensulfone 2G on RKN index

5. Isolation of *Chaetomium globosum* KPC3 antagonistic fungus from potato cyst and its *in vitro* bio efficacy on potato cyst nematode (*Globodera* spp.)

A potential bio-control strain KPC3 was isolated from *Globodera* cyst and was identified as *Chaetomium globosum* based on morphological and rDNA-ITS sequence analysis. The antagonistic effect showed 100% parasitization on cyst and eggs inside the cyst as well as juveniles after 72 h of incubation **(Fig. 24&25)**.

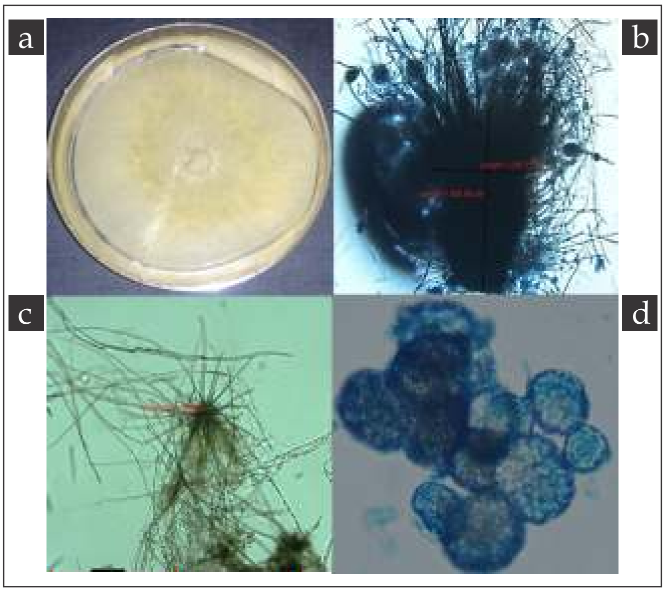


Fig. 24: Morphological characteristics of C. globosum KPC3 (a) Colony, (b) Perithica, (c) Hyphae & (d) Spore

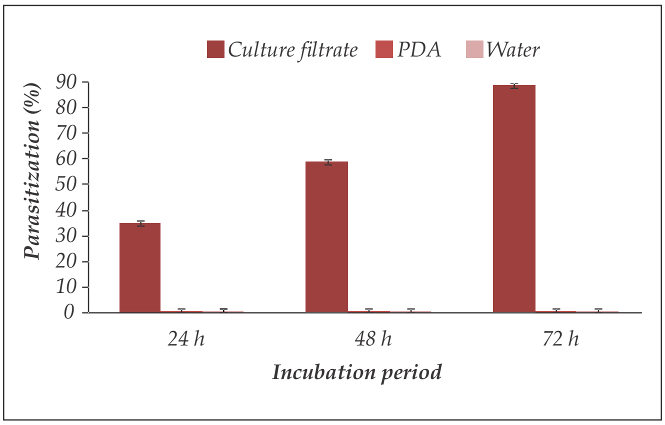


Fig. 25: Effect of C. globosum KPC3 culture incubation period on cyst parasitisation

Whereas, in different concentration of culture filtrate the mortality in second stage juveniles (J_2s) of PCN was started after 24 h of incubation and it reached 96.25% after 72 h of incubation in 100% culture filtrate **(Fig. 26 & 27)**.

Control *Culture Filtrate*

Fig. 26: Effect of C. globosum KPC3 culture filtrate on PCN J_2

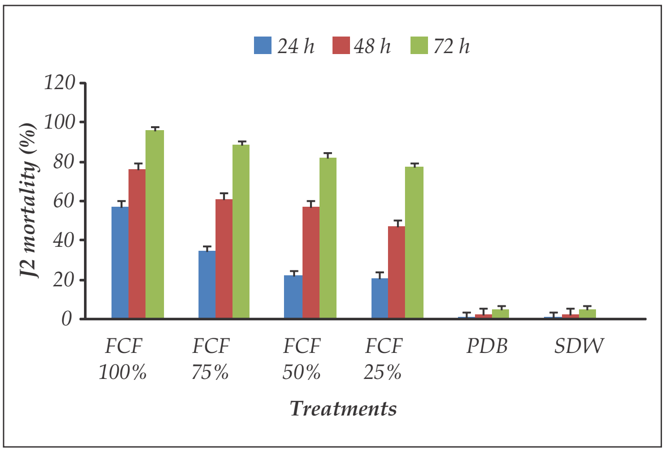


Fig. 27: Effect of C. globosum KPC3 culture filtrate on PCN juvenile's mortality.

6. Analysis of un-known compounds from aeroponic root leachates

To identify the effective PCN hatching compounds present in the aeroponic root leachates (ARL) the ARL collected after 30 and 60 days after planting were analyzed through HR-LCMS at IIT-Bombay. The change in un-known compounds due to crop age under aeroponic system is given below in **(Fig. 28 and 29)**.

Management of Cyst Nematodes

1. Bio-management of Potato Cyst Nematodes

Field experiment was conducted Ooty to see the effect of *Paecilomyces lilacinus* @20 kg/ha talc formulation, *Trichoderma viride* @20 kg/ha talc formulation and *Pseudomonas fluorescens* @20 kg/ha talc formulation, along with treated (carbofuran 3G @65 kg/ha) and untreated control. The application of *Paecilomyces lilacinus* @20 kg/ha (T1) was found more effective, where highest potato yield (38.85

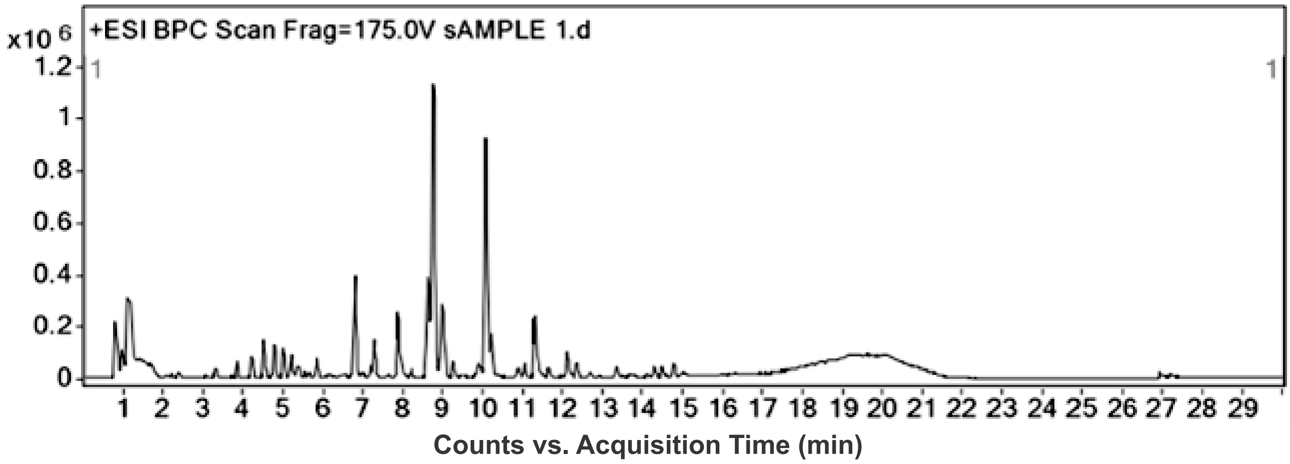


Fig. 28: HR-LCMS analysis of ARL collected 30 DAP

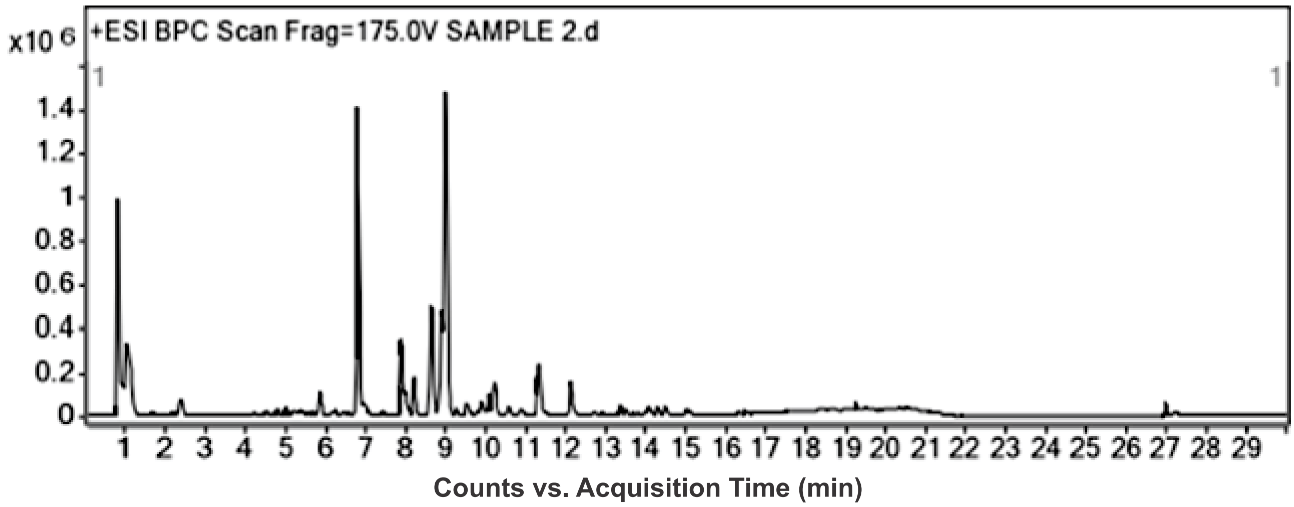


Fig. 29: HR-LCMS analysis of ARL collected 60 DAP

t/ha) was recorded with lowest Rf value (1.12) **(Fig. 30)**.

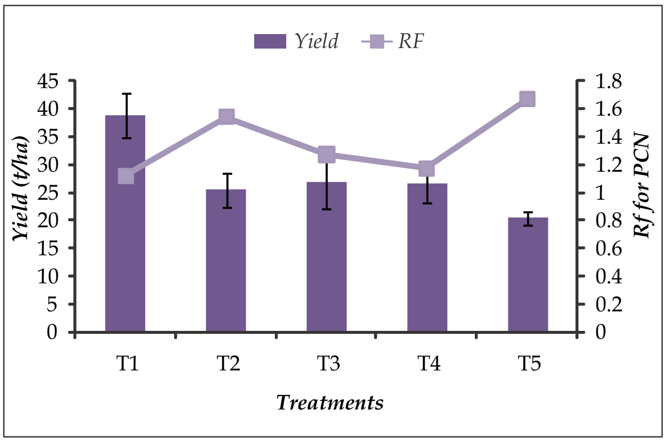


Fig. 30: Evaluation of different biological control agents against PCN

2. Bio fumigation for the management of Potato Cyst Nematodes (Ooty)

Field experiment was conducted to see the effect of incorporation of T1-Radish @12.5 t/ha, T2-Cabbage @12.5 t/ha, T3-Mustred @12.5 t/ha, T4-Califlower @12.5 t/ha along with treated (T5-carbofuran 3G @65 kg/ha) and untreated control (T6) on potato cyst nematodes. Mustard @12.5 t/ha (T3) was found more effective with highest potato yield (19.48 t/ha) followed by Radish @12.5 t/ha (T1) and treated control (T5-carbofuran 3G @65 kg/ha) **(Fig. 31)**.

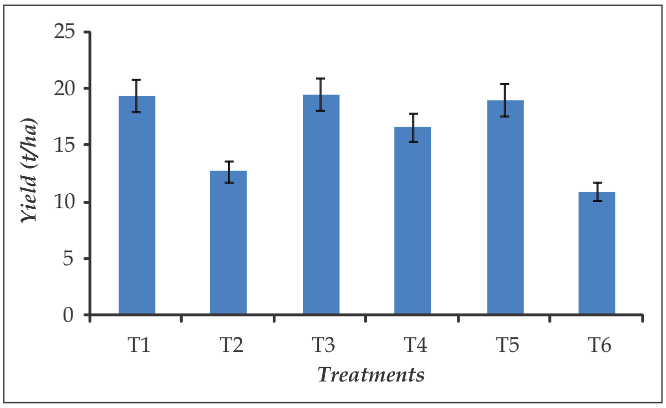


Fig. 31: Effect of different brassica crops on potato yield

3. Trap crops: a potential way to eradicate potato cyst nematodes

Solanum sisymbriifolium was found as the most potential resistant trap crop for management of PCN but presence of sharp spines and poor seed germination makes it difficult to use in cropping sequences. Locally available, *S. mauritianum* can also be used as an efficient trap crop for the management of PCN and can be planted one or two seasons prior to potato crop for attaining good yield by maximum reduction in PCN population. Both the species of *Solanum* exude different hatching factors for PCN, but send common signals to attract the J2s towards the roots and their further invasion. But their development seems to be prevented by both the plants and therefore can be used as trap crops against PCN **(Fig. 32 & 33)**.

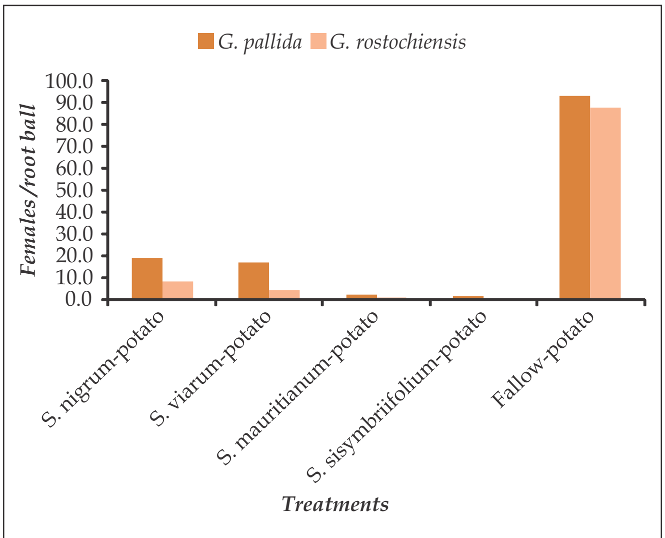


Fig. 32: Solanum species as a trap crop against potato cyst nematode species

Fig. 33: Plant characteristics of S. sisymbriifolium (left) vs S. mauritianum (right) A. Leaf, B. Flower, C. Fruits and D. Seeds

4. Bio-efficacy evaluation of native strain of EPN, *Steinernema cholashanense* against potato tuber moth, *Phthorimaea operculella* (Zeller) at Ooty

A native strain (CPRSUS01) of *Steinernema cholashanense* (Nguyen) isolated from potato rhizosphere was used against PTM under laboratory conditions **(Fig. 34)**. The EPN is able to multiply at 649 IJs mg weight^{-1} of PTM larvae when inoculated at 80 IJs/Larvae. *S. cholashanense* can be exploited as an alternative tool for the management of *P. operculella* in potato production.

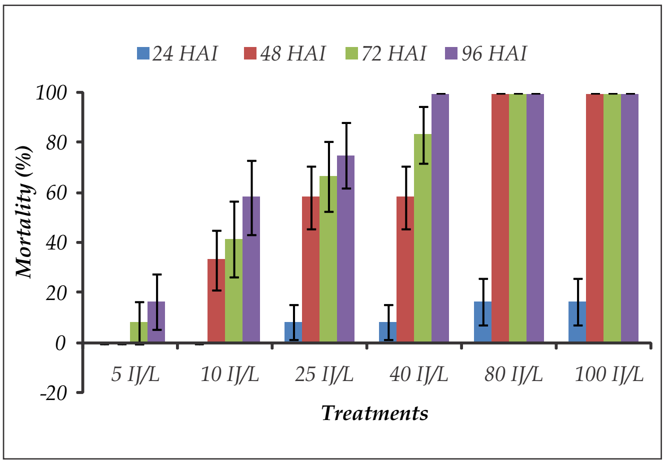


Fig. 34: Efficacy of EPN on larvae of potato tuber moth, Phthorimaea operculella

5. Identification of alternate hosts of nematodes at Ooty

A total of 28 weed species were collected, identified and observed for the presence of root galls formed by *Meloidogyne* spp in nearby area of Ooty. *Oenothera rosae* was found to support the maximum number of galls (2097 plant^{-1}) whereas seven species viz., *Cynadon dactylon, Pennisetum clandestinus, Phalaris arundinacea, Eragrostis tenuifolia, Calceolaria mexicana, Chenopodium sp.*, and *Cystisus scoparius* were found devoid of galls. In addition to this, *Polygonum nepalense* were found infected with Estonian cyst nematode, *Cactodera estonica* whereas none of the weeds were found to support the populations of any species of potato cyst nematodes, *Globodera* spp.

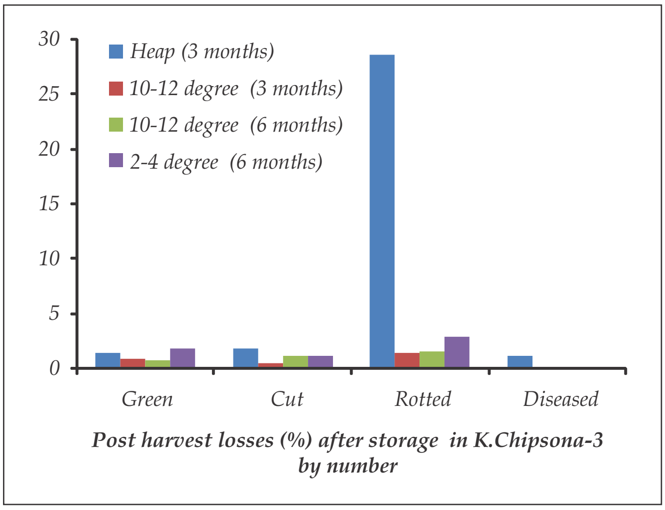
DIVISION OF CROP PHYSIOLOGY, BIOCHEMISTRY AND POST-HARVEST TECHNOLOGY

PROGRAMME: POST-HARVEST MANAGEMENT AND NUTRITIONAL ENHANCEMENT OF POTATOES

This programme aims to assess the post-harvest losses in potatoes and refinement of post-harvest handling and storage techniques to reduce these losses occurring in potatoes. Besides, the programme also emphasizes on the establishment of nutritional quality of potatoes and replace the misconceptions attached to potato consumption. Further there is need to enrich the potatoes with the nutrition and develop products which are nutritious, acceptable to the Indian consumers and can also utilize the non-marketable potatoes. All these issues were dealt during the reported period and the results are being summarized here.

Post-Harvest Loss Assessment

Post-harvest losses in potatoes were estimated using potato variety, Kufri Chipsona-3. Potatoes were harvested, graded and stored in heap, at 2-4°C and 10-12°C. Potato at 2-4°C were removed after six months, from heap after 3 months and from elevated temperature (10-12°C) were sampled twice after three and six months, respectively for loss assessment.



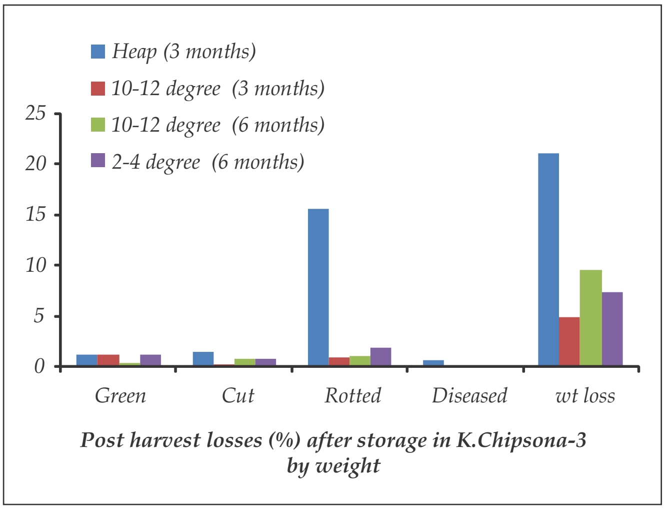


Fig.1: Effect of different storage methods on Post-harvest loss

It was observed that rottage was the maximum in heaps at 3 months after storage (28.48) followed by storage after 6 months at 2-4°C (2.81). None of the diseased tubers were found at 10-12°C, whereas, 1.09% of the diseased tubers were present in heap **(Fig. 1)**. Data pertaining to physiological loss was also monitored.

Sprout suppression with naturally occurring volatile compounds

To confirm the synergistic effect of naturally occurring volatile oils, treatment was conducted on two varieties viz. K Chandramukhi and K Chipsona-1. For each variety 9 different oil combinations were applied in three different volumes i.e. 1.0, 1.5 and 2.0 ml. Similar to previous year's results, three combination treatments T15, T17 and T21 containing a combination of 4, 6 and 9 oils, respectively were found effective up to 300 days of storage at 12°C for both the varieties. Treated potatoes remained totally sprout free with an acceptable level of shrivelling even after 3 months of removal from the controlled temperature chamber. These treatment combinations have the potential to replace the CIPC, which is commercially used for sprout suppression. This study needs large-scale confirmations for further optimization of percentage concentration of component oils.

Method Development for Abscisic acid (ABA) quantification in potato

Plant hormones play a crucial role in controlling plant growth and development. ABA is required for both the initiation and maintenance of tuber dormancy. Accurate quantification of ABA is required for tuber sprouting studies in potato. So, we have standardized LC-MS based protocol for plant hormones estimation. Two grams of frozen potato sample was ground to a powder using liquid N_2. The samples were processed through extraction and filtrations and injected into LC-MS. The standards of ABA (from Sigma-Aldrich) were run using different concentrations to make standard curve **(Fig. 2)**. The method seems reliable and may be used for quantification of ABA in various dormancy related experiments.

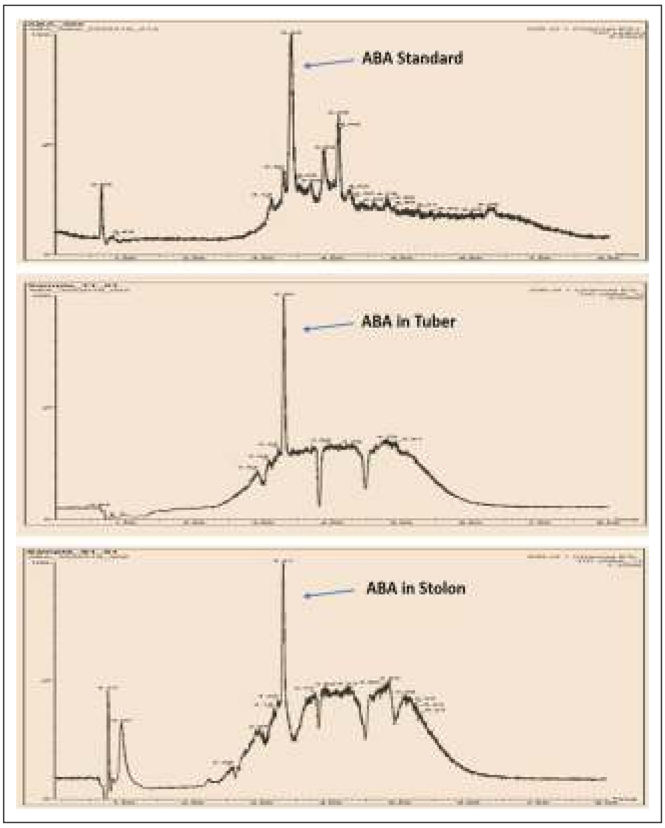


Fig. 2: LC-MS chromatogram of ABA in potato

Quantification of Nutritional Compounds from Potatoes

First report on presence of Insulin like antigens in potatoes: The presence of insulin like antigens (also named as glucokinin) in some plants have been reported and it was planned to check their presence in unsprouted and sprouted potatoes. Presence of insulin like antigens was first checked by SDS-PAGE and then their presence in potato was confirmed with Western Blotting. The varieties used for the study were K. Chipsona 1, K. Surya, K. Pushkar, K. Jyoti and K. Bahar. The SDS-PAGE results indicated a band of expected size viz. ~10 kDa in all the samples (sprouted and unsprouted) along with standard (Insulin from bovine pancreas) after coomassie staining **(Fig. 3)**. Since the obtained band was of same size as that of standard, this hints towards the presence of insulin like antigens in potatoes. In order to further confirm the presence of insulin like antigens in potatoes, western blotting was carried out. The specificity of the protein (~10 kDa) was evaluated by a strong reaction (i.e bands in all the samples along with standard) in western blotting with commercial antibodies, which indicates that these bands were specific for insulin like antigens. Hence presence of insulin like antigens was confirmed not only in unsprouted but sprouted potatoes as well.

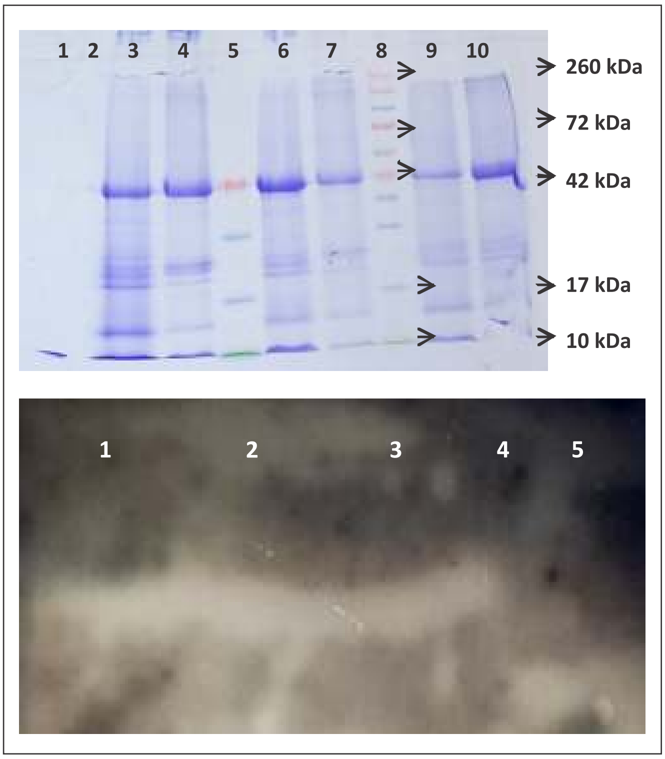


Fig. 3: Top: SDS-PAGE of potato extracts; Insulin from bovine pancrease (1), blank (2), Kufri Chipsona-1 (3), Kufri Surya (4), Low range ladder (5), Kufri Chipsona-1 sprouted (6), Kufri Pushkar (7), Wide range ladder (8), Kufri Jyoti sprouted (9), Kufri Bahar (10); Bottom: Western blotting of potato extracts; 1- Standard Insulin Bovine, 2- Kufri Chipsona-1, 3- Kufri Surya, 4- Kufri Chipsona-1 (sprouted), 5- Kufri Pushkar

Quantification of insulin like antigens in potatoes: Insulin like antigens were quantified from sprouted and unsprouted tubers of K. Jyoti and K. Chipsona 1 and in unsprouted tubers of K. Surya, K. Bahar and K. Pushkar using ELISA technique. The results indicated that these antigens are present in higher concentration in sprouted tubers compared to unsprouted tubers. Sprouted tubers of both K. Jyoti and K. Chipsona 1 contained same concentration of insulin like antigens **(Fig. 4)**. Among the unsprouted tubers, concentration was the maximum in K. Pushkar (67 µg/g DW) and least in K. Chipsona-1 (34 µg/g DW). Concentration of these antigens was significantly high (almost four times) in sprouted potatoes compared to unsprouted ones.

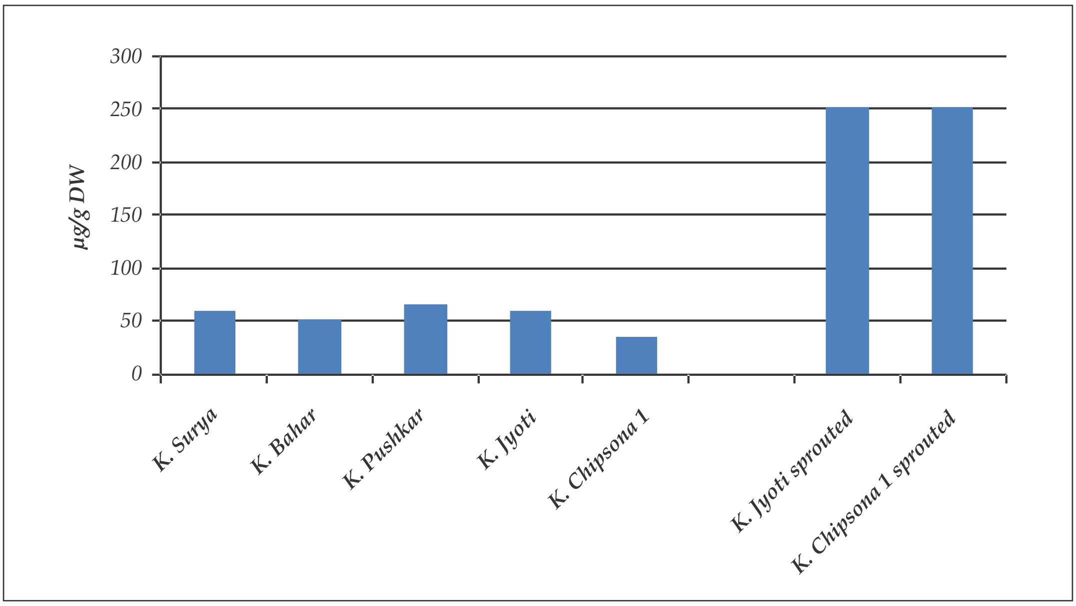


Fig. 4: Insulin like antigens in sprouted and unsprouted tubers

In vivo antihyperglycemic activity of potatoes: Lyophilized powder of three potato varieties viz. K. Bahar, K. Pushkar and K. Surya were analyzed for antihyperglycemic activity in streptozotocin induced diabetic rats. The study was carried out at Central Drug Research Institute, Lucknow. For the experiment, metformin (first line drug to treat diabetes type II) was used as standard. Same dose of metformin and potato samples was administered to diabetic rats. The results showed that potato variety K. Surya decreased the blood sugar level more than metformin. Single dose (300mg/kg body weight) of K. Surya and K. Pushkar caused time dependent decrease in blood glucose level in hyperglycemic rats. After 5 h of treatment, blood glucose decreased to 23.6% with metformin, whereas decrease reported with K. Surya and K. Pushkar dose was 29.7% and 18%, respectively **(Fig. 5)**. Variety K. Bahar did not exert any significant effect on blood glucose level in streptozotocin induced diabetic rats.

