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PREFACE

It is my pleasure to present to you the Annual Report 2018-19 of ICAR-Central Potato Research Institute (CPRI), Shimla. Though potato came to India > 400 years ago, it contributed < 1% of global production till mid-twentieth century. This scenario changed completely after the establishment of ICAR-CPRI in 1949. High yielding potato varieties and location-specific agricultural practices developed by the institute triggered rapid growth in potato production making India the second largest potato producer contributing ~12% of global production. Contribution of ICAR-CPRI, Shimla in achieving this stupendous success and popularizing potato as a sub-tropical crop is globally acclaimed. In the year 2018-19, the country produced 52.59 million tonnes of potatoes from an area of 2.18 million ha with an average yield of 24.08 t/ha (DACFW). This remarkable growth became possible only because of appropriate technologies developed by ICAR-CPRI, Shimla. The institute keeps a constant vigil on emerging farm economy, agro-climatic situations as well as consumer preference and reorients its research priorities on regular basis. This report presents a glimpse of research and development activities carried out at the institute last year.

The institute has been making continuous efforts to enrich potato germplasm repository and presently it constitutes > 4,500 accessions. Three new potato varieties Kufri Ganga, Kufri Neelkanth and Kufri Lima were notified; and three varieties PS/06-88 (Kufri Manik), SM/00-42 (Kufri Karan) and OS/01-497 (Kufri Sahyadri) for table purpose and one MP/4-578 (Kufri FryoM) for French fry were recommended for release. The nutritionally superior clone MSP/15-60 was selected for further evaluation. SSR markers (STIKA and STU6SNRN) were identified for genetic fidelity testing of potato varieties. Genome sequence analysis of dihaploid potato (C-13) revealed 30,241 genes, 1.12 million SNPs and 48,145 indels. Also, advanced progeny of somatic hybrids (MSH/14-07) was developed and functional genomics for improving nitrogen use efficiency in potato was investigated. Besides, CRISPR cas-mediated genome editing was taken up for development of variety-specific true potato seed and transgenics for late blight and heat/drought stress tolerance were developed. In pathogen diagnostics, developed a loop-mediated isothermal amplification (LAMP) assay for detection of PVA, PVY, PSTVd & dipstick kit for detection of PVY, PVM, PVA and PVS. Forecasting using Indo-Blightcast model resulted in saving of three sprays of fungicides. Bacterial endophytes were found effective against late blight, common scab and bacterial wilt diseases. Aphids, whitefly, leafhoppers and mites were monitored and managed in potato fields. In potato production technologies, a decision support system was developed using QUEFTS model for Punjab. Good Agricultural Practices (GAP) protocols for quality potato production were developed. Prediction using Infocrop model indicated increase in fertilizers rate and irrigation frequency might increase yield over farmers' practice. In post-harvest management, the weight loss was found to be the highest in heaped potatoes and least at 2-4°C storage. A few combinations of volatile oils were found effective for sprout suppression up to 300 days of storage at 12°C. The institute produced 2989.13 metric tonnes of nucleus and breeder seed through conventional and hi-tech (tissue culture-cum-aeroponics) systems. The Institute conducted 528 front line demonstrations (FLDs), 29 national and international trainings, and surveys etc. Several exhibitions, krishi melas, celebration of nationally important events, chat shows, etc. were also organized. Expert scientists from different disciplines of ICAR-CPRI participated in various live phone-in programmes on Doordarshan.

I take this opportunity to congratulate the entire team of scientists and other staffs for carrying out outstanding research and development activities during the year. I extend my special thanks to the Editorial board for making this report crisp, comprehensive and informative, and bringing out the publication in time. I would like to thank the Chairperson and members of RAC for their critical guidance for refining different research activities. I am grateful to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR, for his constant support and guidance. I express my sincere thanks to DDG (Horticultural Science) and ADG (HS-I) for providing necessary direction and suggestion.

SK Chakrabarti
Director

CONTENTS

ICAR-CPRI: AN INTRODUCTION

The Indian Council of Agricultural Research (ICAR)-Central Potato Research Institute (CPRI) 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 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 2200 metres above mean sea level and has a wet temperate climate. It has seven regional stations located across the country *viz.* Modipuram (UP) Kufri Fagu (HP), Jalandhar (Punjab), Gwalior (MP), Patna (Bihar), Shillong (Meghlaya) and Ooty (Tamil Nadu) to cater the need for location specific research and extension activities.

The institute has 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, 142 technical staffs and 74 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-CPRI is a non-profit scientific institution under the ICAR, 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 and one service project on potato seed production. In addition to regular research programmes, a total of 11 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.

STAFF & FINANCE

The institute has 597 sanctioned staff strength comprising of 107 scientific, 178 technical, 102 administrative and 210 supporting staff excluding RMP. The staff position as on 31.03.2019 was 387 including 75 scientific, 142 technical, 74 administrative and 96 supporting staff. In 218-19, total allocation was ₹ 72,42,50,000/- and total expenditure was ₹ 72,42,48,656/-. The institute generated about ₹ 10 crore under Revolving Fund Scheme (RFS) by sale of breeder seed etc. During the year, 7 new scientists joined in the institute, 3 joined as inter-institutional transfer, 1 scientist was promoted from Sr. Scientist to Principal Scientist and 1 was promoted to Scientist (SS). In technical category, 19 were newly joined, 27 were promoted, 2 were transferred, 5 were retired and 2 died. Under administrative category, 7 were joined, 2 were promoted, 1 was retired, 2 were transferred on selection basis, 1 was transferred within institute, 4 were granted financial up-gradation under MACP Scheme and 4 cleared probation period. In skilled supporting staff, 18 got grant of MACP benefit, 12 cleared probation, 1 promoted and 11 retired.