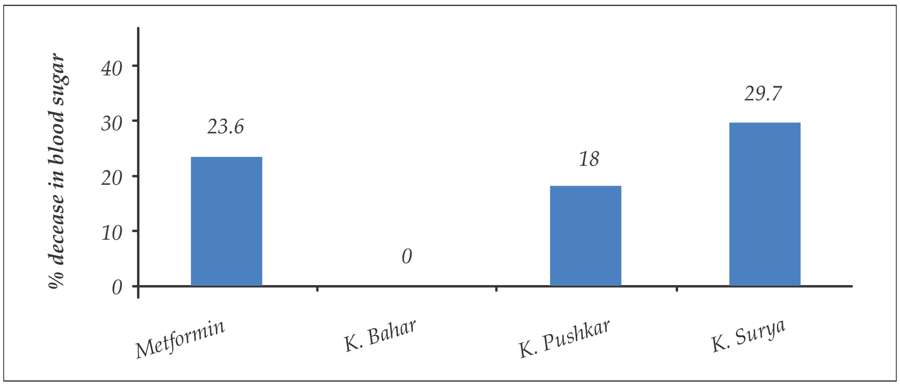


Fig. 5: Antihyperglycemic activity in streptozotocin induced diabetic rats

Purification of Chlorogenic acid: Potatoes are well known to contain high concentrations of phenols, particularly chlorogenic acid (CGA). These phenols are present in higher concentration in peel compared to potato flesh. Therefore, lyophilized potato peel was used to purify chlorogenic acid. Water extract of lyophilized peel was used for purification purposes. After each purification step, the sample was checked through HPLC for purification of chlorogenic acid. The HPLC results indicated that chlorogenic acid was purified to maximum extent, as a clean peak was obtained at same retention time as that of standard chlorogenic acid **(Fig. 6)**.

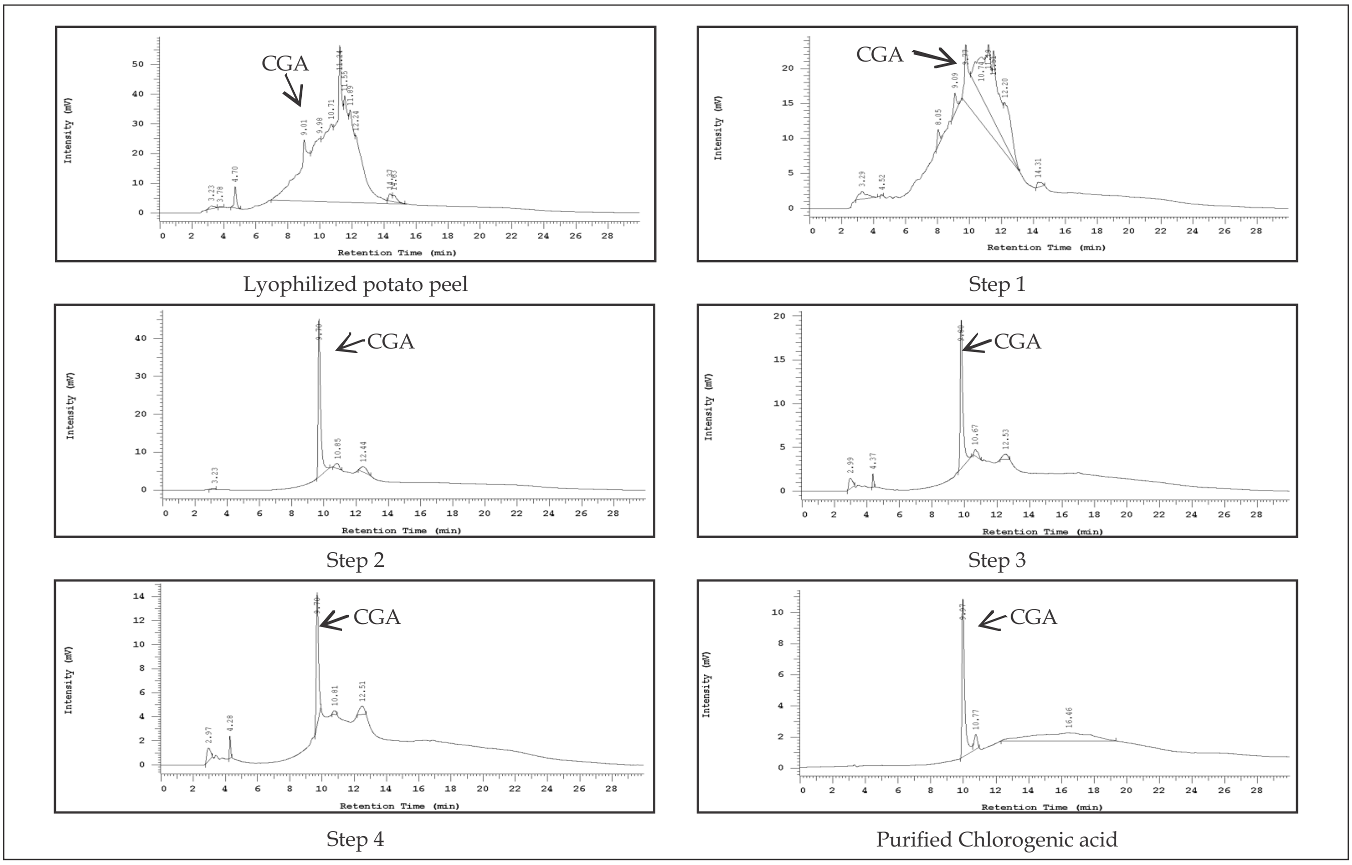


Fig. 6: HPLC chromatograms of chlorogenic acid during purification process

Bioaccessibility of Phytonutrients from Potatoes

Effect of cooking on in vitro bioaccessibility of potato carbohydrates: Effect of cooking on *in-vitro* bioaccessibility of carbohydrates (starch and reducing sugars) in potato varieties Kufri Chipsona-3 (KC3) and Lady Rosetta (LR) was investigated through *in vitro* gastrointestinal model. Starch content in raw, boiled, microwaved and fried tubers of KC3 and LR decreased significantly in gastric and intestinal phase (Figure 7). The decrease in starch content in raw tubers of LR was 22% and 56%; and in KC3 was 57% and 74%, respectively, in gastric and intestinal phase as compared to oral phase. In boiled tubers of LR and KC3, decrease in starch content, in gastric and intestinal phase was 23%, 75%; and 32%, 87% respectively, in microwaved tubers the decrease was 65%, 86% and; 33%, 77%, respectively. In fried tubers, decrease in starch content in gastric and intestinal phase was 14% and 57% in LR and 27% and 42% in KC3, respectively. The results showed that both boiling and microwaving of tubers lead to higher rate of starch breakdown during digestion compared to raw tubers.

Both the varieties showed similar trend for reducing sugars during *in vitro* digestion. Boiled and microwaved tubers released maximum concentration of sugars at start of intestinal phase (130 min), whereas fried tubers released maximum sugars at end of intestinal phase (300 min) **(Fig. 7)**. Reducing sugar release increased form oral to intestinal phase. At start of oral phase, reducing sugars were high in microwaved tubers compared to raw, boiled and fried form. Raw tubers of KC3 released maximum concentration of sugars after 60 min of digestion (gastric phase), whereas LR released maximum concentration of sugars during 120 min of digestion (gastric phase). Boiled and microwaved tubers of both the varieties released maximum concentration of sugars after 130 min (intestinal phase) and concentration of sugars decreased after 150 min of digestion. Fried samples of both the varieties showed different trend, as maximum release of sugars was achieved at 300 min of digestion. The results showed that release of sugars is slow from fried tubers compared to boiled and microwaved tubers.

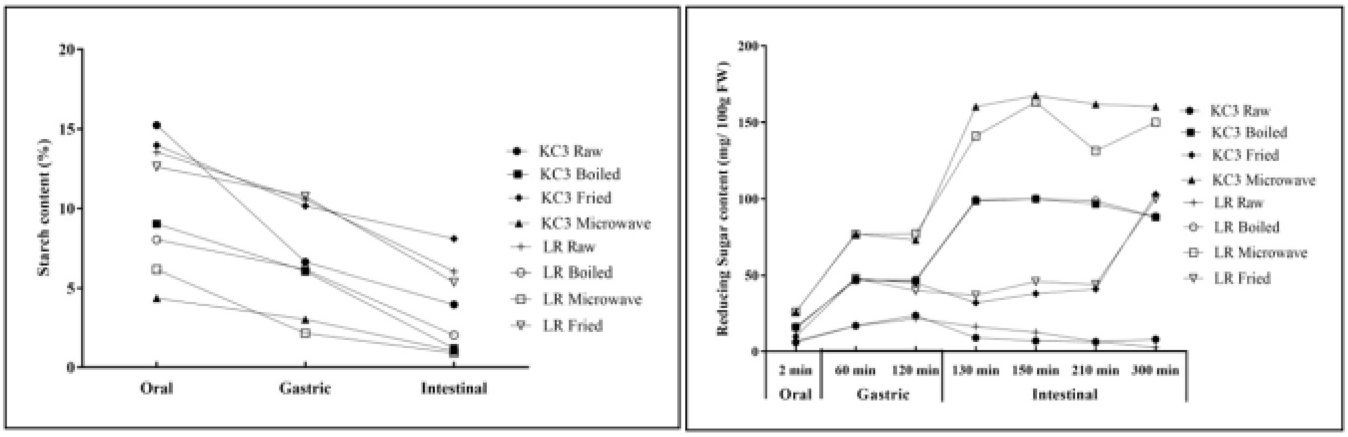


Fig. 7: Left: In vitro starch hydrolysis; Right: In vitro bioaccessibility of reducing sugars

***In vitro* bioaccessibility of potato peels' anti-oxidants evaluated in gastrointestinal model:** Various reports have suggested utilization of potato peel as a food fortificant due to high antioxidant concentration, however, information is lacking on bioaccessibility of potato peels' antioxidants and carbohydrates. Therefore, bioaccessibility of antioxidants and carbohydrates was carried out from peel of K. Chipsona 1, K. Bahar and K. Jyoti. Significantly higher concentration of total phenolic content was obtained in undigested peel of K. Jyoti (95 mg/100g) followed by K. Chipsona 1 (70 mg/100g) and K. Bahar (52 mg/100g) on fresh weight basis. After *in-vitro* gastrointestinal (GI) digestion significant decrease was observed in total phenolic content in oral, gastric and intestinal phases in peel of all varieties **(Fig. 8)**. Phenols were highly bioaccessible in gastric phase followed by intestinal and oral phase. The bioaccessible phenolic content in oral phase was 37 mg/100g, gastric phase was 43 mg/100g and intestinal phase was 38 mg/100g (average of three varieties).

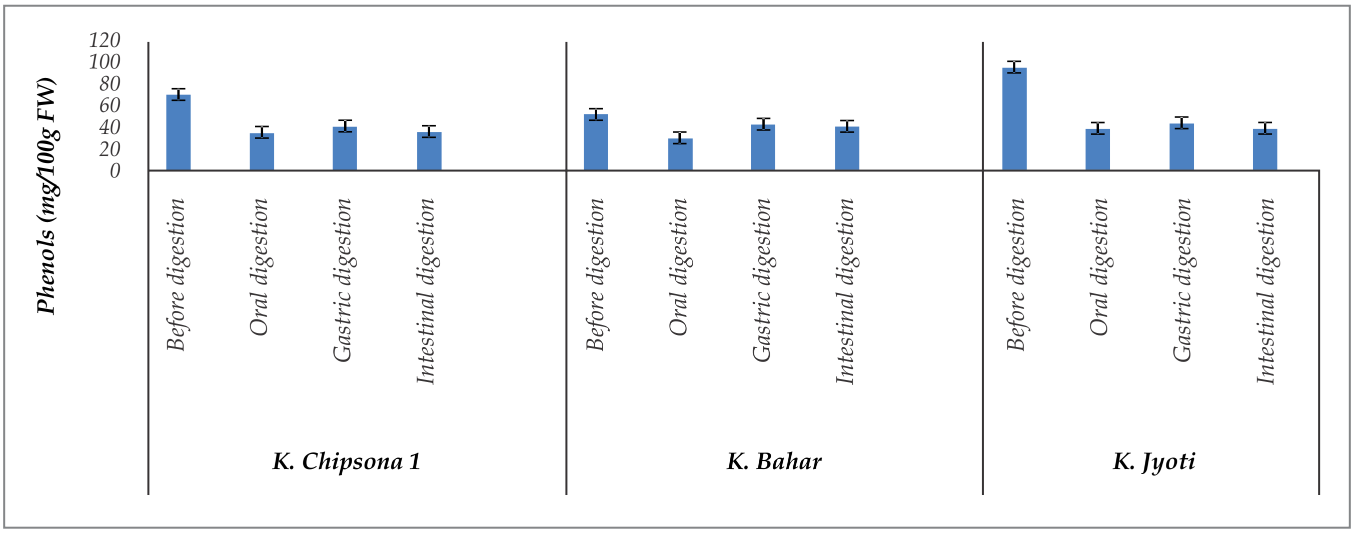


Fig. 8: In vitro bioaccessibility of total phenols

Chlorogenic acid was found to be the most dominant individual phenol in potato peel. Peel contained significantly higher concentration of chlorogenic acid (87 µg/g FW) followed by rutin (24 µg/g FW) and caffeic acid (6 µg/g FW) (average of varieties). In-vitro digestion significantly increased the release of chlorogenic acid, caffeic acid and rutin with maximum bioaccessibility observed in gastric phase **(Fig. 9)**. Chlorogenic acid and rutin showed maximum bioaccessibility and trend was gastric phase> oral phase > intestinal phase. However, in case of caffeic acid trend in K. Chipsona 1 and K. Jyoti was gastric phase> intestinal phase > oral phase. Overall average significant increase in chlorogenic acid after in-vitro digestion was 4-× in oral phase, 5-× in gastric phase and 3-× in intestinal phase. Caffeic acid on an average increased 15-×, 21-× and 18-× in oral, gastric and intestinal phase, respectively. Rutin increased significantly to 7-× in oral phase, 10-× in gastric phase and 1.1-× in intestinal phase.

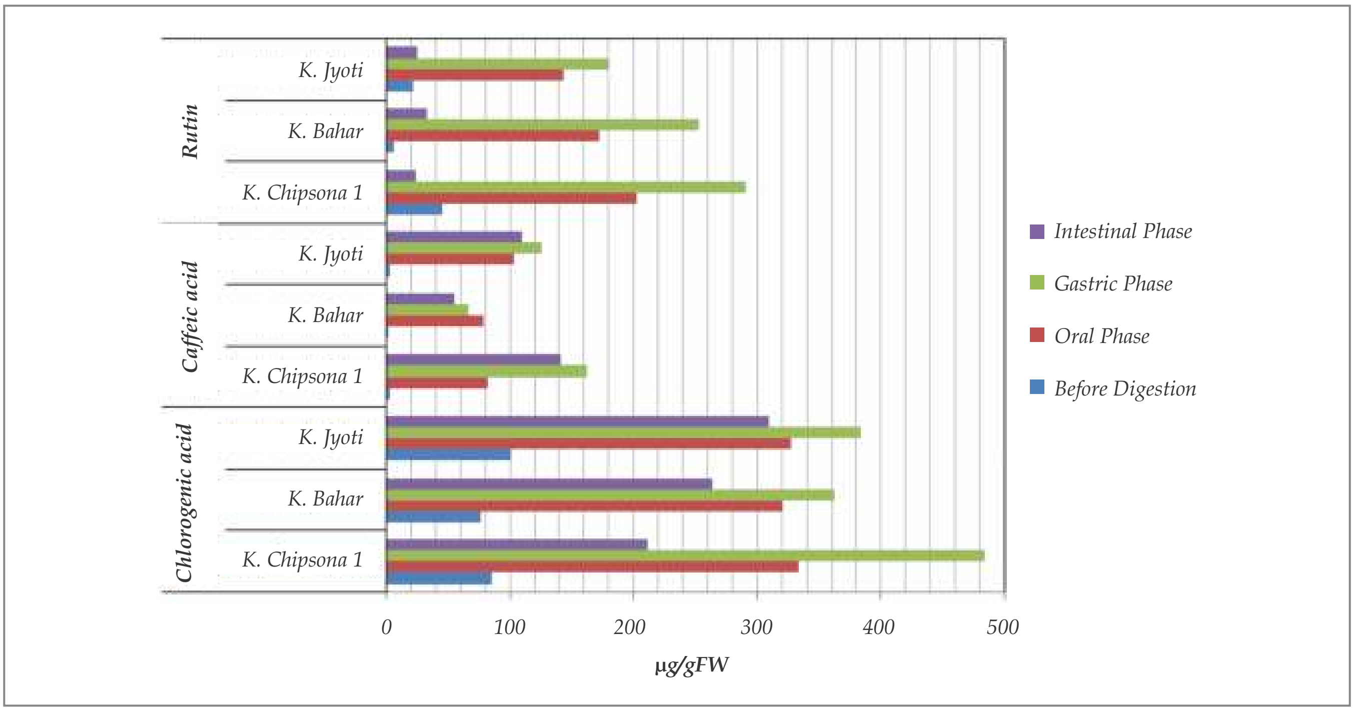


Fig. 9: In vitro bioaccessibility of potato peels' individual phenols

Before digestion, total ascorbic acid content in peel of three varieties ranged from 6 to 8 mg/100g FW. Significant increase was observed in ascorbic acid content after *in-vitro* GI digestion **(Fig. 10)**. Similar trend was noticed in peel of all the three varieties showing maximum bioaccessible amount of ascorbic acid in gastric phase followed by oral phase and intestinal phase. Ascorbic acid increased to 11-× in oral phase, 14-× in gastric phase and 9-× in intestinal phase (average of three varieties).

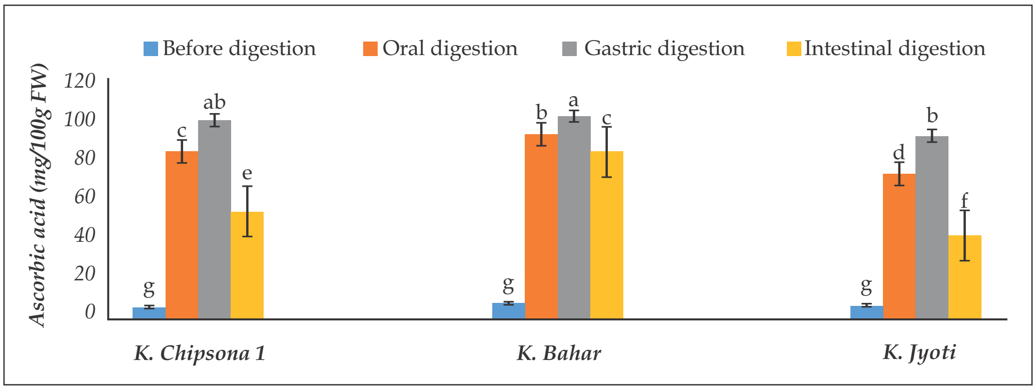


Fig. 10: In vitro bioaccessibility of potato peels' ascorbic acid

Glycemic Index (GI) In Potato

Effect of maturity and texture on GI: The GI is defined as the response of blood glucose measured as an area under the curve (AUC) in test food taken by a person which is expressed as a percentage of the AUC following consumption of reference food consumed by the same person under standard condition. The glucose released from carbohydrate of potato affects blood glucose level and satiety, insulin level, triglyceride metabolism and cholesterol level which ultimately influences the microflora of the gut, exerting a prebiotic effect in the large intestine. Low GI food increases the indigestible starch or the resistant starch which help in fermentation, and is essential for colonic microflora, thus reducing the chances of bowel cancer. The sensory test analysis was done for all the six cultivars. It was found that K. Chipsona-1 (KC1) and K. Chipsona-3 (KC3) were classified as floury texture and have high GI. However, K. Frysona (KF), K Girdhari (KG) and K Jyoti (KJ) all have inherent waxy property, out of which KF and KJ have intermediately high GI whereas KG have high GI. The six varieties also showed variation in GI and texture. High GI variety had floury texture, whereas the variety which has intermediately high GI had waxy texture **(Table 1)**. Similar results were reported, where it was observed that waxy cultivars exhibiting high moisture and low starch had medium GI in potato, whereas the floury potato exhibiting low moisture and high starch had a high GI. All six varieties are grown in India is of medium duration (90 to 100 days), and GI of varieties comes under high and intermediately high GI.

Table 1: GI classification and characterization of potato varieties of ICAR-CPRI.

Potato Variety	GI classification	Crop Type	Texture
KC1	High	Medium duration	Floury
KC3	High	Medium duration	Floury
KF	Intermediately High	Medium duration	Waxy
KG	High	Medium duration	Waxy
KJ	Intermediately High	Medium duration	Waxy
KP	Intermediately High	Medium duration	Waxy

Effect of retrogradation on GI and RS: Many factors are responsible for digestibility of starch. Intrinsic factors like amylose and amylopectin content, granule size of starch and molecular order influence starch digestibility along with the presence of fibre, fats and proteins in carbohydrate food. The extrinsic factor which is responsible for the starch structure and its digestibility is gastrointestinal mobility, the method of cooking and retrogradation. Processing conditions such as cooling can influence the glycemic impact of cooked potatoes through retrogradation of starch polymers. Our result showed that cooling/ retrogradation had significant GI lowering effect when cooked potatoes were stored for 0 h, 12 h, 24 h and 48 h. The maximum lowering effect was seen at 48 h at 4°C. GI of potato varieties after 48 h decreased from its initial value (82.30, 83.08, 76.17, 72.87 and 75.64) to 69, 67.63, 64.05, 66.80, 61.63 and 64.23 for KC1, KC3, KF, KG, KJ and KP respectively **(Fig. 11)**. Minimum lowering of GI was observed in KC1 and maximum in KJ. The retrogradation changes starch structure under low temperature, which ultimately leads to low GI.

The RS was found to increase in the boiled potatoes when stored at 4ºC. In the present study maximum increase in RS was found in KJ while the minimum increase was observed in KC3 after 48 h. There was significant increase in RS after 48 h of cooling in varieties KC1, KC3, KF, KG, KJ and KP, the RS content was found to be 2.59%, 2.55%, 3.70%, 3.40%, 4.52% and 3.36% respectively. During cooling, the gelatinized starch molecules begin to realign and RS formation is enhanced. RS may be recovered by boiling potatoes and cooling or retrogradation which significantly reduce GI. This practice can be easily followed at home on a daily basis to get more dietary fibre.

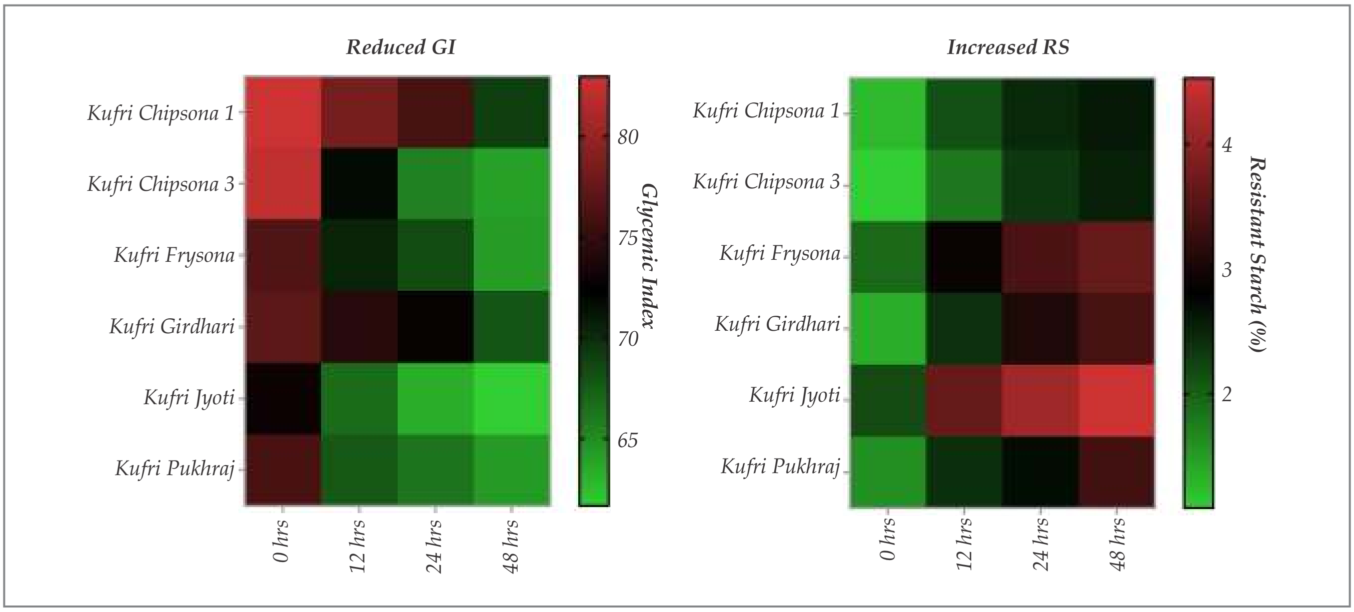


Fig. 11: The effect of retrogradation on (left) glycemic index (right) resistant starch of six potato varieties

Novel Value-Added Products from Potatoes

Production of glucose syrup from potato starch: Sugar syrups are a food grade syrups produced by starch hydrolysis and contain varying amounts of glucose, fructose, maltose and higher oligosaccharides, depending on the grade. The various industrial important foodsweeteners (Glucose syrup, Maltose syrup) can be produced from potato starch by enzymatic action (α-amylase, Amyloglucosidase and Glucose isomerase). To perform the above activity potato starch is needed as a substrate. About 10 Kgs of starch was isolated from K. Frysona cultivar. We have achieved 96 % conversion of potato starch into glucose.

Bioethanol production from waste potatoes: The protocol developed for the saccharification of potato starch into glucose by steam and enzymes i.e. alpha-amylase, amyloglucosidase, pullulanase, etc. which are more cost-effective and high conversion efficiency (81.67%) and fermentation with yeast yield the maximum amount of ethanol, optimized conditions and evaluated different strains of yeast such as *Saccharomyces cerevisiae* MTCC 170, *Saccharomyces cerevisiae* MTCC 171, *Saccharomyces cerevisiae* MTCC 173, *Saccharomyces cerevisiae* MTCC 174, *Saccharomyces cerevisiae* MTCC 177 and *Saccharomyces cerevisiae* MTCC 178. Under the optimized fermentation conditions such as temperature (30 °C), pH (6) and an incubation time of 96 hrs from *Saccharomyces cerevisiae* MTCC 171, produced maximum ethanol yield and productivity 82.4 g/l and 0.858 g/l/ h, respectively.

Potato preserve: Preservation of fruits and vegetables in high concentration sugar syrup or

salt/brine is a very old and commercially accepted method of preservation. Preserve/*Petha* is a popular dessert in the North Indian region, which is widely sold throughout the year in many forms, colours, shapes, and fragrances. Traditionally it is prepared from ash gourd/winter melon (*Benincasa hispida*) and rich in various minerals. Similar to ash gourd, potatoes can also be utilized for the making of preserve.

The short shelf-life of potatoes due to its perishability is a big challenge for its preservation at the consumer level. By using the principle of preservation with concentrated sugar syrup, the process for the potato-based preserve was developed and standardized. Nutritionally potato preserve is rich in vitamin C, potassium, and good quality protein and has a shelf-life of 2 months at ambient storage conditions. Fresh potatoes of medium to large size, potatoes of any shape, dry matter, and variety can be used for the potato preserve. Moreover, partially damaged or cold-stored potatoes can also be utilized. This technology can be easily adopted by industries involved in the production of winter melon preserve, gooseberry preserve or any other fruit/vegetable preserve.

Potato Muffins: Muffins are a small cake type baked product usually made from a mixture of wheat flour, buttermilk, curd, milk, egg, sugar, salt, shortening, and baking powder. Along with these ingredients muffins also contain dry fruits, chocolate chips, and nuts. More than a thousand variants of the muffins are being prepared worldwide. Some gluten-free variants are also available in the market. Even some variants are also available where potato, either in the form of flour, mashed or starch have been used to partially replace the wheat flour for improvement in textural properties of muffins. The process for chemically leavened potato-based gluten-free muffins having more than 60% part of the flour as potato was developed and standardized. At ambient temperature conditions, the shelf life of the muffin is 3-4 days. By using permitted natural or synthetic preservatives the shelf life can be extended up to 15-20 days. This technology has the potential to reduce the percentage of post-harvest losses due to suitability of potatoes of any shape, size, colour, sugar and dry matter. Moreover, partially damaged or cold-stored potatoes can also be utilized. Technology can be easily adopted by the processors involved in the production of bakery items.

DIVISION OF SEED TECHNOLOGY

PROGRAMME: PRODUCTION OF NUCLEUS AND BREEDER SEED OF IMPORTANT NOTIFIED VARIETIES OF POTATO

To maintain the higher productivity as well as yields, it is essential to have a scientifically sound seed production system through which health standard of the seed crop can be maintained. Therefore, a program entitled "Production of nucleus and breeder seed of important notified varieties of potato" has been started under Revolving Fund Scheme. The nucleus and breeder seed production is being monitored by the scientists of the Division at different stations located in different regions of the country. The nucleus and breeder seed production and supply status of breeder seed during 2018-19 is given below:

Seed Production

A. Plains (2018-19)

A total production of 27770.47qtls nucleus and breeder seed was achieved from an area of 152.473 ha. Out of which, 22019.74 qtls production from 124.121 ha was through conventional and 5750.73 qtls from 28.352 ha through hi-tech seed production systems respectively. The percentage of nucleus and breeder seed from conventional system was 79.29 and 20.71 through hi-tech system.

1. Conventional Seed Production System

During 2018-19, total no. of 11302 indexed tubers of different commercial potato varieties were tested at regional stations in the plains and health status ranged between 93-98%.

2. Station/stage wise area and production of different potato varieties is given in **(Table 1)**.

Stage-I: A total production of 153.80 qtls. was achieved from an area of 2.643 ha (Table-1) with average production of 92.76, 28.67, 49.50 & 81.84 qtls./ha at Modipuram, Jalandhar, Gwalior and Patna, respectively.

Stage-II: A total production of 780.45 qtls. was from an area of 6.208 ha (Table-1) with average production of and 134.77, 91.68, 125.23 & 128.96 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively.

Stage-III: A total production of 3679.85 qtls. was from an area of 21.98 ha (Table-1) with average production of 233.20, 109.80, 123.91 & 146.52 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively.

Stage-IV: A total production of 17405.64 qtls. was from an area of 93.29 ha (Table-1) with average production 215.82, 176.37, 151.42 & 161.90 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively.

Table 1: Station & variety wise area and production (qtls) in Conventional system 2018-19 (Plains)

	Stage-I		Stage-II		Stage-III		Stage-IV		TOTAL	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
I. Modipuram										
K. Anand	0.037	3.60	0.17	15.40	0.20	48.20	1.20	236.00	**1.607**	**303.2**
K. Bahar	0.460	39.70	1.20	171.00	4.60	916.00	23.00	4325.00	**29.26**	**5451.70**
K. Chipsona-1	0.087	7.45	0.40	47.80	1.10	237.50	3.15	865.50	**4.737**	**1158.25**
K. Chipsona-3	0.037	3.40	0.12	13.20	0.40	81.50	1.20	300.00	**1.757**	**398.1**
K. Chipsona-4	-	-	-	-	0.15	31.00	0.50	115.00	**0.65**	**146**
K. Frysona	0.038	3.45	0.10	15.95	0.20	64.20	1.00	193.00	**1.338**	**276.6**
K. Khyati	0.038	5.20	0.25	29.50	0.70	223.50	3.60	842.50	**4.588**	**1100.7**
K. Pukhraj	0.060	5.65	0.14	13.45	0.40	117.80	2.00	507.00	**2.6**	**643.9**
K. Surya	0.055	3.50	0.15	15.00	0.35	80.20	1.20	297.00	**1.755**	**395.7**
K.Mohan	0.038	6.90	0.30	59.50	0.50	167.80	2.75	815.00	**3.588**	**1049.2**
K. Garima	-	-	0.17	23.50	0.40	131.10	2.70	650.50	**3.27**	**805.1**
K. Sadabahar	-	-	-	-	-	-	0.70	133.70	**0.7**	**133.7**
Total	**0.85**	**78.85**	**3.00**	**404.3**	**9.00**	**2098.8**	**43.00**	**9280.20**	**55.85**	**11862.15**
II. Jalandhar										
K. Jyoti	0.58	15.62	0.57	50.19	3.65	385.50	10.92	1840.85	**15.72**	**2292.16**
K. Badshah	0.028	1.07	0.027	1.50			0.65	68.83	**0.705**	**71.4**
K. Pukhraj	0.087	3.47	0.10	13.25	0.09	22.00	3.00	638.25	**3.277**	**676.97**
K. Chipsona-1	0.078	0.94	0.02	1.09					**0.098**	**2.03**
K. Khyati	0.03	1.53	0.04	3.22	0.03	6.00	1.00	177.95	**1.1**	**188.7**
K. Himalini	0.01	0.69	0.03	2.90	0.007	1.05	1.10	246.76	**1.147**	**251.4**
K. Surya	0.002	0.05			0.003	0.50	0.75	95.00	**0.755**	**95.55**
KCM	-		-	-	-	-	1.30	234.02	**1.3**	**234.02**
Total	**0.815**	**23.37**	**0.787**	**72.15**	**3.78**	**415.05**	**18.72**	**3301.66**	**24.102**	**3812.23**
III. Gwalior										
K. Chandramukhi	0.12	4.82	0.23	31.50	0.79	104.50	3.30	618.75	**1.14**	**759.57**
K. Jyoti	0.19	6.90	0.44	56.00	1.31	241.50	7.00	912.40	**5.24**	**1216.8**
K. Sindhuri	0.11	4.41	0.38	43.00	1.73	126.50	9.68	1276.53	**9.22**	**1450.44**
K. Lauvkar	0.14	5.48	0.23	25.00	0.51	71.50	1.08	184.05	**10.56**	**286.03**
K. Chipsona-I	0.12	6.42	0.38	51.00	1.51	242.50	4.21	716.15	**3.09**	**1016.07**
K. Chipsona-3	0.08	5.09	0.20	26.00	1.30	100.50	1.89	398.50	**5.79**	**530.09**
K. Surya	0.11	9.73	0.34	43.00	0.90	110.50	-	-	**3.24**	**163.23**
K. Pukhraj	0.01	0.71	-	-	-	-	-	-	**0.01**	**0.71**
K. Frysona	-	-	-	-	-	-	0.26	45.50	**0.26**	**45.5**
Total	**0.88**	**43.56**	**2.20**	**275.50**	**8.05**	**997.50**	**27.42**	**4151.88**	**38.55**	**5468.44**
IV. Patna										
K. Arun	-	-	-	-	0.05	6.00	0.15	23.50	**0.2**	**29.5**
K. Himalini	0.006	0.60	-	-	-	-	-	-	**0.006**	**0.6**
K. Jyoti	0.022	1.50	0.05	8.00	0.20	29.50	0.75	109.00	**1.022**	**148**
K. Khyati	0.025	2.85	0.10	11.00	0.41	66.00	1.45	290.40	**1.985**	**370.25**
K. Keshar	0.006	0.35	-	-	-	-	-	-	**0.006**	**0.35**
K. Kanchan	0.003	0.10	-	-	-	-	-	-	**0.003**	**0.1**
K. Lalit	0.020	1.10	0.03	5.00	0.07	10.50	0.10	11.00	**0.22**	**27.6**
K. Pukhraj	0.008	0.85	0.04	4.00	0.12	16.50	0.30	37.00	**0.468**	**58.35**
K. Sindhuri	0.008	0.67	0.001	0.50	0.30	40.00	1.40	201.00	**1.709**	**242.17**
Total	**0.098**	**8.02**	**0.221**	**28.5**	**1.15**	**168.5**	**4.15**	**671.9**	**5.619**	**876.92**
Plains' Total	**2.643**	**153.8**	**6.208**	**780.45**	**21.98**	**3679.85**	**93.29**	**17405.64**	**124.121**	**22019.74**

2. Hi-Tech Seed Production System

Station/generation wise area and production of different potato varieties is given in **(Table 2)**.

(i) Generation-1: A total production of 1441.18 qtls. was achieved in G-I from an area of 7.042 ha with average production of 240.45, 178.20, 162.16 & 159.41 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively **(Table 2)**.

(ii) Generation-2: A total production of 4309.55 qtls. was achieved in G-2 from an area of 21.31 ha with average production of 239.61, 174.79, 182.68 & 180.31 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively **(Table 2)**.

Table 2: Station & variety wise area and production (Qts.) in Hi-Tech system 2018-19 (Plains)

Variety	G1		G2		TOTAL	
	Area	Production	Area	Production	Area	Production
I. Modipuram						
K. Chipsona-1	0.25	85.00	0.15	42.00	**0.40**	**127**
K. Chipsona-3	0.19	41.00	1.60	409.00	**1.79**	**450**
K. Chipsona-4	0.25	55.50	0.45	102.00	**0.7**	**157.5**
K. Frysona	0.03	7.65	-	-	**0.03**	**7.65**
K. Garima	0.20	36.00	0.10	20.00	**0.3**	**56**
K. Himalini	-	-	0.10	16.70	**0.1**	**16.7**
K. Khyati	0.88	236.00	3.90	897.00	**4.78**	**1133**
K. Mohan	1.50	335.00	-	-	**1.5**	**335**
K. Pukhraj	0.04	9.50	0.40	102.00	**0.44**	**111.5**
K. Surya	0.10	21.50	1.80	448.00	**1.9**	**469.5**
Total	**3.44**	**827.15**	**8.50**	**2036.7**	**11.94**	**2863.85**
II Jalandhar						
KCM	0.64	103.50	0.80	156.02	**1.44**	**259.52**
K. Jyoti	0.057	10.81	0.40	74.50	**0.457**	**85.31**
K. Badshah	0.12	17.46	-	-	**0.12**	**17.46**
K. Pukhraj	0.12	28.00	0.90	197.10	**1.02**	**225.1**
K. Chipsona-1	0.067	14.18	1.00	137.00	**1.067**	**151.18**
K. Chipsona-3	0.043	7.65	0.70	79.30	**0.743**	**86.95**
K. Khyati	0.043	9.00	1.4	249.94	**1.443**	**258.94**
K. Himalini	0.44	84.00	0.50	109.83	**0.94**	**193.83**
K. Surya	0.082	11.73	0.60	69.00	**0.682**	**80.73**
K. Gaurav	0.40	72.20	1.10	220.76	**1.5**	**292.96**
Total	**2.012**	**358.53**	**7.40**	**1293.45**	**9.412**	**1651.98**
III Gwalior						
K.Chandramukhi	0.07	11.50	0.01	5.0	**0.08**	**16.5**
K. Lauvkar	0.30	38.50	0.25	35.00	**0.55**	**73.5**
K. Chipsona-1	0.11	14.50			**0.11**	**14.5**
K. Mohan	0.26	55.50	-	-	**0.26**	**55.5**
K. Himalini	-	-	0.90	183.25	**0.9**	**183.25**
K. Frysona	-	-	0.50	80.00	**0.5**	**80**
Total	**0.74**	**120**	**1.66**	**303.25**	**2.4**	**423.25**
IV Patna						
K. Arun	-	-	0.15	25.00	**0.15**	**25.00**
K. Ashoka	0.02	5.0	0.25	50.30	**0.27**	**55.30**
KCM	-	-	0.03	5.00	**0.03**	**5.00**
K. Chip-1	-	-	0.05	13.00	**0.05**	**13.00**
K. Chip-3	0.50	50.50	0.01	1.60	**0.51**	**52.10**

Variety	G1		G2		TOTAL	
	Area	Production	Area	Production	Area	Production
K. Himalini	0.15	39.50	1.26	294.00	**1.41**	**333.50**
K. Jyoti	-	-	0.15	25.50	**0.15**	**25.50**
K. Khyati	0.04	10.00	0.50	83.50	**0.54**	**93.50**
K. Lauvkar	0.02	4.00	0.10	22.00	**0.12**	**26.00**
K. Mohan	0.04	11.00	-	-	**0.04**	**11.00**
K. Pukhraj	-	-	0.75	77.00	**0.75**	**77.00**
K. Sindhuri	0.04	8.50	0.30	45.00	**0.34**	**53.50**
K. Surya	0.04	7.00	0.20	34.25	**0.24**	**41.25**
Total	**0.85**	**135.5**	**3.75**	**676.15**	**4.6**	**811.65**
Plains Total	**7.042**	**1441.18**	**21.31**	**4309.55**	**28.352**	**5750.73**

3. Total supply of breeder seed

During 2018-19, total 23080.85 qtls breeder seed was supplied to various government and private agencies, from plains **Table-3 (A & B)**.

Table 3: (A): Station and variety wise supply (qtls) during 2018-19

S.No.	Variety	Modipuram	Jalandhar	Gwalior	Patna	Total
1.	Kufri Anand	241.70	-	-	-	**241.7**
2.	Kufri Ashoka	-	-	-	51.82	**51.82**
3.	Kufri Arun	-	-	-	49.90	**49.9**
4.	Kufri Bahar	5647.50	-	-	-	**5647.5**
5.	Kufri Badshah	-	69.33	-	-	**69.33**
6.	Kufri Chipsona-1	925.50	137.00	716.15	14.58	**1793.23**
7.	Kufri Chipsona-3	732.50	78.625	393.00	-	**1204.125**
8.	Kufri Chipsona-4	227.00	-	-	-	**227**
9.	Kufri Chandramukhi	-	402.615	620.45	5.05	**1028.115**
10.	Kufri Frysona	198.05	-	125.50	-	**323.55**
11.	Kufri Gaurav	-	193.85	-	-	**193.85**
12.	Kufri Garima	677.10	-	-	-	**677.1**
13.	Kufri Himalini	16.70	348.09	182.75	297.64	**845.18**
14.	Kufri Jyoti	-	1900.585	912.90	136.85	**2950.335**
15.	Kufri Khyati	1798.50	426.125	-	371.87	**2596.495**
16.	Kufri Lauvkar	-	-	216.20	19.76	**235.96**
17.	Kufri Lalit	-	-	-	11.20	**11.2**
18.	Kufri Mohan	845.30	-	-	-	**845.3**
19.	Kufri Pukhraj	618.80	823.725	-	115.00	**1557.525**
20.	Kufri Sadabahar	134.50	-	-	-	**134.5**
21.	Kufri Sindhuri	-	-	1234.18	245.76	**1479.94**
22.	Kufri Surya	741.70	139.225	1.50	34.77	**917.195**
	Total	**12804.85**	**4519.17**	**4402.63**	**1354.20**	**23080.85**

Table 3: (B) Variety/stage & agency wise breeder seed supply from plains (qtls) during 2018-19

S. No.	Variety	HR	HP	J&K	MP	PB	UP	WB	BR	GJ	Assam	CH	Karna-taka	NHRDF	Uni.	ICAR	Auction	Farmers/ Pvt.	Total
1.	K. Anand	-	-	-	-	-	194.00	-	-	-	-	-	-	-	-	-	37.70	10.00	241.70
2.	K. Arun	-	-	-	-	17.50	-	30.00	-	-	-	-	-	-	-	0.50	-	1.90	49.90
3.	K. Ashoka	-	-	-	-	-	-	10.00	-	-	9.50	-	-	-	0.82	0.50	-	31.00	51.82
4.	K. Badshah	-	-	10.00	-	10.00	-	-	-	-	-	-	-	-	-	0.50	-	48.83	69.33
5.	K. Bahar	-	-	-	-	60.00	1500.00	-	-	-	250.00	-	-	100.00	1675.00	55.50	1813.50	193.50	5647.50
6.	K.CM	-	5.00	-	-	14.00	-	440.00	-	0.50	-	82.00	-	-	1.50	6.50	-	478.615	1028.11
7.	K. Chipsona-1	0.05	-	-	42.00	36.00	856.50	-	-	-	-	10.00	-	100.00	4.00	5.50	112.50	626.68	1793.23
8.	K. Chipsona-3	-	-	-	5.00		-	-	-	-	-	511.00	-	100.00	-	50.00	161.50	376.625	1204.12
9.	K. Chipsona-4	-	-	-	-		44.50	22.00	-	-	-	126.50	-	-	-	-	29.00	5.00	227.00
10.	K. Frysona	-	-	-	-		100.00	10.00	-	100.00	-	-	-	-	-	-	15.05	98.50	323.55
11.	K. Garima	-	-	-	-		300.00	50.00	-	-	-	-	-	-	175.00	10.50	117.60	24.00	677.10
12.	K. Gaurav	-	-	-	70.00	32.00	-	-	-	-	-	-	-	50.00	0.90	3.825	-	37.125	193.85
13.	K. Himalini	-	-	180.00	2.50	53.00	-	179.00	-	-	10.00	10.00	2.75	-	0.975	51.00	0.70	355.255	845.18
14.	K. Jyoti	-	210.00	38.00	-	131.00	-	790.00	-	0.50	0.50	-	2.90	112.50	0.475	13.50	-	1650.96	2950.33
15.	K. Khyati	-	-	33.00	-	32.00	1500.00	-	0.50	-	15.00	10.00	-	100.00	12.125	362.00	133.50	398.37	2596.49
16.	K. Lauvkar	0.05	-	-	35.00	13.00	-	-	-	0.50		-	-	97.00	0.36	59.00	-	31.05	235.96
17.	K. Lalit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.20	11.20
18.	K. Mohan	-	-	-	-	-	375.00	-	-	-	-	-	-	2.00	3.00	26.50	152.80	286.00	845.30
19.	K. Pukhraj	-	-	15.50	-	186.00	231.50	11.50	-	-	-	20.00	-	100.00	0.475	195.50	58.80	738.25	1557.52
20.	K. Sadabahar	-	-	-	-	-	109.00	-	-	-	-	-	-	-	-		25.50	-	134.50
21.	K. Sindhuri	-	-	20.00	-	32.00	500.00	-	-	0.50	-	80.00	-	-	400.00	270.00	-	177.44	1479.94
22.	K. Surya	-	-	119.50	-	-	496.50	30.00	-	-	3.00	-	-	57.50	2.17	70.35	67.20	70.975	917.195
	Total	**0.1**	**215**	**416**	**154.5**	**616.5**	**6207**	**1572.5**	**0.5**	**102**	**288**	**849.5**	**5.65**	**819**	**2276.8**	**1181.175**	**2725.35**	**5651.275**	**23080.85**

B. Hills (2018-19)

- **Multiplication of basic material maintenance of mother stock:** A total no. of 40 pots of 20 varieties were planted and tested with ELISA/PCR against different potato viruses. After carrying out series of testing through PCR/ELISA all healthy varieties were shifted *in vitro* & were included in the microplants multiplication and supply chain. A total 8942 culture tubes were multiplied under tissue culture. In aeroponics, 34,242 minitubers of different varieties were harvested.
- **Maintenance of buffer stock in field at CPRS, Kufri:** The nucleus and breeder seed potato production at Kufri and Fagu farms of CPRS Kufri has been suspended since, 2019. However, the maintenance of varieties viz., K. Jyoti, K. Himalini, K. Girdhari, K. Kanchan, K. Shailja, K. Giriraj, K. Himsona buffer seed stocks under different seed stages of Conventional and Hi-tech systems was carried out in small area. In Kufri, a total 808.64 qtls of seed was produced from an area of 5 ha, 618.45 qtls of seed was sold in the market.

C. Production and supply of quality seed

1. CPRS, Ooty:

- ***Production of quality seed during summer 2018- 19:*** Summer crop was planted in an area of 5.00 ha with Kufri Swarna, Kufri Girdhari, Kufri Himalini, Kufri Jyoti and Kufri Sahyadri and the total production was 19.84 t. More PCN problem in Kufri Himalini, Kufri Girdhari and late blight problem due to heavy rain in Kufri Swarna resulted in very poor yield.
- ***Production of quality seed during autumn 2018- 19:*** During autumn season, quality seed crop was planted in an area of 1.30 ha with Kufri Swarna and 0.44 ha with Kufri Sahyadri. The quantity of quality seed harvested was 13.28 t and 0.84 t respectively.
- ***Supply of quality seed potato:*** A total of 50.35 t of quality seed was harvested from seed crop and experimental area during 2018-19. Out of which 11.62, t of quality seed was supplied to the farmers, 5.00 t to govt. organization, and 1.06 t was disposed as table potatoes and miscellaneous to the staff of ICAR- CPRS/ market. About 12.7 t of quality seeds was used for autumn, experimental, OFT and other planting and remaining 16.39 t were kept for planting during summer 2019-20. A total of Rs. 12, 81,167 /- (Rupees twelve lakhs eighty one thousand hundred and sixty seven only) revenue was generated which includes the last year seed sold during this financial year.

2. CPRS, Shillong:

- At Shillong, total quality seed production of eight varieties was 318.16 qtls from 7.46 ha area through Conventional system and Hi-tech system **(Table 4)**. Out of these 133.8 qtls of quality seed was supplied to the different states and a revenue of Rs. 3,34,500/- has been generated. A total of 38,812 numbers of minitubers of four varieties were produced under aeroponics.

Table 4: Quality seed production and supply in Shillong

Sr. No.	Varieties	Conventional System Yield (qtls)	Hi-tech system Yield (qtls)	Total Yield(qtls)	Total Supply (t)
1.	Kufri Jyoti	93.78	16.35	110.13	76.40
2.	Kufri Giriraj	47.78	39.09	86.87	22.50
3.	Kufri Girdhari	-	19.82	19.82	8.27
4.	Kufri Himalini	12.20	27.83	40.03	7.80
5.	Kufri Megha	29.66	18.70	48.36	14.90
6.	Kufri Kanchan	-	4.15	4.15	-
7.	K. Chipsona-3	-	8.07	8.07	3.73
8.	K. Himsona	-	0.73	0.73	-
9.	K. Pukhraj	-	-	-	0.20
	Total	**183.42**	**134.74**	**318.16**	**133.8**

D. Supply of Aeroponic minitubers

As per the MoU for breeder seed production, the healthy aeroponic minitubers of varities viz., K. Jyoti (1100 no.), K. Khyati (2500 no.) and K. Chandramukhi (1300 no.) were supplied to West Bengal State Seed Co-operation Ltd., West Bengal (WBSSCL) for further multiplication at their farm and a revenue of Rs. 42,000 was generated.

E. Supply of Microplants to Different Seed Agencies

A total 92 virus-free in vitro culture tubes of basic seed material of 18 varieties **(Fig. 1)** were supplied to 13 different seed producing organizations in India **(Table 5)** and a revenue of Rs. 4,60,000/- has been generated.

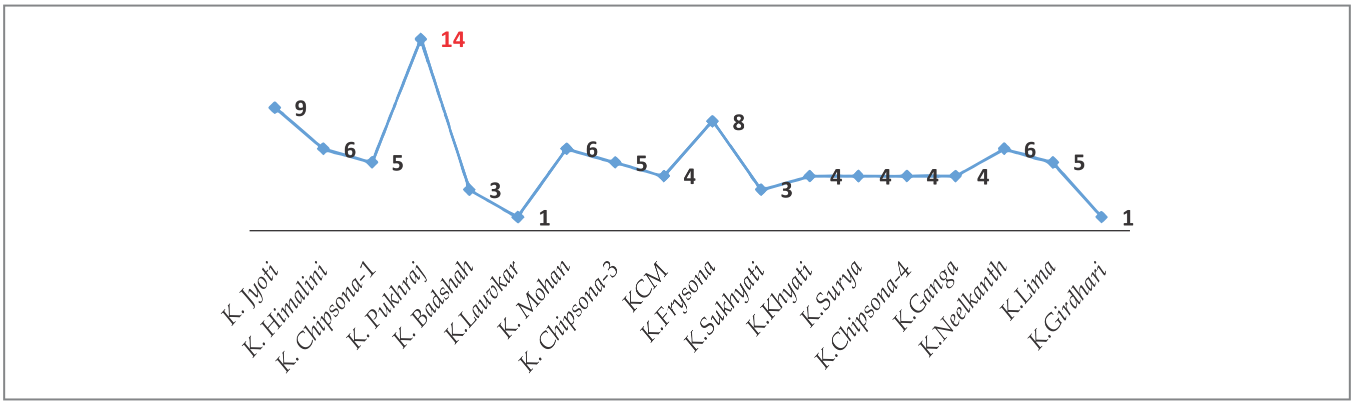


Fig. 1: Variety wise supply to different seed organizations

Table 5: Microplants supply to different Seed Producing Organization

S.No.	Firms	Varieties Supplied
1.	M/s GMS Agritech, Kolakata	KCM, K.Jyoti, K.Pukhraj, K.Himalini, K.Sukhyati
2.	M/s GMS Agritech, Kolakata	K. Neelkanth, K. Lima, KCM, K. Khyati, K. Frysona, K.Jyoti, K. Lauvkar, K. Pukhraj, K. Sukhyati, K. Frysona, K. Chipsona-1, K.Chipsona-3, K. Himalini, K. Badshah
3.	M/s Handa Biotech, Kurukshetra Haryana	K. Chipsona-1, K.Jyoti, K.Pukhraj, K.Himalini, K.Lima, K. Mohan, K. Frysona
4.	M/s ICPL, C/o Vishwas Yadav, Krnataka	KCM, K. Chipsona-4, K. Neelkanth, K. Frysona, K.Jyoti, K. Pukhraj, K. Lima, K. Chipsona-1, K.Chipsona-3, K. Himalini, K. Badshah, K Surya, K. Ganga, K. Mohan
5.	M/s Mahindra, HZPC, Punjab	K. Frysona
6.	The Director, School of Agricultural Biotechnology, PAU, Ludhiana	K. Girdhari
7.	The Head, Department of soil and water engineering, PAU, Ludhiana	K. Jyoti, K. Pukhraj
8.	M/s Deputy Director Horticulture, Potato Technology Center, Shamghah, Karnal	K. Neelkanth
9.	M/s Shashanka Agrotech Pvt Ltd., Ranchi Jharkhand	K. Neelkanth, K. Ganga
10.	M/s WBSSCL, Kolkata	K. Himalini, K. Jyoti, K. Lima, K. Khyati, K. Sukhyati, KCM
11.	M/s Bhatti Tissue Tech, Jalandhar	K. Neelkanth, K. Ganga
12.	M/s Merino Industries, Hapur UP	K. Mohan, K. Khyati, K. Pukhraj, K.Chipsona-3, K.Chipsona-4, K. Surya, K. Frysona
13.	M/s Centre of Excellence for Potato, Dhogri, Distt-Jalandhar, Punjab	K. Jyoti, K. Chipsona-1, K. Pukhraj, K. Himalini

A total of 275 culture tubes of 22 varieties were supplied to different seed production stations/ centers i.e. Modipuram, Jalandhar, Patna, Ooty and Shillong **(Fig. 2)**.

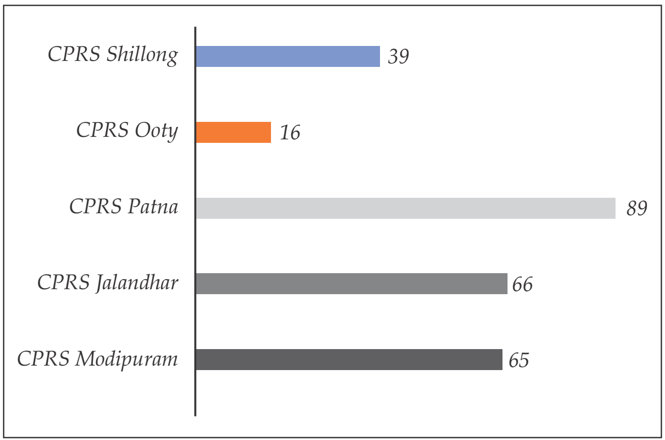


Fig. 2: Station wise supply of virus-free cultures

F. Revenue under RFS

A total of Rs. 10.06 crores/- has been generated by the sale of breeder seed/microplants/ aeroponic minitubers under Revolving Fund Scheme (RFS).

Seed Research

1. ***Evaluation, multiplication and maintenance of advanced hybrids/biofortified clones/ diploids under aeroponic:*** 57 biofortified clones were maintained and multiplied. A total of 3759 minitubers were produced. Diploid cultures were multiplied in tissue culture lab to make the enough plants for the aeroponics. After testing, the infected ones were discarded and finally 26 cultures were planted in aeroponics. 10, 360 minitubers were produced **(Fig. 3)**. 32 CP no's and 13 advanced hybrids were evaluated. 6836 minitubers of CP no's and 513 minitubers of advanced hybrids were produced under aeroponic respectively.

2. ***Standardization of Apical Rooted Cutting (ARC) technology for the production of quality seed potato material:*** Apical cuttings are rooted transplants produced in a glasshouse from tissue culture plantlets. Rather than allowing tissue culture plantlets to mature and produce minitubers, cuttings are produced from the plantlets. Recently, this technology has been standardized at ICAR-Central Potato Research Institute Shimla, India for the very first time. The results were remarkable which suggests that the technology can be used for production of quality planting material at low cost in seed deficit areas. The variety used for the standardization was Kufri Chandramukhi. The initial tissue culture plants were planted in nursery beds or crates. After 10 days depending upon the plant growth, the first apical cutting was taken which was 2-3 cm long with two true leaves. These cuttings were planted in irrigated pro-trays filled with coco peat. Once the apical dominance was lifted, the lateral buds grow into new branches which were further used to increase the multiplication rate. In 4-5 weeks, 5 cuttings were taken which increased the multiplication rate at 1:7-8 times, respectively **(Fig. 4)**. These rooted apical cuttings were transplanting in the field at CPRS Jalandhar and 7-8 tubers from each cutting were harvested. The further refinement in this low cost technology is much needed and is under investigation.

3. ***Comparative performance of aeroponic tubers of three potato cultivars of hills under late planting conditions in polyhouse:*** Due to the very high temperatures during the initial two

Fig. 3: Harvested minitubers of Diploid cultures

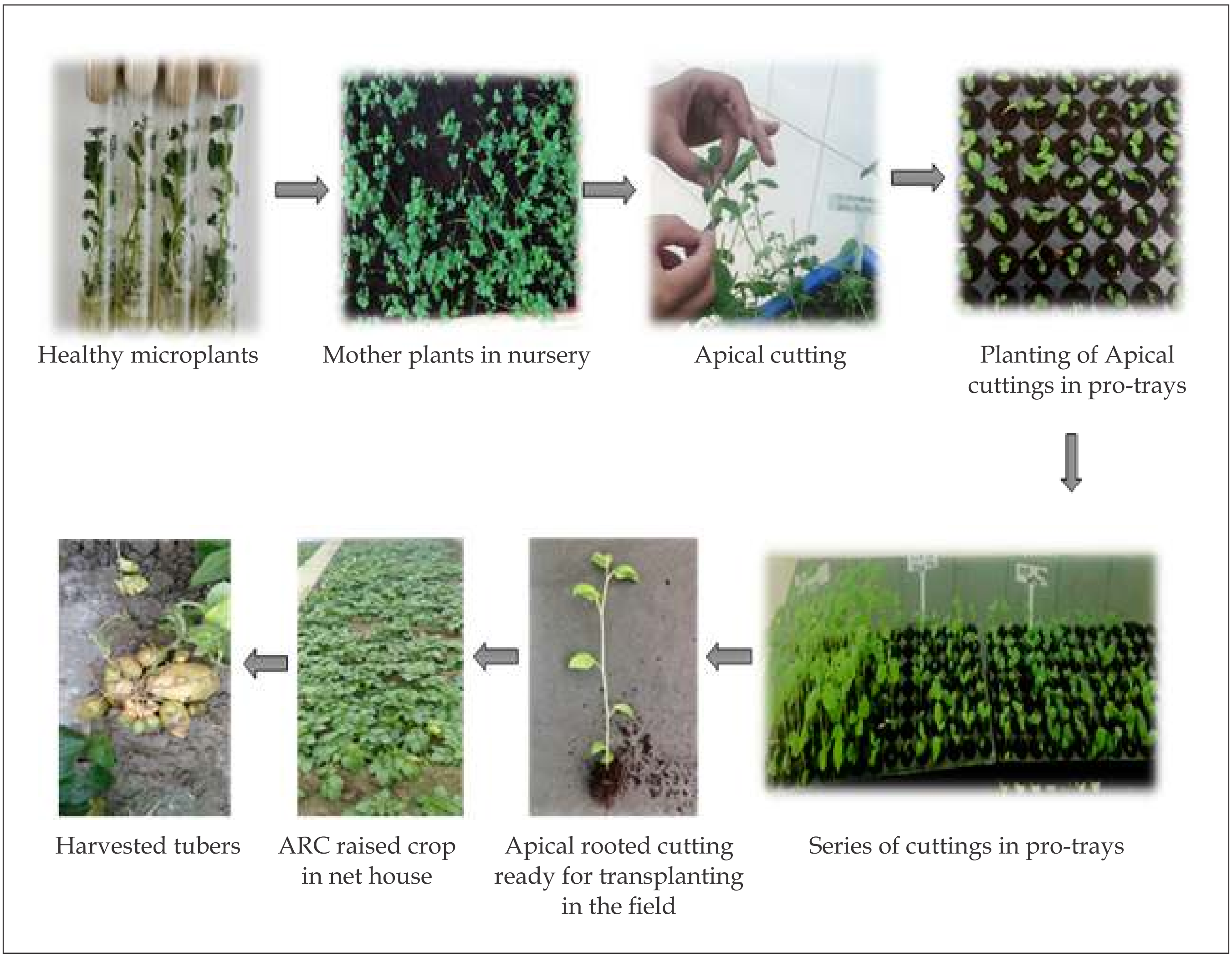


Fig. 4: Step-wise procedure for Seed multiplication through Apical Rooted Cuttings

months, the vegetative growth of potato plants is excessive, even sometimes to a height of 6 feet or more and tuberization starts only with the onset of rainy season when the temperature falls to the favourable levels. The productivity of such a crop is also affected adversely on account of altered dry matter partitioning behaviour. To overcome the problem, an experiment was conducted under late planting conditions using two grades (1.0g & 2.0g + 0.2g) of aeroponic tubers of three potato cultivars viz. Kufri Himalini, Kufri Jyoti and Kufri Girdhari. Planting was done Late (08th August) at 30x10cm spacing. From the study, it was concluded that aeroponic tubers of all the potato cultivars of hills can be successfully multiplied under late planting conditions which will be helpful in reducing the crop duration from 150 to 90 days and thus saving in cost of production **(Table 6)**.

Table 6: Haulms wt. / plant, number of tubers and yield/m2 under late planting conditions

S. No.	Cultiar	Haulms wt. / plant (g) 90DAP			No. of tubers /m^2			Yield (kg/m^2)		
		1±0.2g	2±0.2g	Mean	1±0.2g	2±0.2g	Mean	1±0.2g	2±0.2g	Mean
1.	Kufri Himalini	5.06	5.86	**5.46**	69.5	71.0	**70.2**	1.01	1.03	**1.02**
2.	Kufri Jyoti	11.95	12.76	**12.35**	66.3	72.1	**69.2**	1.16	1.42	**1.29**
3.	Kufri Girdhari	9.01	17.42	**13.22**	47.8	62.7	**55.3**	1.10	1.12	**1.11**
	Mean	**8.67**	**12.01**		**61.2**	**68.6**		**1.09**	**1.19**	

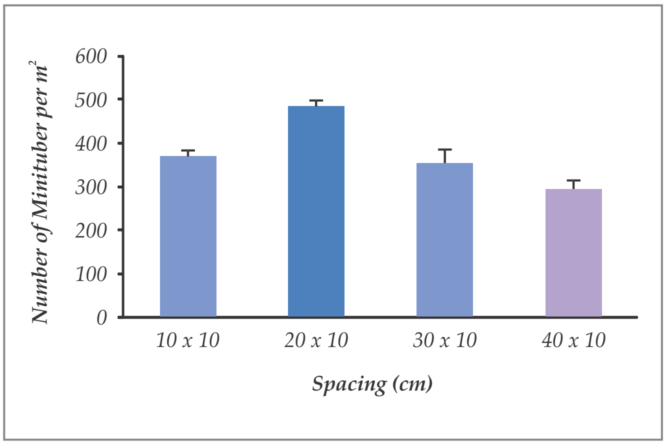
4. ***Effect of method of planting on the production behaviour of different grades of aeroponic tubers of K. Himalini under polyhouse conditions:*** With the objective to standardize the planting geometry for achieving the higher rates of multiplication from aeroponic tubers under polyhouse conditions of hills, an experiment was conducted during the *Kharif* 2019 at Fagu using four grades *viz.* 3, 2 and 1g ± 0.2g of aeroponic tubers of potato variety Kufri Himalini, planted at 30x10cm and 30x20cm with 01 and/or 02 tubers/hill. Yield/m^2, although were higher with the same treatment giving maximum number of tubers (30x20cm with 02 tubers/hill), yet the differences were statistically at par with other geometries. Similarly, a gradual increase in yield with increasing size of seed tuber was noticed but it was not statistically superior. The study suggests that for achieving higher rates of multiplication, the small (<3g) aeroponic tubers should be multiplied at 30x20cm using 02 tubers/ hill than 30x10cm spacing with 01 tuber/hill **(Table 7)**.

Table 7: Effect of method of planting and grade of seed tuber on tuber yield/m^2

Sr. No.	Tuber size (±0.2g)	Tuber Yield (Kg/m^2)			
		30x10cm 01 tuber /hill	30x20cm 01 tuber /hill	30x20cm 02 tuber/hill	Mean
1.	3.0g	3.76	3.63	4.06	3.82
2.	2.0g	3.77	3.20	3.78	3.58
3.	1.0g	3.72	3.36	3.83	3.64
	Mean	**3.75**	**3.40**	**3.89**	

5. ***Comparative performance of one year older and fresh aeroponic minitubers under polyhouse conditions:*** Sometimes good number of aeroponic minitubers remains un-utilized due to one or other reason and no other option lies except to store them till next season. To judge the suitability of such one year older aeroponic minitubers as seed; a comparative study with older (harvested during March/ April 2018) and fresh aeroponic minitubers (harvested during Nov. /Dec. 2018) was conducted. The results revealed that one season older aeroponic minitubers can also be used as a source of seed like normal/ fresh aeroponic minitubers without doubt. The finding will prove to be a boon in fulfilling the everlasting shortages of seed potatoes and will avoid the wastage of the precious planting material.

6. ***High plant density of aeroponically produced minitubers under net-house:*** In present studies, the aeroponic minitubers of potato cv. K. Girdhari were planted in nethouse with four plant densities (10 × 10, 20 × 10, 30 × 10 and 40× 10) at CPRS, Shillong. The canopy development, light interception, dry weight production and tuber weight were investigated to elucidate the mechanism by which the plant density affects the formation and growth of the minitubers. The results showed that the number of the tubers formed per unit area was in line with the increase in plant density. It was concluded that the planting density strongly effect yield and more tuber and yield per square meter are expected in higher planting density.



7. ***Evaluation of the performances of recently released potato varieties under aeroponics:*** Five recently released varieties viz., Kufri Lima, Kufri Sukhyati, Kufri Kesar, Kufri Neelkanth and Kufri Manik were evaluated for their minituber production potential under aeroponics. All the varieties except Kufri Manik performed well under aeroponic and on an a/v 35-40 minitubers per plant were harvested. Whereas, variety Kufri Manik did not perform at all thereby suggesting the further investigation on varietal specific nutrients formulation **(Fig. 5)** .

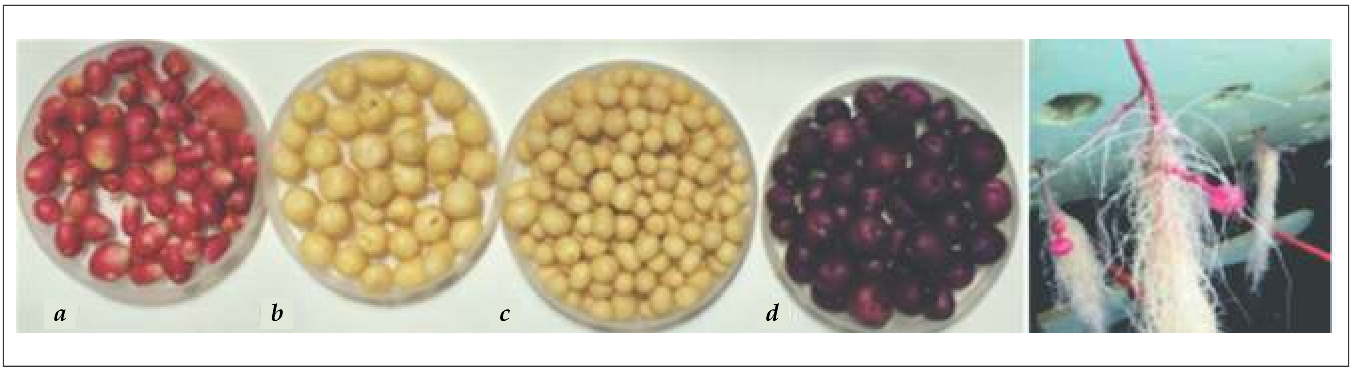


Fig. 5: Freshly harvested aeroponic minitubers {a) K. Kesar, b) K. Sukhyati, c) K. Lima, d) K. Neelkanth)}, K. Manik

8. ***Successful Potato micropropagation with medium devoid of any growth regulators:*** After encountering the deshaping problem in variety, K. Bahar under tissue culture, a policy decision at institute level was taken during 2012 that no growth regulators will be used at any stage of potato micropropagation. Since then, MS media without any growth regulator is being used for the potato micropropagation. An analysis demonstrated that microplants developed without the growth regulators proved to have equivalent potential of increasing the multiplication rate of in vitro potato varieties. There was no significant difference in the growth and morphological parameters of potato cultivars regenerated with and without the use of growth regulators **(Fig. 6)**. The same cost effective protocol has been shared with the seed entrepreneurs and they are successfully following it in their labs.

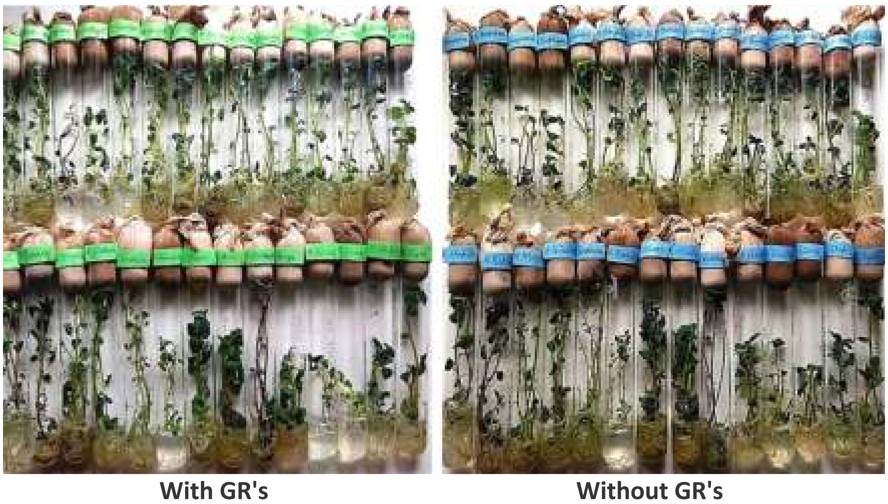


Fig. 6: Multiplication of healthy cultures of 29 potato varieties in tissue culture

9. ***Effect of seed crop haulm killing age on seed tuber grade and its subsequent performance:*** To know the effect of age of seed crop haulm killing on seed tuber grade and its effect on performance in the subsequent season a study was conducted at ICAR-CPRS, Muthorai. The tuber number and yield (25-75 g) was significantly influenced by age of crop at the time of haulm killing, cultivar and its interactions. Tuber number (>75 g) and yield was significantly influenced by age of crop at the time of haulm killing, cultivar and its interactions. Haulm killing done at 120 days after planting resulted significantly maximum number of >75 g tubers whereas, the minimum at 75 days after planting. Significantly maximum yield of total tuber was recorded when the haulm was cut at 105 and 120 days after planting. Among the varieties, Kufri Girdhari and Kufri Himalini recorded maximum total tuber yield. In the interaction, Kufri Jyoti recorded maximum total tuber yield when haulm was cut at 105 and 120 days after planting; Kufri Swarna 120 days after planting and Kufri Girdhari and Kufri Sahyadri at 90, 105 and 120 days after planting.

10. ***Effect of seed crop haulm killing age and seed tuber grade on sprouting behavior potato cultivars:*** In the cultivar Kufri Jyoti, 30 days of storage different grades tuber recorded maximum sprouting in which the seed crop haulm killing was done at 75 days of planting whereas, the minimum in 120 days after planting. In the cultivar Kufri Swarna, 30 days of storage different grades of tuber recorded maximum sprouting in which the seed crop haulm killing was done at 75 days of planting whereas, the minimum in 105 days after planting. In general early crop haulm killing (75 DAP) resulted fast sprouting in all the grade tubers **(Fig. 7)**.

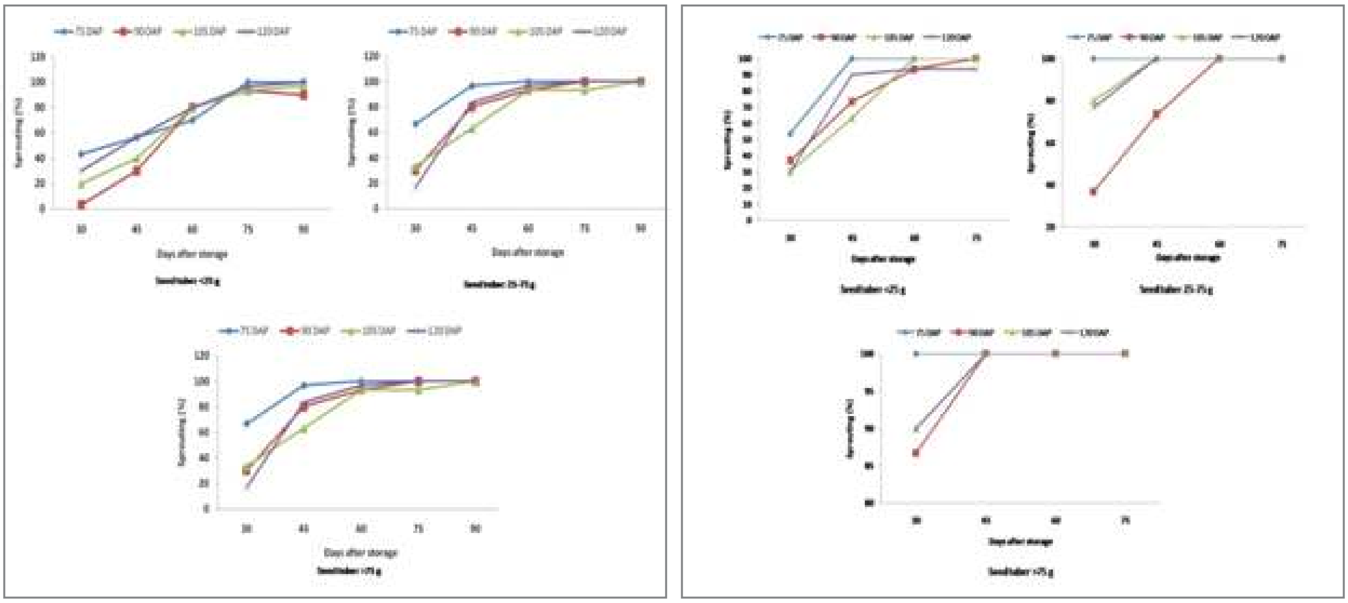


Fig. 7: Effect of seed crop haulm killing age and seed tuber grade on sprouting behavior of Kufri Jyoti, K. Swarna

The cultivar Kufri Himalini, 30 days of storage different grades tuber recorded maximum sprouting in which the seed crop haulm killing was done at 75 days of planting **(Fig. 8)**. The cultivar Kufri Girdhari, seed crop haulm killing done at 75 days of planting recorded maximum sprouting different grades tubers 75 days of storage **(Fig. 8)**. The cultivar Kufri Sahyadri, less than 25 g tubers harvested from different haulm killing age recorded maximum sprouting after 105 days of storage.

11. ***Optimization of Inter and Intra Row Spacing for Production of Seed Size Tubers at Gwalior:*** Highest seed size and total tuber number was recorded in paired row (544 and 1126 thousand/ha) and lowest in 75 x 20 spacing (357 and 674 thousand/ha). Highest seed size tuber number was recorded in 70 days haulm killing crop (seed size 405000/ha) and total tuber 843000/ha in 80 days haulm killing. Similar trend was reported for seed size and total tuber weight where paired row system recorded

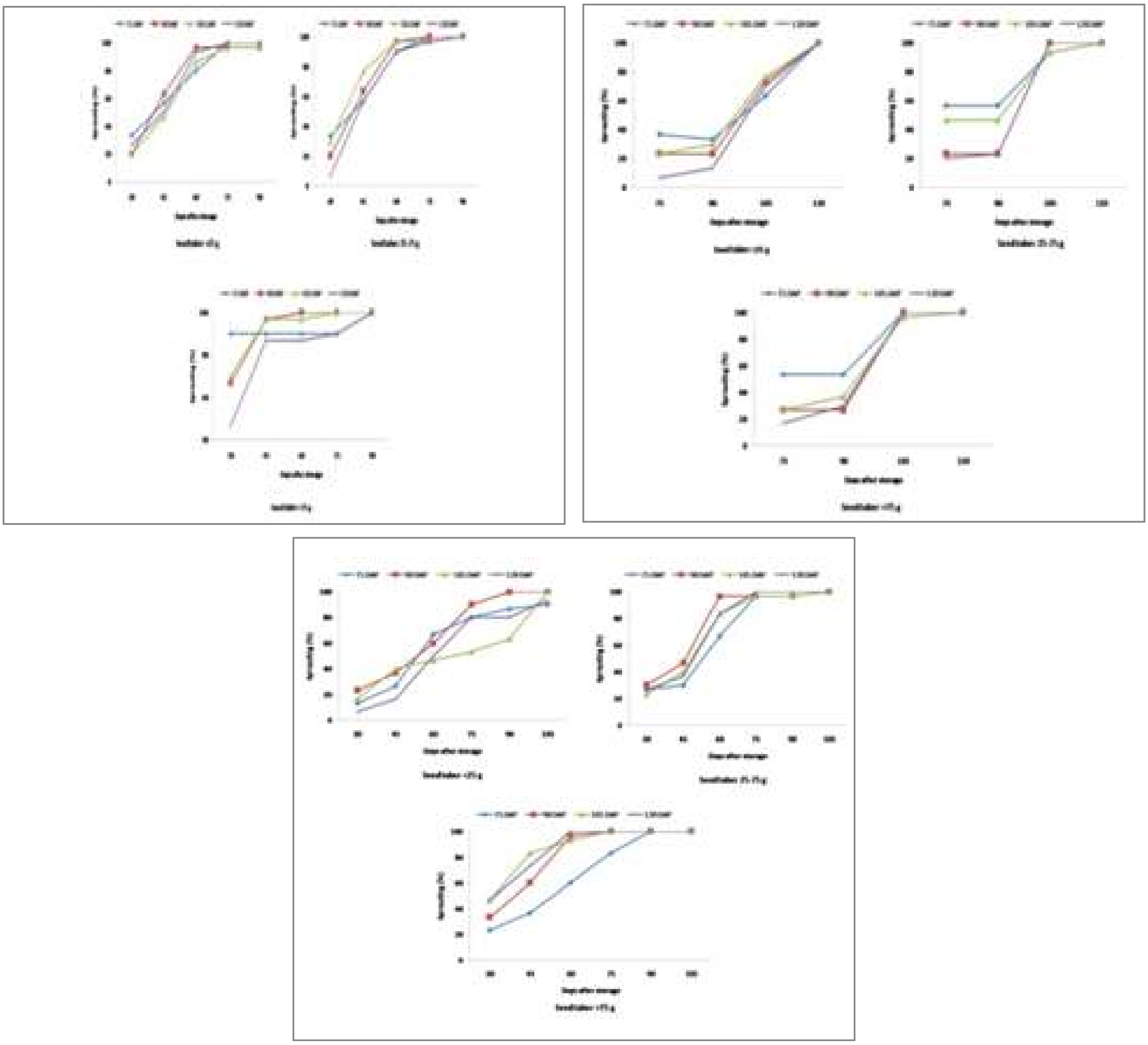


Fig. 8: Effect of seed crop haulm killing age and seed tuber grade on sprouting behavior of Kufri Himalini, Kufri Girdhari, Kufri Sahyadri

highest seed size (30.94t/ha) and total tuber weight (47.08 t/ha) and lowest was recorded in 75x20 spacing (17.60 and 34.66 t/ha respectively). Among haulm killing dates highest was recorded in 90 days haulm killing (24.30 seed size and total weight 43.55 t/ha).

12. *Effect of Different Planting Dates on Production of Seed Size Tubers at Gwalior:* Highest seed size and total tuber number was recorded in 15th November planting (seed size 280000/ha and total tuber 560000/ha respectively) and among variety it was higher in K. Gaurav (293000 seed size and 605000/ha total tuber respectively). Similar trend was reported for seed size and total tuber weight where 19.03 t/ha and 29.51 t/ha seed size and total tuber were recorded in 15th November planting and among varieties 18.55 t/ha seed size and 30.50t/ha total tuber weight in K. Gaurav.

13. *Effect of Different Haulm Killing Dates on Production of Seed Size Tubers:* Highest seed size and total tuber number was recorded in 90 days haulm killing crop (seed size 239000/ha and total tuber 535000/ha respectively) and among variety it was higher in K. Gaurav (264000 seed size and 578000/ha total tuber respectively). Similar trend was reported for seed size and total tuber weight where 15.03

t/ha and 28.62 t/ha seed size and total tuber were recorded in 90 days haulm killing crop and among varieties 14.69 t/ha seed size in K Jyoti and 25.31t/ha total tuber weight in K. Gaurav.

14. ***Optimization of inter and intra row spacing for production of seed size tubers at Patna:*** Significantly highest seed size tuber yield by number and weight was recorded with spacing at 66 x 15 cm (207 thousand/ha and 118.8q/ha) followed by spacing at 60 x 20 cm (195 thousand/ha and 103.6 q/ha). Haulm cutting at 80 days after planting was found suitable for production of less over and small size tubers. The paired row planting was not found suitable with furrow irrigation as it gave the poorest yield.

15. ***Effect of different haulm killing dates on production of seed size tubers at Patna:*** Out of three Potato varieties, significantly higher seed size (25-125g) tuber yield by number and weight was recorded in Kufri Pukhraj (477 thousand/ha and 147.2 q/ha) and Kufri Khyati (471 thousand /ha and 143.1) over Kufri Jyoti (405 thousand/ha and 126.8 q/ha). Haulm cutting at 80 days after planting was found suitable for producing less over size and chat (tubers less than 25g).

16. ***Low tuber deformities contribute for yield resilience under mild water stress in Kufri Neelkanth:*** Among six cultivars evaluated last year (2018-19) results indicated that seed grade yield was moderately reduced (13.5 %) in K. Neelkanth as compared to K. Pukhraj and K. Mohan (19.0% each) when the crop was taken under mild water stress (<20% less watering). Apart from seed grade yield, attention was focused on seed quality, particularly, tuber defects (growth cracks, pointed, de-shapes, dumbbell etc). Results in current experiment indicated similar trend and quality seed grade yield was 24.0 t/ha under mild water stress, which was 11.8 % less, as against 27.2 t/ha under well-watered control **(Fig 9.)**. This could be attributed to reduced tuber numbers. These results suggest reinforce that it may be used as control/potential parent in experiments involving development of varieties resilient to abiotic stresses and sustainable seed grade yield.

17. ***Effect of different haulm killing dates on production of seed size tubers at Jalandhar :*** In case of Kufri Pukhraj, dehaulming at 90 DAP resulted in the maximum total tuber yield 42.12 t/ha, whereas, the yield of seed size tubers was found maximum at 70 DAP i.e. 12.42 t/ha. In case of Kufri Jyoti, de-haulming at 80 DAP resulted in the maximum total tuber yield and seed size tuber yield i.e. 31.73 t/ha, 12.21 t/ha respectively.

18. ***Effect of different planting dates on production of seed size tubers at Jalandhar:*** 15 Oct. planting resulted in the maximum total tuber yield in case of both the varieties Kufri Pukhraj and Kufri Jyoti i.e. 38.07 t/ha & 28.77 t/ha respectively, whereas, maximum seed size tuber was found in 15 Oct. planting in Kufri Pukhraj & Kufri Jyoti i.e. 16.58 t/ha & 9.85 t/ha. Total tuber numbers were found maximum in 15 Nov. planting date in Kufri Pukhraj 538 (000/ha) & 05 Nov. planting date in Kufri Jyoti i.e.385 (000/ha) respectively, whereas, seed size tubers was found maximum, 184 (000/ha) in 05 Nov. planting date in Kufri Pukhraj and in case of Kufri Jyoti, 153 (000/ha) found in 25 Oct. Planting date.

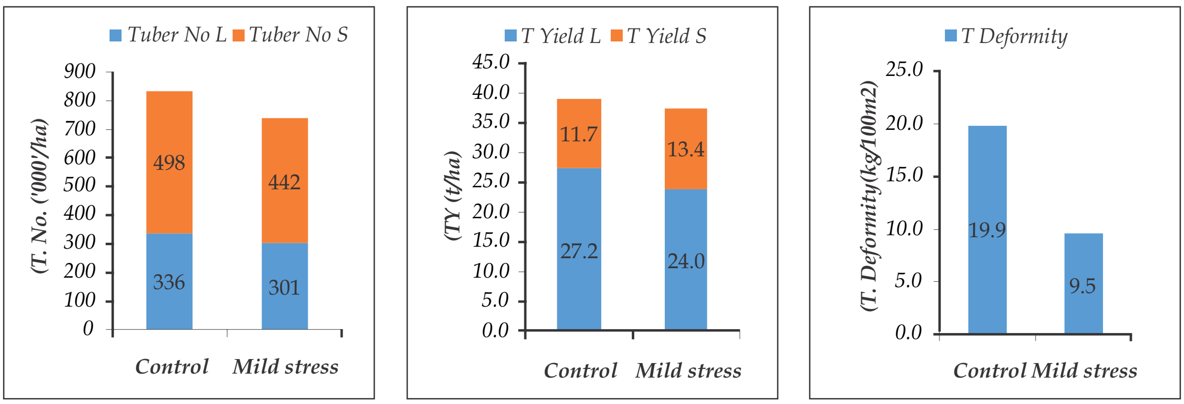


Fig. 9. Yield composition of Kufri Neelkanth grown as ware crop under well watered control and mild water deficit stress. Tuber category L (>25 g) is considered as seed grade in this study

DIVISION OF SOCIAL SCIENCES

PROGRAMME: ASSESSMENT OF POTATO TECHNOLOGIES AND ITS TRANSFER TO STAKEHOLDERS FOR IMPROVING POTATO PRODUCTION

Economic Analysis of Potato Production in Gujarat, Punjab and Haryana

A survey for assessing the cost and income of potato production was conducted by interviewing 120 farmers, 60 each from Banaskantha and Aravalli districts of Gujarat, 90 farmers of Punjab (45 each from Jalandhar and Moga districts) and 60 farmers of Kurukshetra district of Haryana. The findings revealed that overall the highest cost contribution in all the states was that of seed which range from 24 to 33 per cent. Other major cost components were hired human labor (9.5%-14%), rental value of owned land (10%-14%), interests on value of owned fixed assets (10%-13%) and fertilizers and micronutrients (9-13 %).

The study also revealed that on an average, the total cost of potato cultivation (Cost C) in Gujarat, Punjab and Haryana was found to be Rs. 177489/- per ha, Rs. 160280/- per ha and Rs. 149391/- per ha, respectively **(Table 1)**.The net Income was Rs. 200449/- per ha, Rs. 141224/- per ha and 71006/- per ha in Gujarat, Punjab and Haryana with the B: C ratio of 2.1, 1.9 and 1.48, respectively **(Fig. 1)**.

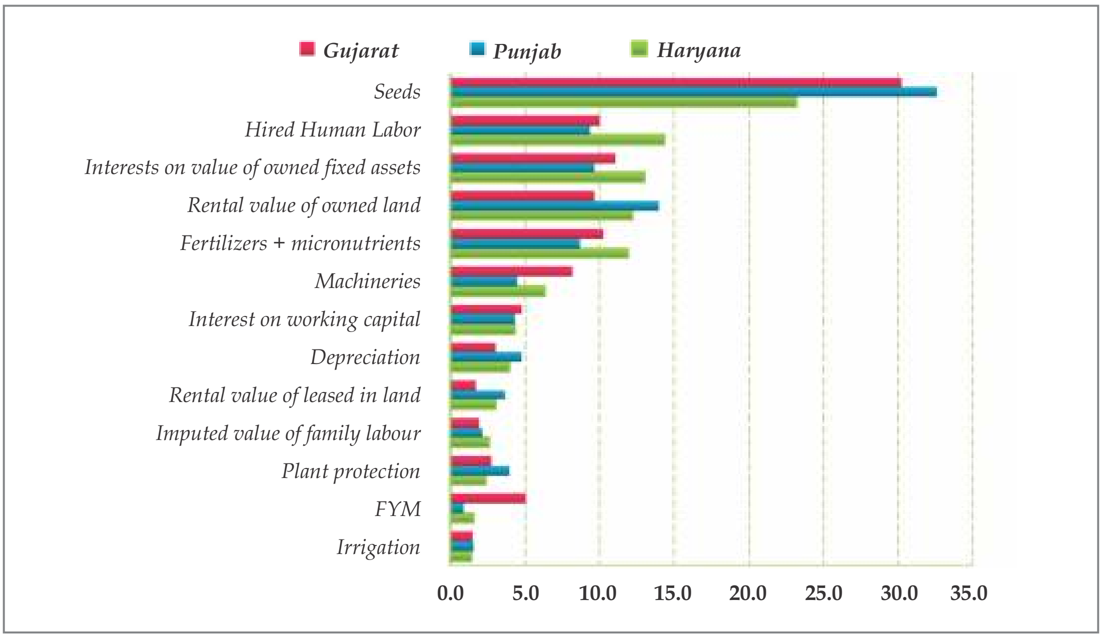


Fig. 1: Graphical representation of different cost components

Table 1: Component wise break up of cost of potato cultivation and income in Gujarat, Punjab and Haryana

Cost components	Gujarat	Punjab	Haryana
Cost A1(Rs. /ha)	134201	113119	103388
Cost A2 (Rs. /ha)	137217	118948	107877
Cost B1(Rs. /ha)	156897	134455	127290
Cost B2 (Rs. /ha)	174072	156803	1455189
Cost A2+FL (Rs. /ha)	140635	122425	111750

Cost components	Gujarat	Punjab	Haryana
Cost C (Rs. /ha)	177489	160280	149391
Cost of production over Cost C (Rs. /ha)	534	656	474
Cost of production over Cost A2+FL (Rs. /ha)	423	502	355
Yield (q/ha)	332	244	315
Price (Rs. /q)	1142	1235	702
Gross Income (Rs. /ha)	377938	301504	220397
Net Income over Cost C (Rs. /ha)	200449	141224	71006
Net Income over Cost A2+FL (Rs. /ha)	237303	179079	108647
B:C Ratio over Cost C (Rs. /ha)	2.1	1.9	1.48
B:C Ratio over Cost A2+FL (Rs. /ha)	2.7	2.5	1.97

Assessment of Seed Replacement Rate of potatoes in Haryana

The study for assessment of seed replacement rate was conducted by interviewing 60 farmers of Kurukshetra district of Haryana. The seed replacement rate model computes the percentage of the total area under the crop that can be covered with the quantity of improved/certified seeds produced or available for the commencing agricultural year. **Table 2** showed that on an average, the SRR for improved varieties in the study area was 97.5 percent and the SRR for certified seeds was only 28.3 percent.

Table 2: Seed Replacement Rate of improved potato varieties and certified seeds in Haryana

Farm size categories	Improved varieties			Certified seeds			SRR of improved varieties	SRR of certified seeds
	Area (Ha)	Quantity (q)	Seed rate (q/ha)	Area (Ha)	Quantity (q)	Seed rate (q/ha)		
Marginal (2)	1.6	50.0	30.9	0.0	0.0	0.0	100.0	0.0
Small (6)	9.3	326.0	35.0	0.0	0.0	0.0	100.0	0.0
Semi-medium (12)	27.9	945.6	34.0	2.5	361.9	36.4	100.0	1.1
Medium (30)	120.0	3887.9	32.2	30.4	1062.6	34.6	96.4	26.4
Large (10)	57.5	1841.2	32.0	20.2	619.7	30.5	100.0	33.7
Overall (60)	**216.3**	**7050.6**	**32.6**	**53.1**	**2044.1**	**34.0**	**97.5**	**28.3**

Note: *Figures in parentheses indicate the number of farmers in each category*

Assessment of varietal adoption pattern in Punjab and Haryana

The varietal adoption patterns were assessed by conducting surveys for 90 farmers, 45 each from Jalandhar and Moga district of Punjab, 60 farmers of Kurukshetra district of Haryana and 120 farmers, 30 each from Nalanda, Buxar, Saran and Muzaffarpur districts of Bihar.It is evident from **(Fig. 2)** that Kufri Jyoti, which covers about 38 percent of potato area was the most popular variety in selected districts of Punjab, which was followed by Kufri Pukhraj (29%), Diamant (10%) and Lady Rosetta (9%). The most popular variety in Kurukshetra, Haryana as showed in **(Fig. 3)** was Kufri Pukhraj (92.4%).

In Bihar, varieties developed by the institute like Kufri Pukhraj (38% of total potato area), Kufri Sindhuri (33%) and Kufri Arun (10%) were the leading potato varieties in the study area. Local/traditional varieties like Lal Gulal and Bhoora aloo were still adopted by some farmers **(Fig. 4)**.

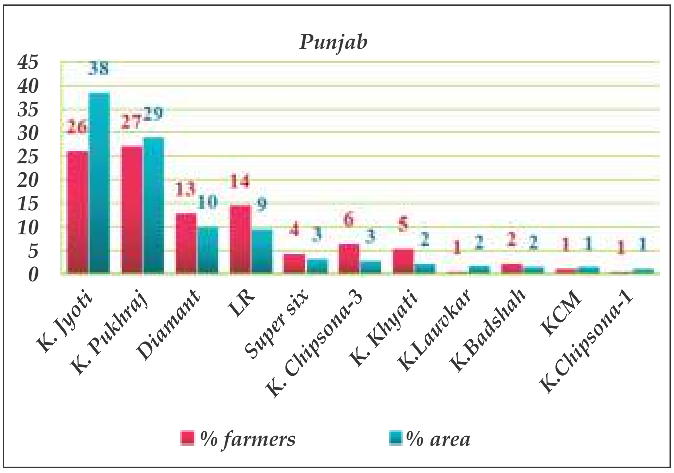


Fig. 2: Varietal adoption pattern in Punjab

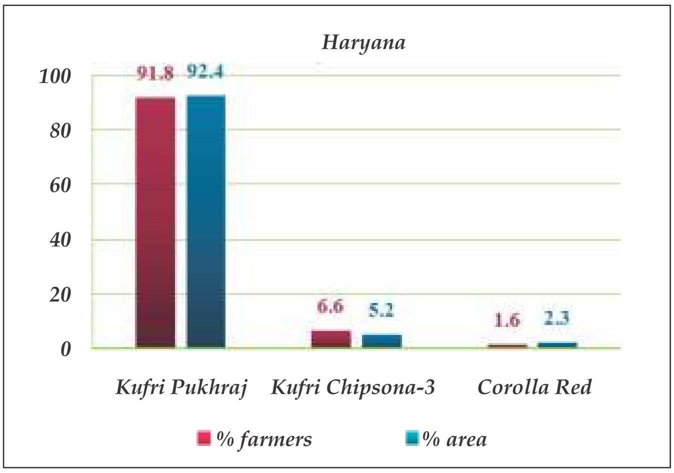


Fig. 3: Varietal adoption pattern in Haryana

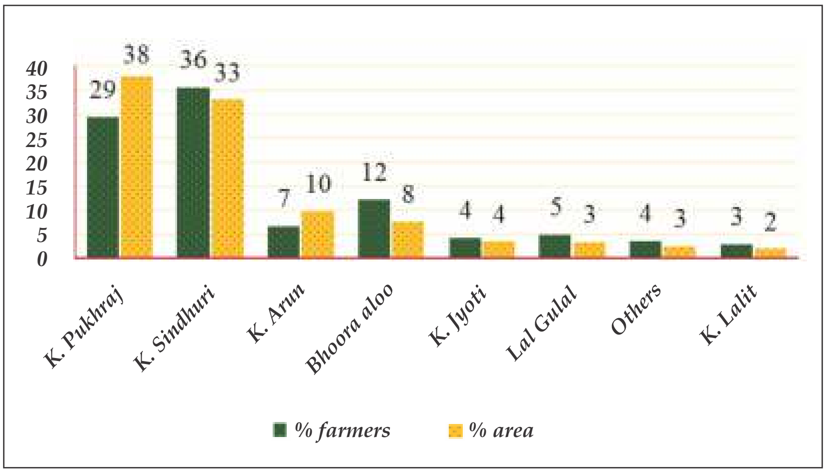


Fig. 4: Varietal adoption pattern in selected districts of Bihar

Adoption level of potato technologies and adoption constraints in Bihar

A survey from 120 farmers, 30 each from Nalanda, Buxar, Saran and Muzaffarpur districts of Bihar found that technologies like use of optimum seed rate, improved varieties, pre-sprouting of seed tubers, use of whole seed tubers, seed retention period, maintenance of spacing, weeding and late blight management were followed by majority of farmers **(Table 3)**. However, there is very poor adoption of technologies like use of certified quality potato seeds, FYM application, recommended dose of NPK fertilizers, irrigation interval and pre-sowing irrigation.

Table 3: Seed Replacement Rate of improved potato varieties and certified seeds in Bihar

Improved production technologies	Nalanda (n=30)	Buxar (n=30)	Saran (n=30)	Muzaffarpur (n=30)	Overall (n=120)
Use of optimum seed rate	66.7	60.0	80.0	73.3	70.0
Use of improved varieties	100	93.33	90	93.33	94.2
Use of certified quality potato seeds	30.0	10.0	6.7	10.0	14.2
Pre-sprouting of seed tubers	100.0	66.7	86.7	90.0	85.8
Use of whole seed tubers	86.7	93.3	43.3	60.0	70.8
Seed retention period (below 4 years)	80.0	73.3	63.3	66.7	70.8

Improved production technologies	Nalanda (n=30)	Buxar (n=30)	Saran (n=30)	Muzaffarpur (n=30)	Overall (n=120)
Maintenance of spacing	90.0	93.3	86.7	90.0	90.0
FYM application	46.7	33.3	53.3	30.0	40.8
First dose of Nitrogen fertilizer	63.3	46.7	70.0	46.7	56.7
Phosphatic fertilizers dose	40.0	40.0	26.7	36.7	35.8
Potash fertilizers dose	46.7	53.3	20.0	23.3	35.8
Second dose of Nitrogen fertilizers	36.7	33.3	26.7	10.0	26.7
Weeding	60.0	60.0	36.7	70.0	56.7
Irrigation interval	53.3	36.7	43.3	43.3	44.2
Pre-sowing irrigation	10.0	10.0	0.0	0.0	5.0
Late blight management	96.7	86.7	86.7	90.0	90.0
Level of adoption (Percentage of respondents): Low =21.67 %, Medium= 60.83% and High=17.50%					

The study also found that none of the respondent farmers adopted all 16 selected technologies. Majority of farmers (23 %) adopted 10 technologies, 22.5 percent adopted 9 technologies, 15 percent adopted 8 technologies, 11 percent adopted 7 technologies and 10 percent adopted 11 technologies **(Fig. 5)**. With respect to the level of adoption of respondents categorised based on Adoption Index, the study revealed that majority of farmers (60.83 %) have medium level of adoption, which was followed by low (21.67 %) and high (17.50 %)

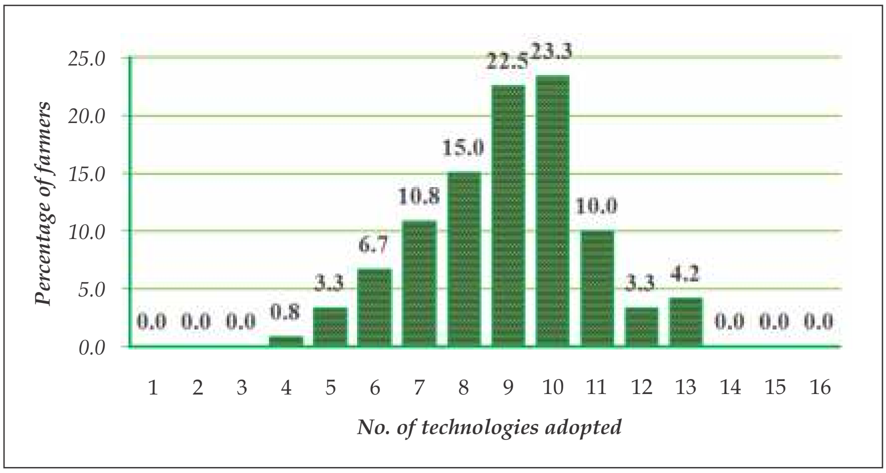


Fig. 5: Distribution of potato technologies adopted by farmer

Transfer of Technology

Technology Transfer Activities Organised by ICAR-CPRI, Shimla as per its mandate, the Division of Social Sciences organized a large no. of technology transfer activities related to potato production at the headquarter and the regional stations.

Training for stenographers /personal assistants/private secretaries and personal secretaries of ICAR HQ/ Institutes

A six days training programme on "Enhancing Efficiency and Behavioural Skills for stenographers/personal assistants /private secretaries and personal secretaries of ICAR HQ/Institutes" was organized during June 20-25, 2019 by ICAR-CPRI, Shimla in collaboration with ICAR-NAARM, Hyderabad. A total of 30 trainees from different ICAR institutes attended the programme. The core contents of the training programme were noting and drafting, stenographic skills, office procedures, conduct rules, leave rules, official language policy, communication skills, interpersonal skills, computer skills, stress management, motivation and positive thinking and personality development. A number of training methodologies like lecture cum discussion, practical sessions, skill demonstration role play and video film shows, etc were implemented during the training.

Model Training Course organized at ICAR-CPRI, Shimla

Eight days Model Training Course on "Protected cultivation, post-harvest technology, value addition and supply chain management of potato" was organized at ICAR-Central Potato Research Institute Shimla from 23 to 30 September 2019. The training program was sponsored by Directorate of Extension, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi and attended by 5 trainees from Gujarat, 3 from Chhattisgarh, 2 each from Punjab, Haryana, and Uttarakhand, one each from Maharashtra and Andhra Pradesh. During the Model training program 24 lectures, 6 laboratory visits with hands-on-training were conducted. Dr SK Chakrabarti, Director, ICAR-CPRI, Shimla emphasized that potato processing and post-harvest management along with export oriented potato production is the need of the hour and its very important to take it seriously in the current Indian potato production scenario. Dr Vijay Kumar Dua, the course director of the training program informed that around 25-30% knowledge gain was observed by pre and post-training evaluation of the participants.

Training organized on Potato seed production and value addition at ICAR-CPRI, Shimla

A three days training programme on "Potato seed production and value addition" was organised for 25 potato growers of Mehsana district of Gujarat during 15-17 October, 2019 at ICAR-CPRI, Shimla. This programme was sponsored by Project Director, ATMA, Mehsana (Gujarat). The aim of this training was to enhance the knowledge and skill of the trainees regarding production of seed potato and value addition in potato. Training methodologies like lecture cum discussion, practical sessions, skill demonstration, field visit and video film show etc. were the modes for imparting the training to the participants.

ICAR-CPRI, Shimla participated in mushroom mela at ICAR-DMR, Solan

ICAR-CPRI, Shimla participated and put up an exhibition stall at ICAR-DMR, Solan on 10th September 2019. Various technologies of the institute were displayed in the exhibition. A total of about 500 farmers, scientists, students, policy makers, NGO members etc. visited the stall put up

in the exhibition by CPRI. They were made aware about various technologies developed by the institute. Institute publications were given to the needful during the mela.

Training on Capacity building Programme towards a secure & resilient workplace organized at ICAR-CPRI Shimla

A first of its kind training for personnel associated with security in ICAR system was held at ICAR-CPRI, Shimla from 25th to 27th November 2019. Around 35 participants from ICAR institutes located all over the country participated in the 3 days training programme. Course Director, Dr SK Chakrabarti welcomed the participants and expressed his views on importance of security in modern times as well as on the deliverables of the training programme. The multifarious aspects of security challenges in ICAR institutes like fire safety, emergency evacuations, disaster management, cyber security, security acts, contracts, labour laws, wild-life acts, security equipment, first aid methodologies, mock drills as well as behavioural aspects of security were dealt in detail. The mode of delivery included not only the lectures but also role plays & field demonstrations, which are crucial in the realm of security. Experts included, Sh. Asif Jalal, DIG Police (Southern Range) Shimla, Sh. DC Sharma, Divisional Fire officer, a disaster expert from NDTV, a retired faculty from ICAR and Dr Shashi Rawat as cyber expert. Sh. Sandeep Singh Dudi, administrative officer apart from taking lectures on general aspects of security, security agencies & laws also coordinated the training programme.

LIVE PHONE-IN PROGRAMME AT DOORDARSHAN

Scientists from CPRI, Shimla participated in the live phone-in programmes during April to October, 2019. The details of the topics along with experts are given below:

Month	Topics	Name of the Expert
April	Potato varieties and planting in the higher hills of Himachal Pradesh	Dr. Rajesh Kumar Singh Dr. Ashwani K. Sharma
May	Cultural operations for potato cultivation in the higher hills of Himachal Pradesh	Dr. VK Dua Dr. Jagdev Sharma
June	Potato storage and marketing in the mid-hills hills of Himachal Pradesh	Dr. NK Pandey Dr. Brajesh Singh
July	Storage and Marketing of potato in the mid-hills of Himachal Pradesh	Dr. NK Pandey Dr. Brajesh Singh
	Different potato varieties in Himachal Pradesh	Dr. NK Pandey
October	Diseases and insect pests of potato and their management	Dr. Ravinder Kumar
	Cultivation of potato in Himachal Pradesh	Dr. Dalamu

Activities of Agriculture Technology Information Centre (ATIC)

Sale and distribution of CPRI Technical and Extension Bulletin : A total number of 360 technical, extension bulletins and CDs/Expert system were sold through ATIC and nearly 2500 publications like CPRI Profile, Crop Calendar and leaflets related to potato technologies were distributed free of cost to the visitors and during different exhibitions. Altogether a revenue of Rs. 15730/- was generated through sale of publications and CDs.

Dissemination of knowledge to visitors: A total number of 3415 persons visited the Institute during 2019. The visitors included 2945 school/B.Sc/M.Sc. /Phd. Students from different states, 159 Scientists/professors/teachers, 245 farmers and 66 extension workers/agri or horti officers. The visitors were made aware about various activities and technologies of the Institute through films, lectures, discussions, visit to important laboratories and institute museum/farmer museum in which the technologies were displayed using posters, panels, live samples and models etc. Altogether revenue generated through visitors' fee was of Rs. 20,370/-.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, MODIPURAM

A Farmer Gosthi was organized on quality potato production and commercialization through organic farming techniques

A Farmer Gosthi was conducted on quality potato production and commercialization through organic farming techniques on 04 August 2019 at ICAR-Central Potato Research Institute, Regional Center, Modipuram, Meerut. More than 150 farmers participated in the program. The Chief Guest at the event was Dr. VS Thakur, Former Vice Chancellor, YS Parmar Agricultural University, Solan and Special Guest Dr. YP Sharma, Former Joint Director, NEH Region. The Gosthi was presided over by Dr. SK Chakrabarty, Director, ICAR-Central Potato Research Institute, Shimla. All scientists of the centre participated in this program. The main objective of this program was to spread awareness among farmers about organic and natural farming and in this direction, the work done by the institute and the work to be done in the coming years were specially discussed. Dr. Jitendra Kumar Arya, Mr. Naresh Sirohi, Mr. Naresh Kumar and Mr. Pandey, who are farmers of organic farming, informed the farmers present the experience of commerciali-zation of organic farming products.

Winter School Conducted on "Advancement in potato production technology & its future prospects" at ICAR-CPRI, RS, Modipuram

An ICAR sponsored Winter School on 'Advancement in potato production technology & its future prospects' from 19 Nov. to 09 Dec., 2019 was organized at ICAR-CPRI, Regional Station, Modipuram, Meerut (UP). Participants were from different Agricultural Universities/Research Institutes and KVKs. The inaugural function of training programme was held on November 19, 2019 and Dr. Birpal Singh, Former Director, ICAR-CPRI, Shimla graced the occasion as Chief Guest. In his enlightening speech, he stressed on the use of advance technologies and techniques of potato production that could be used to meet the future need of quality potato production. During the programme, a total of 55 lectures and practical demonstrations on topics such as breeding potato varieties for processing and ware purpose, agronomic practices, balance use of fertilizers, modern methods of irrigations, potato based cropping systems, important insect pests and diseases of potato and their management and potato seed production through traditional and advanced technology were covered. On the concluding day, Dr. SK Chakrabarti, Director, ICAR-CPRI, Shimla was the Chief Guest of this programme. Dr. SK Chakrabarti spoke on the scenario of potato research and development in India and suggested the participants to use advanced technologies of potato production.

Training Programme and winter school organized

S.No.	Title of training	Duration	Nos. of trainees	Beneficiaries	Sponsored Agency
1.	Kisan Goshthi on "Potato production through organic farming and commercialization"	One day August, 4,2019	150	farmers and agriculture students	ICAR-CPRI, Shimla (HP)
2.	Agronomic practices for potato seed production	Four days September,17-20, 2019	30	In-charge of potato farms of U.P. department of horticulture	Directorate of U.P. Horticulture and food processing Lucknow, U.P.
3.	Improved Techniques of Potato Production	Three days 3-5 October, 2020	25	Farmers of district Agra U.P.	NABARD
4.	Improved Techniques of Potato Production	Three days 3-5 October, 2020	15	Farmers of Haryana	CIP, New Delhi
5.	Winter School on Advancement in potato production technology & its future prospects"	Nov. 19 – December 09, 2019)	22	Scientists, Teachers of various states of country	CIP, New Delhi
6.	Improved techniques of potato production	Three days Dec, 11-13 , 2019	30	Farmers of district Pauri, Uttarakhand	Agriculture Department (Uttarakhand) under ATMA Project

Participation in Kisan mela and Exhibition

CPRI, RS, Modipuram participated in three day Kisan mela (12-14 Sep., 2019) on technological advances with direct marketing linkage in organic farming for rural entrepreneurship development organised by Foundation for Agricultural resources management and environmental remediation (FARMER), Ghaziabad (U.P). The mela was attended by approximately 1200 participants comprising of farmers, rural entrepreneurs and students.

Demonstrations

To popularize the new potato varieties and improved cultivation practices developed by institute for potato crop, 3 field demonstrations of new variety Kufri Ganga at different locations i.e Ghaziabad, Bulandsher and Hapur districts of Uttar Pradesh were conducted. 135 quintal breeder seed of potato variety Kufri Mohan, Kufri Surya and Chipsona -1 and Kufri bahar were distributed to 135 schedule caste farmers of district Meerut, Bulandsher, Ghaziabad and Muzafarnagar of Uttar Pradesh and Haridwar districts of Uttarakhand for comparison to local varieties grown by farmers. Under Mera Gaon Mera Gaurav, 3 field demonstrations of new variety Kufri Ganga and Kufri Mohan at 3 different Farmer Fields of adopted villages Paswara in Meerut, Harsinghpur in Hapur and Mahmoodpur in Muzafarnagar districts of Uttar Pardesh were also conducted.

Others Extension activities organized at the Campus

Programmes/activities	Duration	Participation	Sponsored Agency	Number of beneficiaries
Phones attended at Kisan call centre	2019-2020	Queries of potato growers on various aspects from different districts of U.P., M.P., Rajasthan, Gujrat, Punjab, Uttarakhand, Delhi and Haryana states were answered on phone	CPRI	200
Organized of Soil Day	Dec. 5, 2019	Farmers participated in soil day	CPRI	100

Visitors

Total 190 trainees from various ICAR Institutes, state agriculture departments sponsored by various states, 155 students with faculty and 250 farmers visited Central Potato Research Institute RS, Modipuram (UP).

Talks on Doordarshan and Akashvani

S. No.	Date	Topic	Name of Expert
1	10 Aug, 2019	Aloo fasak ki unnatshil kheti hetu vagyanik sujhav	Dr Anuj Bhatnagar
2	6 Nov, 2019	Aloo fasak ki buvai evam utich pravandhan	Dr Anuj Bhatnagar
3	11 Dec, 2019	आलू की फसल में झुलसा रोग प्रबंधन	Dr Devendra Kumar
4	18 Dec, 2019	आलू फसल की देखभाल	Dr VK Gupta
5	31 Dec, 2019	आलू की फसल मे पिछेता झुलसा की रोकथाम	Dr Manoj Kumar

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, PATNA

Training Programmes

S.No.	Title	Venue	Date	No. of Beneficiaries
1	Farmer's Training on Potato Cultivation for farmers of Latehar, Jharkhand and Samastipur, Bihar	ICAR-CPRI, RS, Patna	09.07.2020	35
2	Training on Potato Production Technologies	ICAR-CPRI, RS, Patna	23.08.2020	24
3	Training on Seed Production and Processing of Potato	BAMETI, Patna	09.12.2020	--
4	Farmers Training on Potato Production Technologies	ICAR-CPRI, RS, Patna	13.12.2020	28
5	Farmers Training on Potato Production Technologies	ICAR-CPRI, RS, Patna	17.12.2020	50
6	Farmers Training on Potato Production Technologies	KVK, Piprakothi, East Champaran	09.01.2020	31
7	Training cum orientation programme under project" Development & promotion of 'Agan ki Kyari' for better health and nutrition.	ICAR-CPRI, RS, Patna	23.01.2020	--
8	Training cum orientation programme under project" Development & promotion of 'Agan ki Kyari' for better health and nutrition.	ICAR-CPRI, RS, Patna	24.01.2020	--
9	Training cum orientation programme under project" Development & promotion of 'Agan ki Kyari' for better health and nutrition.	ICAR-CPRI, RS, Patna	28.01.2020	--
10	Training cum orientation programme under project" Development & promotion of 'Agan ki Kyari' for better health and nutrition.	ICAR-CPRI, RS, Patna	31.01.2020	--

Kisan Melas/ Exhibitions/ Exposure visits

ICAR-CPRI, RS, Patna participated in the following exhibitions and showcased the potato technologies developed by the institute.

- Sonepur Mela at Sonepur, Bihar organized from 11-19 November, 2019 attended by 725 participants.
- Three day Kisan Mela-20 at Dr. RPCAU, Pusa, Samistipur from 16-18 February, 2020 attended by 450 participants.

- 20th Foundation Day of ICAR-RCER, Patna held at ICAR-RCER, Patna on 20th February attended by 71 participants.
- Three day Bihar Kisan Mela-20 held at BAU, Sabour, Bhagalpur from 23-25 February, 2020 attended by 600 participants. ICAR-CPRI, RS, Patna bagged second prize in the best stall category in this mela.

Two exposure visits for 22 persons from Kisan Call Centre was conducted on 23 & 25 November, 2020 to upgrade their knowledge regarding latest technologies developed by the institute in potato cultivation.

Live phone–in programme on Doordarshan, Bihar during the year

S. No.	Date	Title
1	12-09-2019	Aloo satya beej ki nursery tayar karne ki vidhi
2	21-09-2019	Aloo ki buwai se purv khet ki tayari evm urvark ki matra
3	29-10-2020.	आलू की बुआई एवं समसामयिक सस्य क्रियाएं
4	15-11-2019	TPS se aloo ki kheti
5	23-12-2019	Aloo ki kheti se laabh evm mukhya kisme

Demonstration

A total of 105 front line demonstration were conducted on quality seed production through seed plot technique in different villages of East Champaran and Gaya districts of Bihar of the varieties K. Sindhuri, K. Khyati, K. Pukhraj and K. Lalit for the benefit of potato growers. An average yield of 300-325 q/ha was observed for each variety. The yield was nearly 40-45% higher than local controls C-1 or Bhura Aloo. Apart from this, four improved varieties were demonstrated at Gataro Block (Vaishali District) under MGMG scheme.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, JALANDHAR

Training Programmes

S.No.	Title of the Training	Venue	Date & Duration	No. of Beneficiaries
1	Training Program on Aeroponic technology for Potato mini-tuber production.	Potato Technology Centre, Haryana	June 2019	6
2	Awareness session on ICAR-CPRI value added potato products with NGO group.	ICAR-CPRS, Jalandhar	08-07-2019	10
3	Review workshop on CPRI Aeroponic technology.	ICAR-CPRS, Jalandhar	11-09-2019	20
4	Attended training program on "High tech potato seed production – New Business Opportunities" and delivered lecture on "Mini-tuber production under net house".	ICAR-CPRS, Jalandhar	03-10-2019	A group of progressive farmers
5	Attended training program on "High tech potato seed production technology – A Business Opportunity" and delivered lecture on "Plant protection and importance of rouging in potato seed production".	ICAR-CPRS, Jalandhar	23-12-2019	
6	Training on mobile App "Farmer Zone Crop Advisory" to registered farmers under the project "Smart Agriculture, Farmer Zone".	ICAR-CPRS, Jalandhar	March, 2019 to January, 2020	70

Participation in Kisan Mela/ Exhibition

- 6th Jalandhar Potato Growers Association (JIPA) Kisan Mela held on 26th to 27th September, 2019 organized by Jalandhar Potato Growers Association at Kartarpur District Jalandhar.
- Kisan Diwas, Special day organized on 23-12-2019 under Swatchhta Pakhwada organized from 16th to 31st December, 2019 at ICAR-CPRS, Jalandhar.

Demonstration

Demonstration of potato variety, Kufri Khyati was conducted in the fields of 7 farmers in aspirational district Moga through Krishi Vigyan Kendra (KVK), Moga. Potato seed of the variety were supplied to the farmers by the Station.

Print and Electronic Media Advisories

Issued advisories regarding forecast of incidence of late blight of potato in Punjab and adjoining areas in English, Hindi & Punjabi via local newspapers, DD Punjabi and AIR Jalandhar. Also to adjoining areas (trilingual) via email to Director, Dept. of Horticulture, Govt. of Punjab.

MGMG Activities

Sent messages relevant to on-going agriculture activities to the farmers of the adopted villages under Mera Gaon Mera Gaurav programme of Government of India.

Distribution of Soil Health Cards to the registered farmers (461) from Distt. Hoshiarpur, Jalandhar and Kapurthala along with the nutrient recommendation in potato on soil test basis (STV) under the project "Smart Agriculture, Farmer Zone" during October, 2019 - February, 2020.

Visitors

A total of 450 visitors including students, farmers from different states, scientists/professionals /teachers/ extension workers and trainees from different African countries visited the station and were made aware of the various technologies and activities of the institute.

Awareness Programme

Awareness programme on Hi-Tech Potato Seed Production held at ICAR-CPRI, RS, Jalandhar. Agri-business Incubator of Institute organized an awareness programme on 'Business Opportunities in Hi-Tech Potato Seed Production' at ICAR-CPRI, Regional Station, Jalandhar on 23rd December 2019. The purpose of this programme was to create wakefulness about potato seed production system involving tissue culture, aeroponics, net houses etc. The Scientists covered topics on minituber production technologies, promising varieties of potato, management practices for insect, pest and diseases, seed plot technique, rouging and net house cultivation for production of quality seed potatoes during the programme. Total 80 farmers from Punjab and Haryana state participated in this event and took advantage of the information given by the subject experts and hands on training in experimental crop farm.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, GWALIOR

Trainings

The station conducted 7 one day trainings at different venues of the state, sponsored by different agencies in which 290 farmers of that region benefited from the technologies developed by the institute.

Demonstration

Under Schedule Caste sub plan two demonstrations at Bhind, and Gwalior of one quintal breeder seed were laid.

Visitors

A total of 261 farmers including tribal and female farmers from different parts of the state visited the station. They were exposed to the various new scientific methods being used at the station in potato cultivation and healthy seed production.

Radio Talk

A radio talk on 'आलू की अगेती खेती' was given by Dr, SP Singh on 20.08.2019, which was broadcasted on 25.8.2019 by Akashvani Gwalior.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, OOTY

ICAR-CPRI, RS Ooty participated in the following exhibition during the year.

- The Flower Show at Botanical Garden Ooty by Tamil Nadu State Department of Horticulture.
- National Horticulture fair 2019 organised by ICAR-IIHR, Bengaluru, Karnataka.
- Radio Astronomy Centre, TIFR, Muthorai, Ooty.

Visitors

A Total of 1833 visitors (students and farmers) from various states of the country were acquainted with the techniques and methods being followed at the station for healthy potato cultivation and answered to various questions and queries raised by the visitors.

Other Extension Activities

- On Farm Trials (OFT): OFTs were conducted during Autumn season of 2019-2020 in farmer's field at two locations of Nilgiri district viz., Kenthorai and Bembatti villages for popularization of newly released ICAR-CPRI varieties, Kufri Sahyadri (combined

resistance to late blight and potato cyst nematode) and Kufri Karan (combined resistance to late blight, viruses and potato cyst nematode).

- Three villages *viz*., Kallakorai, Nedugula and Kallati were adopted under "Mera Gaon Mera Gaurav" and all the technical inputs related to potato production have been given during crop season.
- Scientist, ICAR-CPRI, RS, Ooty attended and delivered lectures on various aspects of potato cultivation to the state officials at monthly Zonal Workshops conducted by Dept. of Horticulture, The Nilgiris, Tamil Nadu, during 2019-20.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, SHILLONG

Training Programmes

S. No.	Title	Date and Duration	No. of beneficiaries
1	International Training on Potato seed production through aeroponic system	08-12th July 2019 (5 days)	30
2	Potato cultivation with special reference to TPS	16th October, 2019 (One day)	07

Demonstrations

Front Line Demonstration was laid out in two districts of Meghlaya (Jaintia Hills and East Khasi Hills District) during 2019-20. Improved potato cultivation method with high yielding varieties (K. Himalini and K. Girdhari) evaluated with conventional organic practices (*nur-bun method* of potato planting) was demonstrated in 04 farmers field.

Visitors

A total of 150 visitors visited the station during the period under report, which includes students, farmers, state Agriculture/Horticulture officers and foreign visitors (CIP). Technologies developed by ICAR-CPRI and on-going research at the station were explained to the Visitors.

EXTENSION ACTIVITIES AT ICAR-CPRI,RS, KUFRI

Visitors

A total of 2016 visitors which include 1936 students, 55 farmers and 25 officials visited the station in connection with the study tours of students, exposure visit of farmers and officials from Agri./ Horti. Departments.

LIBRARY AND DOCUMENTATION SERVICES

Introduction

In accordance to 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 is stacked with 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 clearing house of potato literature and information 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 below:

Resource Development

At the headquarter (Shimla), a total of 87 documents were purchased, procured and added to library resources. The total collection at Shimla stands at 39987 documents comprised of 16403 books, 15780 back volume of journals, 2753 serials, 2259 annual reports, 583 theses, 251 standards, 51 maps/atlases, 1663 reprints and 198 CD's. The libraries at seven regional stations are having their own library collection of 28,985 books, journals back volumes and other documents i.e. AR/Reprints and Bulletins etc as per the details below **(Table 1)**.

Table 1: Library Collection of CPRI, RS & CPRS

	Regional Stations	Books	Back Vols. of Journals	Other Documents	Total	Current Journals subscribed (Indian)
1	CPRI, RS, Modipuram	4710	6014	2559	13283	06
2	CPRS, Jalandhar	3344	1591	458	5393	06
3	CPRS, Patna*	2098	1280		3378	09
4	CPRS, Gwalior	1187	4	73	1264	-
5	CPRS, Ooty	1674	580	562	2816	09
6	CPRS, Shillong	1540	-	167	1707	-
7	CPRS, Kufri	144	-	-	144	
	TOTAL	**14697**	**9469**	**3819**	**27985**	**30**

Periodicals and Serials Management

Eleven serials entitled advances, annual reviews, reference annuals, yearbooks and statistical data publications *etc.* were purchased. A total of 121 current journals comprising of 16 foreign and 105 Indian have been subscribed at Shimla. Out of which 8 foreign and 93 Indian journals were subscribed on payment basis and rest 20 on exchange or gratis. In all 766 issues of such journals were received, marked and kept in library for use. Besides, 30 titles of different journals were subscribed at CPRS libraries. 87 books were classified, catalogued, labeled, pasted and transcribed and entered in Library Automation Software for use. The library has the complete series of CAB CD (till Dec. 2017 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, 8 institutes subscribed foreign journals and more than 3900+ journals from 913 national and international publishers 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. 784 Extension/Technical Bulletins/Annual Reports/Station Annual Reports/ Content Pages of Potato books available at CPRI library/Training Manuals/Newspaper clipping were scanned and uploaded in institute's website under the link "Institutional Repository of CPRI".

Readers and Reference Service

A total of 864 documents were circulated (borrowed and returned) for home studies and 6688 readers consulted 10031 documents within the library. Besides, 10 outside scientists and research scholars of various research organizations consulted the library resources. 4 new members were enrolled and 9 old members withdrew their library membership due to their transfer or retirement. At present 125 readers are active members of library including RAs/SRAs. Library received thousands of reference queries from the users of the library and responded to them satisfactorily. Besides, 216 job requests were received for 1,21,974 copies of photocopying and printing work of different scientific and administrative documents.

Documentation and Information Services

766 issues of journals (633 issues of national and 133 issues of international journals) were scanned for potato literature and 375 potato articles were found and recorded. Approximately, 87 records of library resources have been successfully added 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. In addition 3,480 content pages of 870 potato books were scanned for integrating into institute OPAC.

Resource Generation and utilization

The library has generated the revenue of Rs.1,25,665.00 which includes the amount charged on account of rendering CDROM searching & photocopying (Rs.5,069.00), IGNOU computer practical (Rs. 36,650.00), library discount on books (Rs.72,297.00) and journals (Rs.11,849.00) in addition to normal 10% GOC discount saved on purchase of library books and journals through CPRI Book store. A total of Rs. *10,63,014.00* was spent on purchase of library resources like books *(Rs.4,19,201.00)*, and subscription of journals *(Rs.6,43,813.00)* at HQ library Shimla.

CDS/ISIS Practical Training

As per MOU between CPRI and IGNOU, New Delhi, 21 days computer, IT, and database creation and operation practical session was organized during 22nd July-11th August, 2019 for 9 MLIS and 41 BLIS students of IGNOU Study Center, Shimla.

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93. शिवप्रताप सिंह, वी के दुआ, संजय रावल, संजय कुमार शर्मा, मुरलीधर ज सदावर्ती, सुभाष कटारे, पूजा मानकर,वाई पी सिंह, श्याम कुमार गुप्ता औरआर के समाधिया(2018–19) फसल आदानों का कुप्रबंधन, खाद्य सुरक्षा एवं जैविक खेती की तरफ झुकाव.प्रयास अंक 8: 27–30

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Patent

1. Filed a patent application entitled "Composition exhibiting sprout inhibitory effect in potatoes" by inventors Ashiv Mehta, Yogesh Gupta, Brajesh Singh, Arvind Kumar Jaiswal, Swarup Kumar Chakrabarti on 23 may 2019. (Application No- 201911020542)
2. Filed a patent application entitled "COUNTING MACHINE" by inventors Er Sukhwinder Singh, Er Brajesh Nare and Dr V K Dua on 17-December 2019 (Application No. 322123-001).
3. Filed a patent application entitled "Trapezoidal blade weeder" by inventors Er Sukhwinder Singh, Er Brajesh Nare, Dr V K Dua, Dr S K Rawal and Dr S K Chakravarti on 19-June 2019 (Application No. 318490-001).
4. Granted a design patent application entitled "CPRI L-Type hoe" by inventors Er Sukhwinder Singh and Er Brajesh Nare on 02-December 2019 (Application No. 313144-001)
5. Granted a design patent application entitled "CPRI Spade" by inventors Er Sukhwinder Singh and Er Brajesh Nare on 01-November 2019 (Application No. 305966).
6. Granted a design patent application entitled "CPRI Weeder" by inventors Er Sukhwinder Singh and Er Brajesh Nare on 18-March 2019 (Application No. 305965).

In addition, Abstrcats published in seminar/ symposia proceedings etc. and sequences submitted to the NCBI are about 42.

INSTITUTE ACTIVITIES

ICAR-CPRI celebrated fifth International Yoga Day-2019

The 5th International Yoga Day was celebrated on 21st June 2019 at the CPRI, Shimla and its 6 regional stations. In Shimla, two very experienced Yoga teachers from Art of Living, Ms. Dhara Saraswati Ji and Shri Abhay Sharma Ji were invited to conduct the yoga session at Shimla. The Aasans, Pranayam and Dhyan of Yoga were demonstrated by the teachers and performed by about 230 staff members, research scholars of the institute and all participants of the ongoing training at the institute. The yoga teachers also explained the benefits of all the demonstrated Aasans, Pranayam and Dhyan techniques. ICAR-CPRI regional stations at Modipuram, Gwalior, Jalandhar, Ooty, Patna, Kufri also celebrated International Yoga Day. On this occasion experienced Yoga teachers from Patanjali and other Yoga Sansthans were invited to conduct the yoga sessions. All Station Heads and their staff members were present in large number on this eve.

Official Language Workshop at ICAR-CPRI, Shimla

A day long Official Language Workshop on **"Rajbhasha Niti Evam Karyanvyan tatha Vitt Karya mein Rajbhasha ka Prayog: Kathnayian Evam Samadhan"** was organized on 18.6.2019 at ICAR-Central Potato Research Institute, Shimla for the administrative category. Mr. Anil Tripathi, Assistant Director (Official Language) and Secretary Town Official Language Implementation Committee, Shimla and Mr. Zakir Hussain, Sr. Finance & Accounts Officer, ICAR-CPRI, Shimla were the Chief Speakers for this workshop. Workshop was inaugurated with address of Chief Guest, Dr. Brajesh Singh, Officiating Director, ICAR-CPRI, Shimla. Chief Guest welcomed the speakers and appealed the officers/staffs to participate in the workshop with great enthusiasm. On this occasion he lauded the efforts made by the Hindi Section in promoting the Hindi usage in the institute and congratulated for bagging the 3rd Rajbhasha Puruskar 2017-18 of the Department of Official Language, Ministry of Home Affairs, Govt. of India, for best implementation of Official Language policy at the institute. Assistant Director (OL) and Secretary, Town Official Language Implementation Committee, Shimla in his address focused elaborately on the provisions made in Indian Constitution Part 5, 6 and 17 and total 11 Articles mentioned therein with regard to Official Language policy and its implementation. The workshop concluded with the address and vote of thanks from Dr. Rakesh Mani Sharma, In-charge, Official Language, ICAR-CPRI, Shimla.

ICAR-CPRI celebrated its 71st Foundation Day

ICAR-CPRI Shimla celebrated its 71st Foundation Day on 22nd August, 2019. Shri Kalraj Mishra, Hon'ble Governor of Himachal Pradesh was the chief guest of the event. On the occasion Hon'ble

Member of Parliament (Shimla Constituency) Sh. Suresh Kumar Kashyap, Mayor, Municipal Corporation, Shimla Smt. Kusum Sadret and Dr. Parvinder Kaushal, Vice Chancellor, Dr. YS Parmar UHF, Nauni, Solan were also present as guests of honour. During the event Best Worker Awards were given to the staff of all categories along with that the sports personnel of the institute were also honoured. Some institute publications were also released on the occasion. The programme was attended by a number of farmers from nearby areas, students, ex-staff of the institute, scientists from other institutes, policy makers, entrepreneurs and other stake holders in agriculture and allied activities. They all were made aware about technologies of the institute.

The Institute Research Committee Meeting (IRC), 2019

The Institute Research Committee Meeting (IRC), 2019 was held at ICAR-Central Potato Research Institute, Shimla from 23rd to 26th July, 2019, which was attended by 63 scientists from the Headquarters and Stations. Dr V. K. Dua, Secretary, IRC welcomed Dr S. K. Chakrabarti, Chairman IRC and Director CPRI, and all participants. The Chairman emphasized scientists to focus on new areas of research like the development of hybrid/dihaploid varieties with improved vigor, production of apomictic seed, TPS for Kufri Jyoti variety, nutrient and water use efficiency, use of genomics in developing new technologies, climate-resilient varieties etc. He said that scientists should work on reducing cost of production for aeroponics, tuberization signalling in potato for increasing tuber number, TPS technology and making it available to farmers. The chairman informed the participants about 100 days targets given by the Govt. of India and discussed some important points from the Govt. of India's manifesto-like doubling farmers' income, varietals import, assurance of quality seeds at farmers' door step at affordable price, improved varieties, doorstep testing, increase yield under organic production etc.

7th Quinquennial Research Team (QRT) meeting of the Institute was held during May 31 and June 1, 2019

The meeting of the 7th Quinquennial Research Team (QRT) of ICAR-Central Potato Research Institute (ICAR-CPRI), Shimla was held at CPRI, Shimla during May 31 and June 1, 2019 under the chairmanship of Dr. SM Paul Khurana, Former Director ICAR-CPRI and former Vice-chancellor, Rani Durgawati University Jabalpur and Director Amity Institute of Biotechnology, Amity University, Gurgaon, Haryana. Other members of the QRT (Dr. Pritam Kalia, Former Head, Division of Vegetable Science, IARI, New Delhi; Dr GP Rao, Principal Scientist, Division of Plant Pathology, IARI, New Delhi; Dr. VK Chandla, Principal Scientist (Rtd.), ICAR-CPRI, Dr. Srinivasan, Principal Scientist (Rtd), NRCPB, IARI, New Delhi, Dr. BN Sadangi, Ex. Head, Social Science Division, CRRI) were also present in the meeting. During the meeting, Director, ICAR-CPRI presented the contributions and achievements of the Institute in last six years. Chairman QRT praised the work done by ICAR-CPRI and emphasized to do work on war-footing on water and nutrient use efficiency in potato and climate change resilience. He suggested assessing the hybrids in field based on yielding ability, processing attributes, climate resilience and adaptability. QRT advised that CPRI scientist must develop a major program on genetic engineering mediated improvements in nutritional qualities of the potato (vitamins, proteins, carotenoids, minerals, resistant starch and other health promoting compounds etc.), neutral and geo-neutral varieties.

Cleanliness drive under Mera Gaon Mera Gaurav

A one day cleanliness drive was organised under Mera Gaon Mera Gaurav programme on September 24, 2019 in the selected area of Cheog Panchayat as a part of Swachhta Pakhwara celebration of the institute. Students and staff of Govt. High School, Cheog along with staff of the institute, farmers and residents of the villages were actively involved in cleaning the school premises, surroundings and the market during this event. Dr. Jagesh K. Tiwari sensitized all participants about the objectives and importance of Swachhta Pakhwara and motivated them to make cleanliness a part of their daily routine.

Delegation from BIMSTEC visited ICAR-CPRI, RS Modipuram

A delegation from BIMSTEC Group member countries (India, Myanmar, Bhutan, Bangladesh, Sri-Lanka) visited ICAR-CPRI, Regional Station, Modipuram on 13 December 2019. During the visit, the scientists shared Institute's ongoing activities related to the potato breeding and seed production system in India. The delegation showed special interest in the potato varieties, storage and plant protection techniques developed by the Institute.

Glimpse of Hindi Pakhwara Celebration -2019

Hindi Pakhwara from 13-28 September 2019 was celebrated at ICAR-CPRI, Shimla. Concluding day was organized on 01 October, 2019 and Dr. SK Singh, Director, ICAR- DKMA, New Delhi grace the occasion as chief guest and Dr. SK Chakrabarti, Director, ICAR-CPRI, Shimla presided over the programme. Dr. RK Singh, In-Charge (Official Language), ICAR-CPRI, Shimla welcomed the dignitaries and all the staff present and briefly highlighted about Hindi related work being done and the various competitions organized during the Hindi Pakhwara in the institute. Subsequently, in his presidential address, Dr. SK Chakrabarti thanked everyone for participating in the competitions organized during the fortnight and making it successful. He advocated that Hindi is the language of the common people and it was given the place of official language because it is the most widely spoken and understood language in the country. He also said that the people of the country still hesitate to adopt and use their language, because in today's era, the English language has been establishing itself as a symbol of prestige and a language of the upper class. He called upon everyone to use Hindi language more and more in their life as well as in daily work. The chief guest Dr. SK Singh emphasized the abolition of mental slavery towards English. He called on everyone to teach their children the first Hindi alphabet in place of the English alphabet, so that they have respect for their language and they can use it with pride even later. In addition, the winners of the 07 competitions held at the institute during the fortnight were rewarded by the chief guest and participation certificates were given to the remaining participants. Under the Hindi Incentive Scheme, the victorious employees were also awarded during this period.

Swacchta Abhiyan 2019 (Swachhta hi Seva) pakhwara celebrated at ICAR-CPRI, Shimla

As a part of the concluding of Swachhta Pakhwara celebration of the institute, a one full day cleanliness drive was organised at the institute and its regional stations on 02-10-2019. The celebration started with cleaning of the institute and its nearby areas as well as the roads connecting the institute. After that an awareness play giving message for cleanliness including Taekwondo display by the children of th staff was held at the institute auditorium. At the end the staff engaged in the day to day cleaning of the institute and others who contribute regularly in maintenance of the clean environment in the institute were honoured by the director of the institute. The function ended with a motivational speech of the director towards maintaining cleanliness in the daily routine. Hindi Pakhwara was also celebrated by CPRI regional stations.

ICAR-CPRI won overall champion trophy and Best Disciplined Team Award in ICAR Zonal Sports Meet at Kanpur

ICAR-CPRI participated in ICAR Zonal Sports meet held at ICAR-IIPR, Kanpur from 12-14 December, 2019. 43 men and women players from CPRI and its regional stations participated in this meet. ICAR-CPRI won 7 Gold Medals in Discuss, Table Tennis, Shotput, Badminton, Volleyball Shooting events; 5 Silver medals in Carom, Shotput, Discuss, Javelin, Volleyball smashing and 2 Bronze medals in athletics events during this meet. 24 ICAR Institutes from different parts of India and about 824 players from different Institutes participated in this event. It was a matter of proud for whole potato family when ICAR-CPRI was adjudged **"BEST DISCIPLINED TEAM"** of the meet. Besides this, ICAR-CPRI also won **OVERALL CHAMPIONS TROPHY**. Director, ICAR-CPRI, Shimla and Heads of Stations along with all staff members welcomed the team at Shimla and regional stations.

Vigilance Awareness Week 2019

Vigilance awareness week was observed at ICAR-CPRI, Shimla and its regional stations from 28th October to 02nd Nov. 2019. On the first day i.e on 28th October, 2019, all the staff of the Institute took oath of integrity and all pledged to fight against corruption. All the employees demonstrated their commitment to end the corruption which is a barrier in the progress of the country and determined to be honest and follow the rules of law in all walks of life. During the Vigilance awareness week, a workshop/Seminar on Vigilance Awareness with theme **"Integrity- A way of life"** was organized at ICAR-CPRI, Shimla. All the staff members of the Institute participated in the said workshop. On the occasion of workshop, Dr. SK Chakrabarti, Director, ICAR-CPRI, Shimla addressed the CPRI Staff and stressed upon being vigilant of all laws, rules and compliance mechanism in the conduct of our official work. Sh. Pankaj Kumar, CAO & Sh. Sandeep Dudi, AO conveyed that we shall promote ethical work practices and should commit to good governance based on transparency and fairness. Sh. Anurag Garg, Addl. Director General, State Vigilance & Anti-Corruption Bureau was the lead speaker in this workshop/seminar. In his address, he told the staff that we should be aware of the do and don't's while working in the Institute and we should neither take bribe nor offer bribe. Every citizen should be vigilant and commit to uphold high standards of honesty and integrity. Dr. NK Pandey, Institute Vigilance Officer, CPRI also emphasized upon being vigilant of all laws, rules and compliance mechanism in the conduct of our official work. Vigilance awareness week was also observed at some of the local schools and children participated in this event with high spirit.

Essay Competition and Quiz Competition organized at the Institute in which staff of CPRI participated in high spirits.

Constitution-Day was celebrated at ICAR-CPRI, Shimla

To mark the 70th anniversary of the formation of Indian Constitution, Constitution Day (26th November, 2019) was celebrated at ICAR-CPRI, Shimla. On the Occasion, the preamble of the constitution was read out by the Director followed by reading out of the fundamental duties of the Indian citizens. The handbills of the fundamental duties were also distributed among the staffs and the visiting trainees of capacity building. The same exercise was carried out among the students and teachers of a Middle School and the residents of nearby area. A team of CPRI visited Shoghi, where farmers from many villages of Shoghi Panchayat (Shimla) were gathered. They were also made aware of the rights and duties of Indian citizens framed in the Indian constitution by reading out the same and also by means of distribution of handbills. During the occasion three flagship programmes of Govt. of India viz. Doubling Farmers Income, Soil Health Card and Per Drop More Crop were also emphasised among the farming Community.

Diwali Mela organized at ICAR-CPRI, Shimla

ICAR-CPRI organised Diwali Mela on 19 October, 2019 for the Institute staff and their families. A number of stalls comprising decoration material by an NGO, eatables by staff members and other local vendors, games for children and others, banking sector etc. were put up in this mela. Tombola and tug of war among different divisions were the main attraction of this mela along with slow scooter race for elders, musical chair for ladies and different kind of races for children were also a part of this mela. The winners of different events were given prizes by the chief guest Mrs. Piali Chakrabarti along with lucky coupon draw at the end of the day long mela.

TRAINING AND CAPACITY BUILDING

Training and capacity building programmes/ conference/ seminar/ symposium/ workshop etc attended by Scientific, Technical and Administrative staffs of ICAR-CPRI, Shimla in 2019.

S.No.	Name of employee	Programme name	Venue & Date
A	**Scientific Staff**		
1.	Drs. Vinay Bhardwaj, VK Gupta, JK Tiwari, Salej Sood & Ratna P. Kaur	Breeding Management System (BMS) workshop under the BMGF project organized by ICAR-IIMR, Hyderabad in collaboration with EiB and ICRISAT	ICRISAT, Hyderabad 12-17 August, 2019
2.	Dr. VU Patil	Next generation sequencing and its application to crop science.	ICAR-NRCPB, New Delhi 3-23 Sep, 2019
3.	Dr. Shambhu Kumar	Stress Management	ICAR-NAARM, Hydrabad 26-29 June, 2019
4.	Dr. Devendra Kumar	Management development programme on Leadership development.	ICAR-NAARM, Hydrabad 11-22 June, 2019
5.	Dr. Tanuja Buckseth	One day workshop on use of Hindi in Scientific work	ICAR-CPRI, Shimla
6.	Dr. Sunayan Saha	Recent Advacnes in Crop Micrometerology	MPKV, Rahuri 17 Sep-7Oct, 2019
7.	Dr. Aarti Bairwa	Novel techniques in mass culturing of smart microbial biocontrol agents for the development of bio pesticides	ICAR-NBAH, Bangaluru 3-23 Dec, 2019
8.	Dr. Prince Kumar	Assessing soil plant atmosphere continuum (SPAC) for enhanced input use efficiency	PAU, Firozepur 1-21 Oct, 2019
9.	Er. Sukhwinder Singh	Plasticulture Technologies in agriculture	ICAR-CIPHET, Ludhiana 5-25 Nov, 2019
10.	Dr. G. Vanishree	Leadership and organisation development for women scientists and technologists.	COD, Hydrabad 14-18 Oct, 2019
11.	Dr. Rahul R. Bakarde	Winter School on Advancement in Potato Production Technology and its future prospects	ICAR-CPRIRS, Modipuram 19 Nov. to 9 Dec., 2019
12.	Dr. Raghavendra KV	Winter School on Advancement in Potato Production Technology and its future prospects	ICAR-CPRIRS, Modipuram 19 Nov. to 9 Dec., 2019

S.No.	Name of employee	Programme name	Venue & Date
13.	Dr. VK Gupta and Dr. Salej Sood	Workshop on "Breeding Management System"	9-12 July, 2019, ICRISAT, Hyderabad
14.	Dr. JK Tiwari	International Conference on "Plant Genetics and Genomics: Germplasm to Genome Engineering".	17-18 Oct. 2019, NAAS, New Delhi
15.	Dr. JK Tiwari	2nd International Conference on "Recent advances in agricultural, environmental and applied sciences for global development (RAAEASGD-2019)"	27-29 Sept. 2019 Nauni, Solan
16.	Dr. KN Chourasia	International conference on "Electron Microscopy and Allied Analytical Techniques"	5-9 June, 2019 HPU, Shimla
17.	Dr. Divya K Lekshmanan	National Symposium on "Potential crops for food and nutritional security"	14 – 15 December 2019 TNAU, Coimbatore, TN
18.	Dr. Janani P	National Symposium on Organic Potato	July 29, 2019 Shillong, Meghalaya
19.	Dr. Paresh Chaukhande	NICRA-Technical Review Workshop for institutes working under Integrated Modelling at Indian Institute of Technology (IIT), Chennai	17-19 December, 2019 NASC, New Delhi
20.	Dr. MJ Sadawarti	Training programme on 'Breeding data digitization	12-13 November, 2019 ICAR-CPRI, RS, Modipuram.
21.	Drs. Sanjay Rawal, N Sailo and P Janani	'National Symposium on Organic Potato in Meghalaya and Other North-Eastern States'	29 July 2019 (CIP) at Shillong, Meghalaya, India'
22.	Dr. Janani P	Training Programme On "Positive selection for improving quality of farm-saved seed potato in Meghalaya"	16th May 2019 at Wahlygngkeng in East Khasi Hills district, Meghalaya
23.	Dr. Pinky Raigond	Training programme on 'Procedure for sampling and sample preparation for mineral and biofortification analyses as well as measuring of vitamin C and glycoalkaloids' held	International Potato Centre, Lima, Peru from 23-9-2019 to 2-10-2019.

S.No.	Name of employee	Programme name	Venue & Date
24.	Sh. Milan Kumar Lal	Workshop on 'CRISPR/ Cas system for genome engineering'	July 3-5, 2019 at Amity University, Noida.
B	**Technical Staff**		
1.	Sh. Rajdeep Bux	Workshop on "Preventive Conservation of illustrated Manuscripts"	August 27-31, 2019 at Himachal State Museum Shimla and Manuscript conservation Centre, Shimla
2.	Sh. Rajdeep Bux	Training Awareness Workshop on "J-gate@CeRA for Northern Region"	October 23, 2019 NASC Complex, New Delhi
3.	Mr. Rajinder Kumar	Plant Qurantine, national regulations and procedures.	NIPHM, Hydrabad 15-19 July, 2019
4.	Mr. Rakesh Kumar	Recent Extension Approaches for Entrepreneur-ship development in agriculture and allied sector	CSKHPKVV, Sundernagar 10-14 June, 2019
5.	Mrs. Jatinder Kaur Arora	Recent Extension Approaches for Entrepreneur-ship development in agriculture and allied sector	CSKHPKVV, Sundernagar 10-14 June, 2019
6.	Mr. Sushil Singh, Mr. Vipin Kumar	Automobile maintenance, road safety and behavioural skills	ICAR-CIAE, Bhopal 24-30 Sep, 2019
7.	Mr. Pardeep Kumar Upadhaya	Farm Equipment for Plant Health Management	ICAR-NIPHM, Hydrabad 27-29 Aug, 2019
8.	Dr. Ashok Kumar	Social skills for extension management	MANAGE, Hydrabad 8-12 July, 2019
9.	Mr. Santosh Kumar	Farm Equipment for Plant Health Management	ICAR-NIPHM, Hydrabad 27-29 Aug, 2019
10.	Sh. Arun Kumar Singh, Sh. Naresh Kumar Sharma	Capacity Building Programme towards secure and resilient workplace at ICAR	ICAR-CPRI, Shimla 25-27 Nov, 2019
C	**Administrative Staff**		
1.	Mrs. Sunita Thakur	One day workshop on Rajbhasha use in financial works with problems and solutions	ICAR-CPRI, Shimla
2.	Mr. Suresh Kumar Verma, Sh. Gurjeet Singh	Enhancing efficiency and behavioural skills for stenographers	ICAR-CPRI, Shimla 20-25 June, 2019

S.No.	Name of employee	Programme name	Venue & Date
3.	Sh. Om Prakash	Reservation in Services for SC/ST/OBC at ISTM, New Delhi	ISTM, New Delhi 26-29 Aug, 2019
4.	Sh. Suresh Kumar	Training on "Rajbhasha"	ICAR-CPRI, Shimla
5.	Smt. Poonam Sood, Sh. Narendra Paul, Sh. Ashish Kalyan	Capacity Building Programme towards secure and resilient workplace at ICAR	25-27 Nov. 2019 ICAR-CPRI, Shimla
	Drs. Manoj Kumar, RK Singh, VK Dua, B. Singh, NK Pandey, V. Bhardwaj, S Sharma, V. Sagar, V. Kumar, AK Sharma, S Rawat, KK Sharma, Pankaj Kumar, Sandeep Singh Dudi, Vivek Kumar, Chanda Ram, Krishan Lal, Hans Raj, Nirmala Chauhan, Mohinder Singh, Kundan Lal, Meena Verma, Pawan Kumar, Poonam Jyoti, Narender Paul, Poonam Sood, Sunita Thakur, Om Parkash, Ashish Kalyan, Joginder Singh Thakur, Urmila Verma, Babli Bhawani, Rita Walia, Shyam Lata, Ashwani Gupta, Tej Singh, Raghubir Singh, C.P. Sharma, Amar Chand, Deep Ram, Kamal Chand Verma, Geeta Devi, Sonia Chauhan, Gokal Ram, Shashi Bala Thakur, Ram Chand, Suresh Kumar, Sachin Kanwar, Rakesh Negi, Mohit Oberoi, Nand Lal, Rajdeep Bux, Madhu Bala, CM Bist, Rahul, Sh. Naresh Kumar Sharma, Gurjeet Singh, Avnish Attrey, Vinod Kumar, Dharminder Verma, Girish Thakur, Harvinder Singh, Kana Singh Chauhan, Sukhpal Sharma, Daishy Tuli, Daljeet Singh, Sandeep, Sunil Kumar, Chandni Bhagta, Rajesh Chauhan, Surender Singh, Pradyuman K. Saraswat, IC Dharmapual, Padam Chand and Kiran	Training on e-office conducted by IASRI	ICAR-CPRI, Shimla

AWARDS AND HONOURS

CPRI BEST WORKER AWARD FOR YEAR 2019

S.No.	Name of the the Person	Category	Year
1.	Dr. Murlidhar Sadawarti, Scientist SS, ICAR-CPRS, Gwalior and Dr. Raj Kumar, PS, ICAR-CPRS, Jalandhar	Scientific	2019
2.	Sh. Ram Singh, Sr. TA and Smt. Asha Thakur, Sr. TA, ICAR-CPRI, Shimla. Sh. Shayam Kumar Gupta, T-6, ICAR-CPRS, Gwalior and Sh. Mahesh Kumar, CTO, ICAR-CPRI-RS, Modipuram	Technical	2019
3.	Sh. Joginder Singh Thakur, AAO, Smt. Shashi Bala, PS, Sh. Chanda Ram, AAO, ICAR-CPRI, Shimla and Sh. Rajesh Kumar, PA, ICAR-CPRI-RS, Modipuram	Administrative	2019
4.	Sh. Roshan Lal, SSS, Sh. Padam Dev, SSS, ICAR-CPRI, Shimla and Sh. Mannu Singh, SSS, ICAR-CPRS, Gwalior	Supporting	2019

1. Drs. SK Chakrabarti (Team Leader), JK Tiwari (Associate) and Sundaresha S. (Associate) received ICAR – Hari Om Ashram Trust Award for Biennium 2016-17 by ICAR, New Delhi in 2019.
2. Dr. Brajesh Singh received Fellowship of Indian Academy of Horticultural Sciences, New Delhi in 2019.
3. Drs. SK Luthra, JK Tiwari, Dalamu, B Kaundal, P Riagond, J Sharma, B Singh, VK Dua, V Kumar, VK Gupta received IPA Gold medal for the best research paper (*Potato Journal* 2018, 45: 81-92).
4. Dr. JK Tiwari received Young Scientist Award-2019 by Agro-Environment Development Society (AEDS), Rampur UP during Recent Advances in Agricultural, Environmental & Applied Sciences for Global Development held on September 27-29, 2019 UHF, Nauni, Solan.
5. Dr. Pinky Bagged 'Young Achiever Award-2019' conferred by Society for Advancement of Human and Nature (SADHNA), DR YS Parmar University of Horticulture and Forestry Nauni, Solan 173230, Himachal Pradesh, India.
6. Dr. Pinky Bagged 'Young Women Scientist Award-2019' conferred by Agro-Environmental Development Society during International Conference on 'Recent Advances in Agricultural, Environmental & Applied Sciences for Global Development' held during 27-29 September 2019 at Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, H.P.
7. Bagged First prize in Oral presentation (co-author) for the presentation entitled 'Betanins rich purple potato chips: An innovative fusion product with enhanced functionality' authored by A. Joshi, S. Sethi, V. R. Sagar, B. S. Tomar, P. Raigond and B. Singh in International conference on 'Contemporary Issues in Integrating Health and Nutrition with the Emerging Areas of Food Technology, Agriculture, Environment and Allied Sciences' organized by Dept of Food Technology, Shyama Prasad Mukherji College for Women, University of Delhi on 6th April, 2019"
8. Dr. RK Singh Fellowship (2019) by Uttar Pradesh Academy of Agriculture Sciences (UPAAS), UPCAR, Lucknow, Uttar Pradesh.
9. Drs. Tanuja Buckseth, Rajesh K Singh and SK Chakrabarti. Awarded Author of the year 2019 for the article id. 11187 entitled Aeroponic: a novel system of seed potato production. Agriculture & Food: e-Newsletter. ISSN 25818317.
10. Dr. RK Singh Fellowship (2019) by Society for Horticultural Research andDevelopment (SHRD), SD-70, Shastri Nagar, Ghaziabad, Uttar Pradesh, India.
11. Best article award for the article authored by Buckseth Tanuja, Singh RK, Clarissa Challam, JK Tiwari and Chakrabarti SK. 2019. article id.

22242 Apical Root Cutting (ARC): a low cost technology for the production of quality seed potato material for the farmers. Agriculture & Food: e-Newsletter. ISSN 25818317.

12. Dr. Pynbianglang and Dr. N.K. Pandey were awarded Best Paper on Doubling Farmers Income : Issues, strategy and option for potato producers in North East India during 24-25 January 2020.
13. Dr. Pynbianglang K., Dr. N.K. Pandey and Dr. Dhiraj K. Singh received Best Poster Award on Consumers preference for potato attributes in Jalandhar and Ludhiana district of Punjab.
14. Dr. Shashi Rawat received Certificate of Appreciation from DDG (Agril. Edu.) & DDG (NRM) for proactively implementing KRISHI.
15. Dr. Shashi Rawat received Best Poster Award for research paper Real time knowledge based resource information system for potato in the theme AI & ICT in potato R&D.
16. Drs. BP Singh, PM Govinda Krishnan, VK Dua, Shashi Rawat, Sanjeev Sharma, Islam Ahmad, SK Chakrabarti, SS Lal received IPA-Kaushalya Sikka Memorial Award 2013-17 for research on Decision Support Tools for Potato Research & Development.
17. Dr.Baswaraj Raigond received Achiever Award by Society for Advancement of Human & Nature, Nauni, Solan during a National Seminar on Doubling Income Through Sustainable and Holistic Agriculture held on 5th June 2019 at UHF, Nauni, Solan.
18. Dr. Baswaraj Raigond received Young Scientist Award by Agro Environmental Development Society, Rampur, UP during 2nd International Conference on Recent Advances in Agriculture, Environmental & Applied Sciences for Global Development held on September 27-29, 2019 at UHF, Nauni, Solan.
19. Dr. Gaurav Verma received Young Plant Pathologist Award by Agro Environmental Development Society, Rampur, UP on September 27-29, 2019 at UHF, Nauni, Solan.
20. Dr. Gaurav Verma received Young Scientist Award by the Society for Scientific Development in Agriculture and Technology (SSDAT).
21. Dr. Ravinder Kumar received Young Scientist Award 2019 by National Education Empowerment & Development Foundation, Lucknow, UP on 20 June 2019 at IISR, Lucknow.
22. Dr. Ravinder Kumar received Excellence in Research Scientist Award 2019 by Agricultural Technology Development Society, Muradnagar, Ghaziabad, UP, India during 3rd International Conference on Global Initiatives in Agricultural and Applied Sciences for Eco friendly Environment held on June 16-18, 2019 at Tribhuvan University, Kathmandu, Nepal.
23. Dr. Ravinder Kumar received Young Scientist Associate Award 2019 by Society for Recent Development in Agriculture, Meerut, UP during 3rd Global Meet on Science and Technology for Ensuring Food and Nutritional Security held on December 01-03, 2019 at NRC on Seed Spices, Ajmer (Rajasthan).
24. Drs. Aarti Bairwa, Sundaresha S, Venkatasalam E P, Bhawna Dipta, Sanjeev Sharma, Chakrabarti S K (2019) received best oral presentation award for the paper entitled Gene expression interference of parasitism genes flp-32(c) and flp-32(p) in potato cyst nematode (*Globodera* spp.) during International conference on plant protection in Horticulture held at IIHR, Bengaluru on July 24-27, 2019.

Foreign Deputation in 2019

- Dr. Vinay Bhardwaj, Head, Division of Crop Improvement, ICAR-CPRI, Shimla to visit International Potato Centre, Lima, Peru in training programme entitled "Development of Diploid Potatoes" during 14.10.2019 to 25.10.2019.
- Dr. Sanjeev Sharma, Head, Division of Plant Protection, ICAR-CPRI, Shimla for deputation to Beijing, China to attend 3rd Asia Blight International Conference organized by CIP Centre and China Center for Asia Pacific during 22-31 October, 2019.
- Dr. Pinky Raigond, Scientist, Division of CPB & PHT, ICAR-CPRI, Shimla to visit International Potato Centre, Lima, Peru in training programme entitled "Procedure for sampling and sample preparation for mineral and biofortificat ion analyses as well as measuring Vitamin C and glycoalkaloids" during 23.09.2019 to 02.10.2019.
- Dr. Sundaresha S., Sr. Scientist, Division of Plant Protection, ICAR-CPRI, Shimla to visit Bangladesh to attend 7th South Asia Biosafety Conference during 14-16 September, 2019.

STAFF POSITION

NAME OF STAFF AT ICAR-CPRI, SHIMLA & ITS REGIONAL STATIONS AS ON 31.3.2020

Director

Dr. SK Chakrabarti (retired on 31.03.2020)

SCIENTIFIC

ICAR-CPRI, Shimla

AICPIP Unit

1. Dr. Vinod Kumar, Pr. Scientist

Division of Crop Improvement

2. Dr. Vinay Bhardwaj, Pr. Scientist & officiating Head
3. Dr. Jagesh Kumar Tiwari, Sr. Scientist
4. Sh. Virupakshagauda U Patil, Scientist
5. Dr. (Mrs.) G Vanishree, Scientist
6. Sh. Hemant Balasaheb Kardile, Scientist
7. Dr. Salej Sood, Scientist
8. Dr. Kumar Nishant Chourasia, Scientist

Division of Seed Technology

9. Dr. Rajesh Kumar Singh, Pr. Scientist & Head
10. Dr. (Mrs.) Tanuja Buckseth, Scientist
11. Sh. Raj Kumar, Scientist

Division of Crop Production

12. Dr. VK Dua, Pr. Scientist & Head
13. Dr. Jagdev Sharma, Pr. Scientist
14. Dr. Anil Kumar Choudhary, Sr. Scientist
15. Dr. (Ms.) Pooja Praful Mankar, Scientist
16. Sh. Paresh Baldeorao, Scientist
17. Ms. Preeti Singh, Scientist

Division of Social Sciences

18. Dr. NK Pandey, Pr. Scientist & Head
19. Sh. Pynbianglang Kharumunid, Scientist

Division of Plant Protection

20. Dr. Sanjeev Sharma, Pr. Scientist & Officiating Head
21. Dr. Vinay Sagar, Pr. Scientist
22. Dr. Baswaraj R., Sr. Scientist
23. Dr. Sundersha S, Scientist
24. Dr. Ravinder Kumar, Scientist
25. Dr. Gaurav Verma, Scientist
26. Dr. (Ms.) Aarti Bairwa, Scientist
27. Dr. Kailash Chandra Naga, Scientist
28. Sh. Rahul Kumar Tiwari, Scientist
29. Sh. Subhash. S, Scientist

Division of Crop Phy. & PHT

30. Dr. Brajesh Singh, Pr. Scientist & Head
31. Dr. Som Dutt, Pr. Scientist
32. Dr. (Mrs.) Pinky Raigond, Scientist
33. Dr. Changan Sushil Sudhakar, Scientist
34. Dr. Dharmendra Kumar, Scientist
35. Sh. Milan Kumar Lal, Scientist

AKMU

36. Dr. Shashi Rawat, Pr. Scientist

ICAR-CPRI, RS, Modipuram

37. Dr. Manoj Kumar, Pr. Scientist & Joint Director
38. Dr. Devendra Kumar, Pr. Scientist
39. Dr. SK Luthra, Pr. Scientist
40. Dr. Name Singh, Pr. Scientist
41. Dr. Vinay Singh, Pr. Scientist
42. Dr. Anuj Bhatnagar, Pr. Scientist
43. Dr. Sanjay Rawal, Pr. Scientist
44. Dr. Dhruv Kumar, Pr. Scientist
45. Dr. Vijay Kishore Gupta, Pr. Scientist
46. Dr. (Mrs.) Babita Chaudhary, Pr. Scientist
47. Dr. Mehi Lal, Sr. Scientist
48. Dr. (Ms) Bandna, Scientist

ICAR-CPRI, RS, Jalandhar

49. Dr. Raj Kumar, Pr. Scientist & officiating Head
50. Dr. Anil Sharma, PS
51. Er. Sukhwinder Singh, Scientist (SG)
52. Er. Sunil Gulati, Scientist (SG)
53. Dr.(Ms) Ratna Preeti Kaur, Scientist
54. Dr. Prince Kumar, Scientist
55. Dr. Mohd. Abas Shah, Scientist
56. Dr.(Mrs.) Sugani Devi, Scientist
57. Er. Brajesh Nare, Scientist
58. Dr. Arvind Kumar Jaiswal, Scientist
59. Dr. Sunayan Saha, Scientist

ICAR-CPRI, Gwalior

60. Dr. Shiv Pratap Singh, Pr. Scientist & officiating Head
61. Dr. Murlidhar .J.Sadawarti, Scientist
62. Dr. Subhash Katare, Senior Scientist

ICAR-CPRI, Shillong

63. Dr. Ngursangzuala Sailo, Scientist & officiating Head
64. Ms. Clarissa Challam, Scientist
65. Sh. Bappi Dass, Scientist
66. Dr. (Mrs.) P Janani, Scientist

ICAR-CPRI, Muthorai

67. Dr. EP Venkatsalam, Pr. Scientist & Incharge
68. Mrs. Divya K Lekshmanan, Scientist
69. Dr. Mhatre Priyank Hanuman, Scientist

ICAR-CPRI, Kufri

70. Dr. Ashwani Kumar Sharma, Pr. Scientist & Incharge
71. Dr. (Ms.) Dalamu, Scientist

ICAR-CPRI, Patna

72. Dr. Shambhu Kumar, Pr. Scientist & officiating Head
73. Dr. Raj Kumar, Sr. Scientist
74. Sh. Rahul R Bakade, Scientist
75. Dr. Sarla Yadav, Scientist

NAME OF TECHNICAL STAFF AT ICAR-CPRI, SHIMLA & ITS REGIONAL STATIONS AS ON 31.3.2020

TECHNICAL

ICAR-CPRI, Shimla

1. Dr. Sushil Kumar, ACTO
2. Mrs. Tarvinder Kochhar, ACTO
3. Mr. Dharminder Verma, ACTO
4. Mrs. Shelly Chopra, ACTO
5. Mr. Rajdeep Bux, STO
6. Dr. (Mrs.) Sumita Sharma, STO
7. Mr. Parvesh Jassal, ACTO
8. Mr. Kameshwar Sen, ACTO
9. Mr. Avinish Kumar Atrey, ACTO
10. Mr. Chander Mohan Singh Bist, ACTO
11. Mr. Yogesh, ACTO
12. Mr. Harvinder Singh (Overseer Civil), STO
13. Mrs. Shruti Gupta, STO
14. Mr. Vinod Kumar, STO
15. Mr. Tilak Raj, STO
16. Mr. Dharam Prakash Gautam, TO
17. Mr. Kana Singh Chauhan, STO
18. Mr. Sheesh Ram Thakur, TO
19. Mr. Sushil Singh, TO (Driver)
20. Mr. Naresh Kumar Sharma, TO
21. Mr. Naresh Chand, TO
22. Mrs. Manjeet Syal, STA
23. Mrs. Madhu Bala, STA

24. Mrs. Asha Thakur, TO
25. Mr. Hari Kishore, STA
26. Mr. Ram Singh, STA
27. Mr. Dharminder Kumar Gupta, TO
28. Mr. Rajinder Kumar, TO
29. Mr. Rakesh Kumar Patyal, TO
30. Mr. Roop Lal (Driver), STA
31. Mr. Ravinder Kumar, STA
32. Mr. Naresh Kumar, STA
33. Mr. Ranjesh Bhardwaj, STA
34. Mr. Deep Ram, STA
35. Mr. Ashok Kumar, STA (Driver)
36. Mr. Rakesh Kumar, STA
37. Mrs. Jatinder Kaur Arora, STA
38. Mr. Jagdish Chand, TA (Welder)
39. Mr. Jagdish Chand, ST (T-13) Carpenter
40. Mr. Dev Raj, ST
41. Mr. Ram Dayal, ST
42. Mr. Parmesh Dutt, ST
43. Mr. Anil Kumar Dube, ST
44. Mr. Neem Chand, ST
45. Mr. Laiq Ram, ST
46. Mr. Surinder Pal, ST
47. Mr. Mansha Ram, Technician
48. Mr. Arjun Dass, Technician
49. Mr. Vivek Kumar, TT
50. Mr. Rahul, TT
51. Mr. Sanjay Kumar, TT
52. Mr. Rakesh Kumar, TT
53. Mrs. Sonam, TT
54. Miss Vandana Parmar, TT
55. Miss Vineeta Sharma, TT
56. Miss Nisha Verma, TA (Hindi Translator)

ICAR-CPRI, Kufri

57. Mr. Kapil Kumar Sharma, ACTO
58. Mr. Santosh Kumar, ACTO
59. Mr. Kedar Singh, TO
60. Mr. Ajit Singh, STA
61. Mr. Ram Jivan, TA
62. Mr. Mohan Lal, ST
63. Mr. Rajat, TT

ICAR-CPRI, Modipuram

64. Mr. Mahipal Singh Bharti, CTO
65. Mr. Harvir Singh, CTO
66. Dr. Ashok Kumar, CTO
67. Mr. Krishan Pal Singh, ACTO
68. Mr. Ompal, ACTO
69. Mrs. Kusum Singh, ACTO
70. Mr. Harvir Singh, STO
71. Mr. Murari Lal, ACTO
72. Mr. Omvir Singh, STO
73. Mr. Subhash Chand, STO
74. Mrs. Vineet Sharma, STO
75. Mr. Avinash Chaudhary, STO
76. Mr. Dinesh Singh, ACTO
77. Mr. Pushpendra Kumar, STO
78. Dr. Sanat Kumar, STO
79. Mr. Udai Vir Singh, STO
80. Mr. Ved Singh, STO
81. Mr. Krishan Pal Singh, TA
82. Mr. Udhha Prasad Paudel, TA
83. Mr. Sayed Danish Abbas Rizvi, STA
84. Mr. Pawan Kumar Malik, TO
85. Mr. Mahesh Pal Singh, TA (T-I-3) Driver
86. Mr. Vipin Kumar, TA (Driver)
87. Mr. Madan Pal, ST
88. Mr. Satpal Singh, ST
89. Mr. Siddharth Saroha, TT
90. Mr. Rohit Verma, TT
91. Mr. Ajay Kumar, TT

ICAR-CPRI, Jalandhar

92. Mr. Munna Lal, ACTO
93. Mr. Jaswinder Singh, ACTO

94. Mr. Yogesh Kumar Gupta, ACTO
95. Mr. Akhilesh Kumar Singh, STO
96. Mr. Parveen Kumar, STA
97. Mr. Som Dutt Randev, STA
98. Mr. Narinder Mayer, STA
99. Mr. Kulwinder Singh, STA
100. Mr. Anil Kumar Chandel, TA
101. Mr. Pardeep Kumar Upadhaya, TO
102. Mr. Vijay Kumar, STA
103. Mr. Pawan Kumar, ST
104. Mr. Virender Kumar, TT

ICAR-CPRI, Gwalior

105. Dr. Yogendra Pal Singh, STO
106. Dr. Sanjay Kumar Sharma, STO
107. Mr. Shyam Kumar Gupta, STO
108. Mr. Rajender Kumar Samadhiya, STO
109. Mr. Surendar Singh, TO
110. Mr. Radha Kishan, TA (T-13)
111. Mr. Nihal Singh, TA
112. Mr. Bijendra Singh, ST
113. Mr. Tara Chand, ST
114. Mr. Chet Ram, ST
115. Mr. Vinod Kumar Meena, TT

ICAR-CPRI, Patna

116. Mr. Arun Kumar Singh, CTO
117. Mr. Arjun Kumar Sharma, STO
118. Mr. Rakesh Srivastava, TO
119. Mr. Anil Kumar, TO
120. Mr. Alekh Narain, TO
121. Mr. Narendra Kumar, ST
122. Mr. Lal Babu Das, STA (Driver)
123. Mr. Sunil Kumar Singh, ST
124. Mr. Pravesh Kumar Yadav, ST
125. Mr. Rishav Kumar, TT
126. Mr. Pratish Kumar Patel, TT
127. Mr. Sanjeev Kumar Meena, TT

ICAR-CPRI, Shillong

128. Mr. Ram Das Rai, TA (T-13)
129. Mr. Phishalis Roy Khongbuh, TA
130. Mr. Sabarius Nongrum, ST
131. Mr. Sumit Kumar, TT

ICAR-CPRI, Muthorai

132. Mr. V. Rajendran, TO
133. Mr. R Lakshmanan, STA
134. Mr. B. Suresh, ST

ADMINISTRATIVE STAFF

ICAR-CPRI, Shimla

1. Dr. Pankaj Kumar, CAO
2. Sh. Sandeep Singh Dudi, AO
3. Sh. Chander Prakash, AFAO
4. Sh. Ashish Dhangar, AFAO (on lien)
5. Sh. Joginder Singh Thakur, AAO
6. Sh. Chanda Ram, AAO
7. Smt. Poonam Sood, AAO
8. Sh. Jai Ram Thakur, AAO
9. Smt.MeenaVerma, AAO
10. Smt. Babli Bhawani, AAO
11. Sh. Krishan Lal, Asstt.
12. Ms. Rita Walia, Asstt.
13. Sh. Amar Chand, Asstt.
14. Mrs. UrmilaVerma, Asstt.
15. Mrs. Sunita Thakur, Asstt.
16. Sh. Om Parkash, Asstt.
17. Mrs. Shyam Lata Beakta, Asstt.
18. Sh. Deep Ram, Asstt.
19. Sh. Pawan Kumar, UDC
20. Sh. Sachin Kanwar, UDC
21. Sh. Hans Raj, UDC
22. Mrs. Nirmala Chauhan, UDC
23. Sh. Kamal Chand Verma, UDC
24. Sh. Ashwani Gupta, UDC
25. Sh. Tej Singh, UDC
26. Mrs.Geeta Devi, UDC
27. Mrs. Sonia Chauhan, UDC
28. Mrs. Punam Jyoti, UDC
29. Sh. Mohinder Singh, UDC
30. Sh. Narender Paul, UDC
31. Sh. Raghubir Singh, UDC
32. Sh. Gokal Ram, UDC
33. Sh. Ashish Kalyan, LDC
34. Sh. Rakesh Negi, LDC
35. Sh. Kundan Lal, LDC
36. Sh. Nand Lal, LDC
37. Sh. Gurjeet Singh, Pvt. Secy.
38. Sh. Ram Chand, Pvt. Secy.
39. Smt. Shashi Bala Thakur, Pvt. Secy.
40. Sh. Suresh Kumar, PA
41. Sh. Girish Thakur, SG-III
42. Sh. Mohit Oberoi, SG-III

ICAR-CPRI, Kufri

43. Smt. Chandni Bhagta, Asstt.

ICAR-CPRI, Jalandhar

44. Miss. Prawartika Das, AAO
45. Sh. Sukhpal Sharma, Asstt.
46. Ms. Sandhya Srivastava, Asstt.
47. Sh. Rakesh, Asstt.
48. Mrs Bimla Salhotra, UDC
49. Mrs. Daishey Tuli, UDC
50. Sh. Daljit Singh, UDC
51. Sh. Naresh Kumar, LDC
52. Sh. Suresh Kumar Verma, PA

ICAR-CPRI, Modipuram

53. Sh. Jaspal Singh, AO
54. Sh. Sandeep, AAO
55. Smt. Sneh Lata, UDC
56. Smt. Seema Verma, UDC
57. Sh. Ashok Kumar, UDC
58. Sh. Sunil Kumar, LDC
59. Sh. Suraj Singh, LDC
60. Sh. Rajesh Kumar, Pvt. Secy.

ICAR-CPRI, Patna

61. Sh. Jagbir Singh, AAO
62. Sh. Sanjib Kumar, Asstt.

63. Sh. RK Gupta, UDC
64. Sh. Rajesh Chauhan, LDC
65. Sh. Pawan Kumar, SG-III

ICAR-CPRI, Gwalior

66. Sh. Surender Singh, Asstt.
67. Sh. Pradyuman Kumar Saraswat, UDC

ICAR-CPRI, Muthorai

68. Smt. IC Dharmapaul, AAO
69. Smt. M. Rani, Asstt.

ICAR-CPRI, Shillong

NIL

SKILLED SUPPORT STAFF

ICAR-CPRI, Shimla

1. Sh. Charan Dass , SSS (SS Gr. III)
2. Sh. Kanhiya Prasad ,SSS(SS Gr. III)
3. Sh. Subhash Chand, SSS (SS Gr. III)
4. Sh. Mansa Ram, SSS(SS Gr. III)
5. Sh. Babu Ram, SSS(SS Gr. III)
6. Sh. Ramesh Kumar, SSS (SS Gr. III)
7. Sh. Rajinder Kumar, SSS (SS Gr. II)
8. Sh. Kulwant Singh, SSS (SS Gr. II)
9. Sh. Sanjeevan Kumar, SSS (SS Gr. II)
10. Sh. Ashok Kumar , SSS(SS Gr. I)
11. Sh. Narender Kumar , SSS(SS Gr. I)
12. Smt. Kajal , SSS(SS Gr. I)
13. Sh. Padam Dev , SSS (SS Gr. I)
14. Sh. Roshan Lal, SSS (SS Gr. I)
15. Smt. Manjit , SSS(SS Gr. I)
16. Sh. Amar Nath , SSS(SS Gr. I)
17. Sh. Hira Singh, SSS(SS Gr. I)
18. Sh. Rajinder Singh, SSS
19. Sh. Padam Chand, SSS(SS Gr.I)
20. Smt. Kiran, SSS

ICAR-CPRI, Kufri

21. Sh. Hira Singh , SSS(SS Gr. III)
22. Sh. Saran, SSS (SS Gr. III)
23. Smt. Muni Devi, SSS(SS Gr. II)
24. Sh. Madan Lal, SSS(SS Gr. I)
25. Sh. Roop Singh, SSS(SS Gr. I)
26. Sh. Jia Lal, SSS(SS Gr. I)
27. Smt. Sodha Devi, SSS

ICAR-CPRI, Modipuram

28. Sh. Amiruddin, SSS(SS Gr. II)
29. Sh. Jagtey, SSS (SS Gr. II)
30. Sh. Som Pal, SSS(SS Gr. II)
31. Sh. Mani Ram, SSS (SS Gr. I)
32. Sh. Rajpal, SSS (SS Gr. I)
33. Sh. Rajvir Singh, SSS (SS Gr. I)
34. Sh. Raj Kumar, SSS (SS Gr. I)
35. Sh. Sudesh Pal, SSS (SS Gr. I)
36. Sh. Tej Bir Singh, SSS (SS Gr. I)
37. Sh. Gyanendra Kumar, SSS (SS Gr. I)
38. Sh. Ramphal, SSS (SS Gr. I)
39. Sh. Mukesh, SSS(SS Gr. I)
40. Sh. Murari, SSS (SS Gr. I)
41. Sh. Rajpal Singh, SSS (SS Gr. I)

ICAR-CPRI, Jalandhar

42. Sh. Komal, SSS (SS Gr. III)
43. Sh. Satnam Singh, SSS (SS Gr. II)
44. Smt. Passo, SSS (SS Gr. II)
45. Smt. Rashpal Devi, SSS(SS Gr. II)
46. Sh. Ram Lubhaya, SSS(SS Gr. II)
47. Sh. Sukhwinder , SSS(SS Gr. II)
48. Sh. Jagai Ram, SSS(SS Gr. II)
49. Sh. Paramjit Singh, SSS(SS Gr. II)
50. Sh. Ram Sarup, SSS(SS Gr. I)
51. Sh. Joginder Pal, SSS(SS Gr. I)
52. Sh. Ram Nath, SSS(SS Gr. I)
53. Sh. Jagan Nath, SSS(SS Gr. I)

ICAR-CPRI, Patna

54. Sh. Tapan Burman , SSS(SS Gr. III)
55. Sh. Ram Kisun Ram, SSS(SS Gr. II)
56. Sh. Teka Rai, SSS(SS Gr. II)
57. Sh. Jagat Kumar, SSS(SS Gr. II)
58. Sh. Bishun Rai, SSS(SS Gr. I)
59. Sh. Akhilesh Singh, SSS (SS Gr.I)

ICAR-CPRI, Gwalior

60. Sh. Ram Babu, SSS(SS Gr. II)

61. Sh. Mohan Lal, SSS(SS Gr. II)
62. Sh. Shiv Singh, SSS(SS Gr. II)
63. Sh. Niranjan Singh, SSS(SS Gr. II)
64. Sh. Kailash, SSS (SS Gr. II)
65. Sh. Ram Singh, SSS(SS Gr.II)
66. Sh. Jagdish, SSS(SS Gr. II)
67. Sh. Shyam Singh, SSS(SS Gr. II)
68. Sh. Parkash Tomar, SSS(SS Gr. II)
69. Sh. Virendra Singh, SSS(SS Gr. II)
70. Sh. Ranbir Singh, SSS(SS Gr. II)
71. Sh. Kallu, SSS(SS Gr. II)
72. Sh. Ashok Kumar, SSS (SS Gr. II)
73. Smt. Vimla Devi, SSS(SS Gr. I)
74. Sh. Jaswant Singh, SSS(SS Gr. I)
75. Sh. Kedar, SSS (SS Gr. I)
76. Sh. Parasu Ram, SSS(SS Gr. I)
77. Sh. Punjab Singh, SSS(SS Gr. I)
78. Sh. Ram Parkash, SSS(SS Gr. I)
79. Sh. Bharat Singh, SSS(SS Gr. I)
80. Sh. Mannu Singh, SSS(SS Gr. I)
81. Sh. Lala Ram, SSS
82. Sh. Kali Charan, SSS
83. Sh. Tilak Singh, SSS
84. Sh. Net Ram, SSS
85. Sh. Mangal, SSS
86. Sh. Jandel Singh, SSS
87. Sh. Bhagirath, SSS
88. Sh. Ramdin, SSS
89. Sh. Sikander Singh, SSS

ICAR-CPRI, Shillong

90. Smt.Theibet Thawmuit, SSS (SS Gr. III)
91. Mrs. Tellinora, SSS (SS Gr. III)

ICAR-CPRI, Muthorai

92. Sh. K. Ramasamy, SSS (SS Gr. I)

SANCTIONED, FILLED & VACANT POSITION OF SCIENTIFIC STAFF OF ICAR-CPRI & ITS REGIONAL STATIONS AS ON 31.03.2020 (EXCLUDING 01 RMP POSITION)

Sl. No.	Discipline	HoD/HoRS			Principal Scientist (DR)			Senior Scientist (DR)			Scientist (including Sr. Sci. & PS promoted Through CAS)			Total		
		S	F	V	S	F	V	S	F	V	S	F	V	S	F	V
1.	Agricultural Biotechnology	-	-	-	-	-	-	1	-	1	3	3	-	4	3	1
2.	Agronomy	-	-	-	-	-	-	1	1	-	4	4	-	5	5	-
3.	Ag. Entomology	-	-	-	-	-	-	2	2	-	5	3	2	7	5	2
4.	Ag. Economics	-	-	-	-	-	-	1	-	1	1	-	1	2	-	2
5.	Ag Metrology	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-
6.	Agricultural Microbiology	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-
7.	Com. Appln.	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-
8.	Ag. Extension	-	-	-	-	-	-	1	-	1	1	1	-	2	1	1
9.	Ag. Engg.(fm&p)	-	-	-	-	-	-	-	-	-	3	3	-	3	3	-
10.	Pl.biochemistry	-	-	-	-	-	-	1	1	-	2	2	-	3	3	-
11.	Food Technology	-	-	-	-	-	-	1	-	1	1	1	-	2	1	1
12.	Veg. Science	-	-	-	-	-	-	1	-	1	14	14	-	15	14	1
13.	Nematology	-	-	-	-	-	-	-	-	-	2	2	-	2	2	-
14.	Genetics & Plant Breeding	-	-	-	-	-	-	2	2	-	8	8	-	10	10	-
15.	Pl. Pathology	-	-	-	-	-	-	2	2	-	7	7	-	9	9	-
16.	Pl. Physiology	-	-	-	-	-	-	1	-	1	5	4	1	6	4	2
17.	Soil Science, Soil Chem./Fert. Micro	-	-	-	-	-	-	1	1	-	2	2	-	3	3	-
18.	Seed Science & Technology	-	-	-	-	-	-	1	1	-	3	3	-	4	4	-
19.	Joint Director, Modipuram	1*	1	-	-	-	-	-	-	-	-	-	-	1	1	-
20.	Head, Seed Technology	1*	1	-	-	-	-	-	-	-	-	-	-	1	1	-
21.	Head, Social Science	1*	1**	-	-	-	-	-	-	-	-	-	-	1	1	-
22.	Head, Crop Production	1*	1**	-	-	-	-	-	-	-	-	-	-	1	1	-
23.	Head, Cpb&pht	1*	1**	-	-	-	-	-	-	-	-	-	-	1	1	-
24.	Head, Plant Protection	1*	-	1	-	-	-	-	-	-	-	-	-	1	-	1
25.	Head, Cprs, Jalandhar	1*	-	1	-	-	-	-	-	-	-	-	-	1	-	1
26.	Head, Cprs, Patna	1*	-	1	-	-	-	-	-	-	-	-	-	1	-	1
	Total	**8**	**5**	**3**	**-**	**-**	**-**	**16**	**10**	**6**	**64**	**60**	**4**	**88**	**75**	**13**

S-Cadre Strength F-In position V-Vacancy
*Independent to discipline.
**Extended tenure for 6 months or till regular Heads joins, whichever is earlier.

New Joining

1. Dr. Anil Sharma, Principal Scientist (Soil Science) joined at ICAR-Central Potato Research Station, Jalandhar on 09.12.2019 (FN).
2. Dr. Anil Kumar Choudhary, Senior Scientist (Agronomy) joined at ICAR-Central Potato Research Institute, Shimla on 17.01.2020 (FN).

Transfers

1. Dr. Raghavendra K.V., Scientist (Agricultural Entomology) ICAR-Central Potato Research Institute, Regional Station, Modipuram relieved to join at ICAR-National Centre for Integrated Pest Management (NCIPM), New Delhi from 26.11.2019 (AN).

Promotions

1. Dr. Prince Kumar, Scientist (RGP Rs.6000/-) ICAR-Central Potato Research Station, Jalandhar promoted to the next higher grade of Scientist (RGP Rs. 7,000/-) under CAS w.e.f. 01.01.2018 vide ICAR office order no. 6-33/2015-AU dated 18.09.2019.
2. Dr. (Mrs.) Tanuja Buckseth, Scientist (RGP Rs.6000/-) ICAR-Central Potato Research Institute, Shimla promoted to the next higher grade of Scientist (RGP Rs. 7,000/-) under CAS w.e.f. 01.01.2018 vide ICAR office order no. 6-33/2015-AU dated 18.09.2019.
3. Dr. Mehi Lal, Scientist (RGP Rs.7000/-) ICAR-Central Potato Research Institute, Regional Station, Modipuram promoted to the next higher grade of Scientist (RGP Rs. 8,000/-) under CAS w.e.f. 10.02.2018 as Senior Scientist vide ICAR office order no. 6-33/2015-AU dated 18.09.2019.
4. Dr. N. Sailo, Scientist (RGP Rs.6000/-) ICAR-Central Potato Research Station, Shillong promoted to the next higher grade of Scientist (RGP Rs. 7,000/-) under CAS w.e.f. 27.04.2015 vide ICAR office order no. 6-33/2015-AU dated 18.09.2019.
5. Dr. (Mrs.) G. Vanishree, Scientist (RGP Rs. 6000/-) ICAR-Central Potato Research Institute, Shimla promoted to the next higher grade of Scientist (RGP Rs. 7,000/-) under CAS w.e.f. 09.05.2016 vide ICAR office order no. 6-33/2015-AU dated 18.09.2019.
6. Dr. Baswaraj Raigond, Scientist (RGP Rs.7000/-) ICAR- Central Potato Research Institute, Shimla promoted to the next higher grade of Scientist (RGP Rs. 8,000/-) under CAS w.e.f. 04.11.2018 as Senior Scientist vide ICAR office order no. 6-33/2015-AU dated 19.12.2019.
7. Sh. Virupakshagouda Patil, Scientist (RGP Rs.7000/-) Central Potato Research Institute, Shimla promoted to the next higher grade of Scientist (RGP Rs. 8,000/-) under CAS w.e.f. 10.02.2019 as Senior Scientist vide ICAR office order no. 6-33/2015-AU dated 19.12.2019.
8. Dr. Arvind Kumar Jaiswal, Scientist (RGP Rs. 6000/-) Central Potato Research Station, Jalandhar promoted to the next higher grade of Scientist (RGP Rs. 7,000/-) under CAS w.e.f. 01.07.2018 vide ICAR office order no. 6-33/2015-AU dated 19.12.2019.

Retirement

1. Dr. (Mrs.) Kamlesh Malik, Principal Scientist, ICAR-Central Potato Research Institute, Regional Station, Modipuram retired from Council's service w.e.f. 31.12.2019 (AN).
2. Dr. SK Chakrabarti, Director, ICAR-CPRI, Shimla, retired from Council's service w.e.f. 31.03.2020(AN).

Functional Group	Hqrs.		Shillong		Jalandhar		Modipuram		Gwalior		Patna		Ooty		Kufri		Total		
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	V
Field Farm Technician (FFT)																			
Cat. I Jr. Tech. Asstt. / Sr. Field Asstt./ Field Asstt.	29	33	5	3	8	7	13	10	4	5	12	9	4	3	8	5	**83**	**75**	**08**
Cat. II Sr. Tech. Asstt. (T-4) Tech. Asstt. (T-3)	9	8	-	-	4	3	13	09	2	2	3	2	-	-	-	1	**31**	**25**	**06**
Cat. III Farm Supdt. T-6	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	**2**	**1**	**1**
Lab. Technician																			
Cat. I Computer (T-2)	2	2	-	-	-	-	1	1	-	-	-	-	-	-	-	-	**3**	**3**	**0**
Projector Operator, T-2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**0**
Cat. II Lab. Tech. (T-4)/ Lab. Tech. (T-3)	3	2	-	-	1	-	1	1	1	1	-	-	-	-	-	-	**6**	**4**	**2**
Cat. III Computer programmer T-6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0**	**1**
Lib. Information / Documentation																			
Cat. II Lib. Asstt. (T-3)	1	1	-	-	1	1	1	-	-	-	-	-	-	-	-	-	**3**	**2**	**1**
Asstt. Librarian (T-5)	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**0**
Document list, T-3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**-**	**1**
Tech. Asstt.(Stat.) (T-3)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**-**	**1**

Functional Group	Hqrs.		Shillong		Jalandhar		Modipuram		Gwalior		Patna		Ooty		Kufri		Total		
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	V
Photography																			
Cat. I Photographer	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**-**	**1**
Press & Editorial Staff Cat. II																			
Hindi Translator, T-3	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	**2**	**2**	**0**
Workshop & Engg. Staff																			
Cat. I Blacksmith-cum-Carpenter	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**-**
Sr. Mechanic (T-2)	-	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-	**2**	**2**	**0**
Fitter (T-1)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**	**-**	**1**
Welder	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**0**
Mechanic cum Electrician	1	1	-	-	2	-	1	1	-	-	-	-	-	-	-	-	**4**	**2**	**2**
Operator Electrical	1	1	-	-	-	1	1	-	-	-	1	1	-	-	-	-	**3**	**2**	**1**
Driver	3	2	2	-	2	-	2	3	2	-	2	1	-	-	-	-	**13**	**6**	**7**
Tractor Driver	1	1	1	-	1	-	4	-	3	2	1	-	1	-	-	-	**12**	**4**	**8**
Cat. II Foreman (T-4)	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	**2**	**1**	**1**
Asstt. Foreman (T-3)	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	**1**	**1**	**0**
Overseer (Civil) T-3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**0**
Cat. III Instrument Engineer, T-7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**1**
Total	**61**	**57**	**08**	**04**	**22**	**13**	**42**	**28**	**13**	**11**	**19**	**12**	**05**	**03**	**08**	**07**	**178**	**135**	**43**

SANCTIONED FILLED AND VACANT POSITION OF TECHNICAL CATEGORY AS ON 31.03.2020

S.No.	Category	Sanctioned	Filled	Vacant
1	Category-I	125	97	28
2	Category-II	49	37	12
3	Category-III	04	01	03
	Total	**178**	**135**	**43**

New Appointments

1. Sh. Vinod Kumar Meena, Tech. Trainee, Joined at CPRS, Gwalior on 30.9.2019

Promotions

1. Sh. Kana Singh, Tech. Officer, CPRI, Shimla promoted to Sr. Tech. Officer from 27.3.2015
2. Sh. Ved Singh, Tech. Officer, CPRIRS, Modipuram promoted to Sr. Tech. Officer from 12.2.2018
3. Sh. Sh. Dinesh Singh, Sr.Tech. Officer, CPRIRS, Modipuram promoted to Asstt. Chief Tech. Officer from 17.2.2018
4. Sh. Surendar Singh, Sr. Tech. Asstt, CPRS, Gwalior promoted to Tech. Officer from 10.1.2007
5. Sh. Naresh Chand, Sr. Tech. Asstt CPRI, Shimla promoted to Tech. Officer from 24.2.2018 (Review case).
6. Sh. Syed Danish Abbas Rezvi, Tech. Asstt. Modipuram promoted to Sr. Tech. Asstt. from 24.01.2019
7. Sh. Chet Ram, Technician, CPRS, Gwalior promoted to Sr. Technician from 13.9.2018
8. Sh. Yogesh Kumar Gupta, Sr. Tech. Officer, CPRS, Jalandhar promoted to Asstt. Chief Tech. Officer w.e.f. 10.4.2016
9. Sh. Dharminder Kumar Gupta, Sr. Tech. Asstt, CPRI, Shimla promoted to Technical Officer w.e.f. 6.6.2016
10. Sh. Sushil Singh, Sr. Tech. Asstt.(Driver), CPRI, Shimla promoted to Technical Officer w.e.f. 19.6.2019
11. Sh. Ravinder Kumar, Tech. Asstt, CPRI, Shimla promoted to Sr. Tech. Asstt. w.e.f. 30.6.2019
12. Sh. Pradeep Kumar Upadhayay, Tech. Asstt, promoted to Sr. Tech. Asstt. w.e.f. 2.8.2014 and Promoted to Tech. Officer w.e.f. 2.8.2019
13. Sh. Pawan Kumar Malik, Sr. Tech. Asstt. CPRIRS, Modipuram promoted to Tech. Officer w.e.f. 24.12.2016
14. Smt. Asha Thakur, Sr. Tech. Asstt. CPRI, Shimla promoted to Tech. Officer w.e.f. 4.6.2016
15. Smt. Jitender Kaur Arora, Tech. Asstt., CPRI, Shimla promoted to Sr. Tech. Asstt. w.e.f. 10.8.2015
16. Sh. Deep Ram, Tech. Asstt, CPRI, Shimla promoted to Sr. Tech. Asstt w.e.f. 23.7.2019
17. Sh. Rakesh Kumar, Tech. Asstt, CPRI, Shimla promoted to Sr. Tech. Asstt. w.e.f. 10.6.2019
18. Sh. Ajit Singh, Tech. Asstt, CPRS, Kufri promoted to Sr. Tech. Asstt. w.e.f. 26.7.2019
19. Sh. Alekh Narain, Sr. Tech. Asstt, CPRS, Patna promoted to Tech. Officer w.e.f. 11.6.2019
20. Sh. Anil Kumar, Sr. Tech. Asstt, CPRS, Patna promoted to Tech. Officer w.e.f. 9.8.2015

Transfers

within Institute and Inter institute transferred

1. Sh. Rohit Verma, Tech. Trainee, CPRI, Shimla transferred to CPRIRS, Modipuram and joined on 27.7.2019
2. Sh. Santosh Kumar, ACTO, CPRIRS, Modipuram transferred to CPRS Kufri and joined on 5.8.2019
3. Sh. Ajay Kumar, Technical Training , CPRS, Patna transferred to CPRIRS, Modipuram and joined on 10.02.2020

4. Dr. Rakesh Mani Sharma, CTO relieved to join as University Librarian at Dr. Rajendra Prasad Central Agricultural University, Pusa-samastipur, Bihar from 31.8.2019.

RETIREMENTS/ RESIGNATION

1. Sh. Mahesh Kumar, CTO, CPRIRS, Modipuram retired on 30.4.2019.
2. Sh. Dhanvantri Meena, Tech. Trainee, CPRS, Gwalior has resigned on 28.6.2019 (AN).
3. Sh. Ranbir Singh, Sr. Technician(T-2), CPRIRS, Modipuram retired on 31.7.2019
4. Sh. Kamal Singh, Sr. Technician (T-2), CPRIRS, Modipuram retired on 31.12.2019
5. Sh. Ram Kumar Verma, CTO, CPRIRS, Modipuram retired on 31.12.2019.
6. Sh. Sanjay Kumar, Tech. Asstt. (T-3), CPRI, Shimla resigned on 11.12.2019
7. Sh. Vijay Kumar Yadav, Sr. Tech. Officer, CPRIRS, Modipuram retired on 29..2.2020

DEATH

1. Sh. Jasvir Singh, ACTO, CPRIRS, Modipuram expired on 16.1.2020.

ADMINISTRATIVE STAFF AS ON 31.03.2020

	Shimla			Shillong			Jalan-dhar			Modi-puram			Gwalior			Patna			Ooty			Kufri			Total		
	S	F	V	S	F	V	S	F	V	S	F	V	S	F	V	S	F	V	S	F	V	S	F	V	Sancti-oned	Filled	Vacant
CAO	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
SF&AO	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
AO	2	1	1	0	0	0	0	0	0	0	1	-1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
AAO	5	6	-1	0	0	0	1	1	0	2	1	1	1	0	1	1	1	0	0	1	-1	0	0	0	10	10	0
AF&AO	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
AD (OL)	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
PS	3	3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0
PA	7	3	4	0	0	0	1	1	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	10	5	5
Asstt.	20	8	12	2	0	2	1	3	-2	3	0	3	1	1	0	1	1	0	1	1	0	1	1	0	30	15	15
UDC	5	14	-9	1	0	1	3	3	0	3	3	0	1	1	0	2	1	1	1	0	1	1	0	1	17	22	-5
LDC	14	4	10	1	0	1	2	1	1	3	2	1	1	0	1	2	1	1	1	0	1	0	0	0	24	8	16
	61	42	19	4	0	4	8	9	-1	12	8	4	5	2	3	7	5	2	3	2	1	2	1	1	102	69	33

APPOINTMENT/NEW JOINING

1. Dr. Pankaj Kumar, Chief Administrative Officer, CPRI, Shimla joined on 26.07.2019 (AN)
2. Sh. Shri Krishan, LDC, CPRS, Gwalior on 31.12.2019
3. Sh. Santosh Kumar, Assistant, CPRS, Gwalior on 29.02.2020

RETIREMENTS

1. Smt. Kanta Rani, Asstt., Engineering Section, CPRI, Shimla – 31.08.2019

TRANSFERS OUTSIDE INSTITUTE

1. Sh. Ratnesh Kumar, Chief Admn. Officer relieved w.e.f. 20.05.2019 to join as Director/Registrar at IARI, New Delhi

2. Sh. Zakir Hussain Khilji, Sr. Finance & Accounts Officer relieved w.e.f. 26.08.2019 to join as CF&AO at ICAR-NAARM, Hyderabad
3. Sh. Jagdish Chand, Asstt., CPRI, Shimla relieved w.e.f. 25.09.2019 to join at ICAR-IISWC(RS), Chandigarh on his own request.
4. Sh. Sandeep Verma, Assistant, CPRI, Shimla relieved w.e.f. 25.11.2019 to join at ICAR-VPKAS, Almora on his own request.

Transfer within Institute

1. Sh. Rajesh Chauhan, LDC, CPRI, Shimla transferred to CPRIRS, Patna and joined on 15.04.2019
2. Smt. Babli Bhawani, AAO, CPRIRS, Kufri transferred to CPRI, Shimla and joined on 01.05.2019
3. Sh. Jagbir Singh, AAO, CPRIRS, Modipuram transferred to CPRIRS, Patna and joined on 01.06.2019

Granted under MACP Scheme

1. Smt. Rita Walia, Asstt., CPRI, Shimla granted 3rd MACP w.e.f. 09.08.2019 in Pay Matrix Level 7.
2. Sh. Amar Chand, Asstt., CPRI, Shimla granted 3rd MACP w.e.f. 19.08.2019 in Pay Matrix Level 7.
3. Sh. Sachin Kanwar, UDC, CPRI, Shimla granted 2nd MACP w.e.f. 16.04.2019 in Pay Matrix Level 5
4. Smt. Nirmala Chauhan, UDC, CPRI, Shimla granted 2nd MACP w.e.f. 16.04.2019 in Pay Matrix Level 5
5. Smt. Poonam Jyoti, UDC, CPRI, Shimla granted 2nd MACP w.e.f. 16.04.2019 in Pay Matrix Level 5
6. Sh. Mohinder Singh, UDC, CPRI, Shimla granted 2nd MACP w.e.f. 16.04.2019 in Pay Matrix Level 5
7. Smt. Sneh Lata, UDC, CPRIRS, Modipuram granted 2nd MACP w.e.f. 05.05.2019 in Pay Matrix Level 5
8. Smt. Sonia Chauhan, UDC, CPRI, Shimla granted 2nd MACP w.e.f. 26.07.2019 in Pay Matrix Level 5
9. Sh. Narender Paul, UDC, CPRI, Shimla granted 2nd MACP w.e.f. 26.07.2019 in Pay Matrix Level 5
10. Sh. Kundan Lal, LDC, CPRI, Shimla granted 2nd MACP w.e.f. 22.04.2019 in Pay Matrix Level 3
11. Sh. Shri Krishan, LDC, CPRIRS, Gwalior granted 2nd MACP w.e.f. 04.07.2018 in Pay Matrix Level 3

Clearance of Probation Period

1. Sh. Deep Ram, Assistant, CPRI, Shimla, probation cleared w.e.f. 17.01.2019
2. Sh. Sanjib Kumar, Assistant, CPRIRS, Patna, probation cleared w.e.f. 27.01.2019
3. Sh. Rakesh, Assistant, CPRIRS, Jalandhar probation cleared w.e.f. 11.09.2019

SANCTIONED/FILLED & VACANT POSITION OF SKILLED SUPPORT STAFF AS ON 31.03.2020

Name	Sanctioned	Filled	Vacant
Shimla	72+3*= 75	20	55
Kufri	12	07	05
Patna	20	06	14
Jalandhar	26	12	14
Modipuram	42	14	28
Shillong	12	02	10
Ooty	08	01	07
Gwalior	12	30	(-)18
Total	**207****	**92**	**115**

**Canteen staff*
*** Sanctioned strength reduced to 105 by Council vide Office Order No. 14-2/2017-E-1(R&P) dated 17.06.2019*

GRANT OF MACP BENEFIT

1. Sh. Subhash Chand, SSS, CPRI, Shimla granted 3rd MACP w.e.f. 12.09.2019 in Pay Matrix Level 4
2. Sh. Babu Ram, SSS, CPRI, Shimla granted 3rd MACP w.e.f. 19.09.2019 in Pay Matrix Level 4
3. Sh. Mansa Ram, SSS, CPRI, Shimla granted 3rd MACP w.e.f. 29.09.2019 in Pay Matrix Level 4
4. Smt. Kajal, SSS, CPRI, Shimla granted 2nd MACP w.e.f. 22.04.2019 in Pay Matrix Level 3
5. Sh. Ashok Kumar, SSS, CPRI, Shimla granted 2nd MACP w.e.f. 22.04.2019 in Pay Matrix Level 3
6. Sh. Narender Kumar, SSS, CPRI, Shimla granted 2nd MACP w.e.f. 22.04.2019 in Pay Matrix Level 3
7. Sh. Padam Chand, SSS, CPRI, Shimla granted 2nd MACP w.e.f. 22.04.2019 in Pay Matrix Level 3
8. Sh. Padam Dev, SSS, CPRI, Shimla granted 2nd MACP w.e.f. 22.04.2019 in Pay Matrix Level 3
9. Sh. Akhilesh Singh, SSS, CPRI(RS), Patna granted 2nd MACP w.e.f. 26.09.2019 in Pay Matrix Level 3
10. Sh. Roshan Lal, SSS, CPRI, Shimla granted 2nd MACP w.e.f. 23.04.2019 in Pay Matrix Level 3
11. Sh. Ramesh Kumar, SSS, CPRI, Shimla granted 3rd MACP w.e.f. 02.11.2019 in Pay Matrix Level 4
12. Sh. Hira Singh, SSS, CPRI, Shimla granted 3rd MACP w.e.f. 02.11.2019 in Pay Matrix Level 4
13. Sh. Saran, SSS, CPRI(RS), Kufri granted 3rd MACP w.e.f. 02.11.2019 in Pay Matrix Level 4
14. Sh. Komal, SSS, CPRI(RS), Jalandhar granted 3rd MACP w.e.f. 08.02.2020 in Pay Matrix Level 4

CLEARANCE OF PROBATION PERIOD

1. Smt. Kiran, Skilled Support Staff, CPRI, Shimla, w.e.f. 18.08.2019

RETIREMENTS

1. Smt. Smt. S. Pankajam, SSS, CPRS, Muthorai – 30.04.2019
2. Sh. Roshan Lal, SSS, CPRI, Shimla – 31.08.2019
3. Smt. N. Angamma, SSS, CPRS, Muthorai – 31.10.2019

DEATH

1. Sh. Krishan Pal, SSS (SS Gr. I), CPRI (RS), Modipuram on 15.06.2019

Institute Budget (2019-20)

Details of Institute Govt. Grant expenditure for the year 2019-20

(Amount in Rupees)

S. No.	Head	Allocation Govt. Grant 2019-20	Allocation Internal Resource + Additional amount	Total Allocation 2019-20	Expenditure (Govt. Grant) 2019-20				Expenditure (Revenue Generation) 2019-20	Total Expenditure 2019-20
1	2	3	4	5 (3 + 4)	6				7	8 (6 + 7)
					NEH	TSP	SCSP	Other than NEH & TSP		
1	**Works**									
	A. Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B. Building									
	i. Office building	2258000.00	0.00	2258000.00	0.00	0.00	0.00	449209.00	0.00	449209.00
	ii. Residential building	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	iii. Minor Works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Equipments	9800000.00	0.00	9800000.00	0.00	0.00	0.00	9786839.00	0.00	9786839.00
3	Information Technology	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Library Books and Journals	1042000.00	0.00	1042000.00	0.00	0.00	0.00	1041083.00	0.00	1041083.00
5	Vehicles & Vessels	700000.00	0.00	700000.00	0.00	0.00	0.00	697123.00	0.00	697123.00
6	Livestock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Furniture & fixtures	200000.00	0.00	200000.00	0.00	0.00	0.00	197810.00	0.00	197810.00
8	Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total-CAPITAL (Grants for creation of Capital Assets)	14000000.00	0.00	14000000.00	0.00	0.00	0.00	12172064.00	0.00	12172064.00

(Amount in Rupees)

S. No.	Head	Allocation Govt. Grant 2019-20	Allocation Internal Resource + Additional amount	Total Allocation 2019-20	Expenditure (Govt. Grant) 2019-20				Expenditure (Revenue Generation) 2019-20	Total Expenditure 2019-20
	2	3	4	5 (3 + 4)	6				7	8 (6 + 7)
					NEH	TSP	SCSP	Other than NEH & TSP		
1	**Establishment Expenses(Salaries)**									
	i. Establishment Charges	404191000.00	0.00	404191000.00	0.00	0.00	0.00	404189803.00	0.00	404189803.00
	ii. Wages	500000.00	0.00	500000.00	0.00	0.00	0.00	499869.00	0.00	499869.00
	iii. Overtime Allowance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total – Establishment Expenses (Grant in Aid - Salaries)	404691000.00	0.00	404691000.00	0.00	0.00	0.00	404689672.00	0.00	404689672.00
1	**Pension & Other Retirement Benefits**	250000000.00	0.00	250000000.00	0.00	0.00	0.00	249999956.00	0.00	249999956.00
2	**T.A.**									
	A. Domestic TA / Transfer TA	6000000.00	0.00	6000000.00	0.00	0.00	0.00	5999987.00	0.00	5999987.00
	B. Foreign TA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total – Traveling Allowance	6000000.00	0.00	6000000.00	0.00	0.00	0.00	5999987.00	0.00	5999987.00
3	**Research & Operatinal Expenses**									
	A. Research Expenses	14317000.00	0.00	14317000.00	0.00	0.00	0.00	14316835.00	0.00	14316835.00
	B. Operational Expenses	10000000.00	0.00	10000000.00	0.00	0.00	0.00	10000077.00	0.00	10000077.00
	Total - Research & Operational Expenses	24317000.00	0.00	24317000.00	0.00	0.00	0.00	24316912.00	0.00	24316912.00
4	**Administrative Expenses**									
	A. Infrastructure	13555000.00	0.00	13555000.00	0.00	0.00	0.00	13555391.00	0.00	13555391.00
	B. Communication	583000.00	0.00	583000.00	0.00	0.00	0.00	582539.00	0.00	582539.00

(Amount in Rupees)

S. No.	Head	Allocation Govt. Grant 2019-20	Allocation Internal Resource + Additional amount	Total Allocation 2019-20	Expenditure (Govt. Grant) 2019-20				Expenditure (Revenue Generation) 2019-20	Total Expenditure 2019-20
	2	3	4	5 (3 + 4)	6				7	8 (6 + 7)
					NEH	TSP	SCSP	Other than NEH & TSP		
	C.Repair & Maintenance									
	i. Equipments,Vehicles & Others	5056000.00	0.00	5056000.00	0.00	0.00	0.00	5056302.00	0.00	5056302.00
	ii. Office building	2287000.00	0.00	2287000.00	0.00	0.00	0.00	2287057.00	0.00	2287057.00
	iii.Residential building	2544000.00	0.00	2544000.00	0.00	0.00	0.00	2543747.00	0.00	2543747.00
	iv. Minor Works	275000.00	0.00	275000.00	0.00	0.00	0.00	275376.00	0.00	275376.00
	D. Others (excluding TA)	12457000.00	0.00	12457000.00	0.00	0.00	0.00	12456567.00	0.00	12456567.00
	Total - Administrative Expenses	36757000.00	0.00	36757000.00	0.00	0.00	0.00	36756979.00	0.00	36756979.00
5.	**Miscellaneous Expenses**									
	A. HRD	408000.00	0.00	408000.00	0.00	0.00	0.00	408060.00	0.00	408060.00
	B. Other Items (Fellowships, Scholarships etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C. Publicity & Exhibitions	18000.00	0.00	18000.00	0.00	0.00	0.00	17754.00	0.00	17754.00
	D. Guest House – Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	E. Other Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total - Miscellaneous Expenses	426000.00	0.00	0.426000.00	0.00	0.00	0.00	425814.00	0.00	425814.00
	Total --Grants in Aid - General	317500000.00	0.00	317500000.00	0.00	0.00	0.00	317499648.00	0.00	317499648.00
	Grand Total (Capital + Establishment+General)	736191000.00	0.00	736191000.00	0.00	0.00	0.00	734361384.00	0.00	734361384.00
	Loans and Advances	0.00	3250000.00	3250000.00	0.00	0.00	0.00		2279900.00	0.00
	Swachh Bharat Mission									2600000

हर कदम, हर डगर
किसानों का हमसफर
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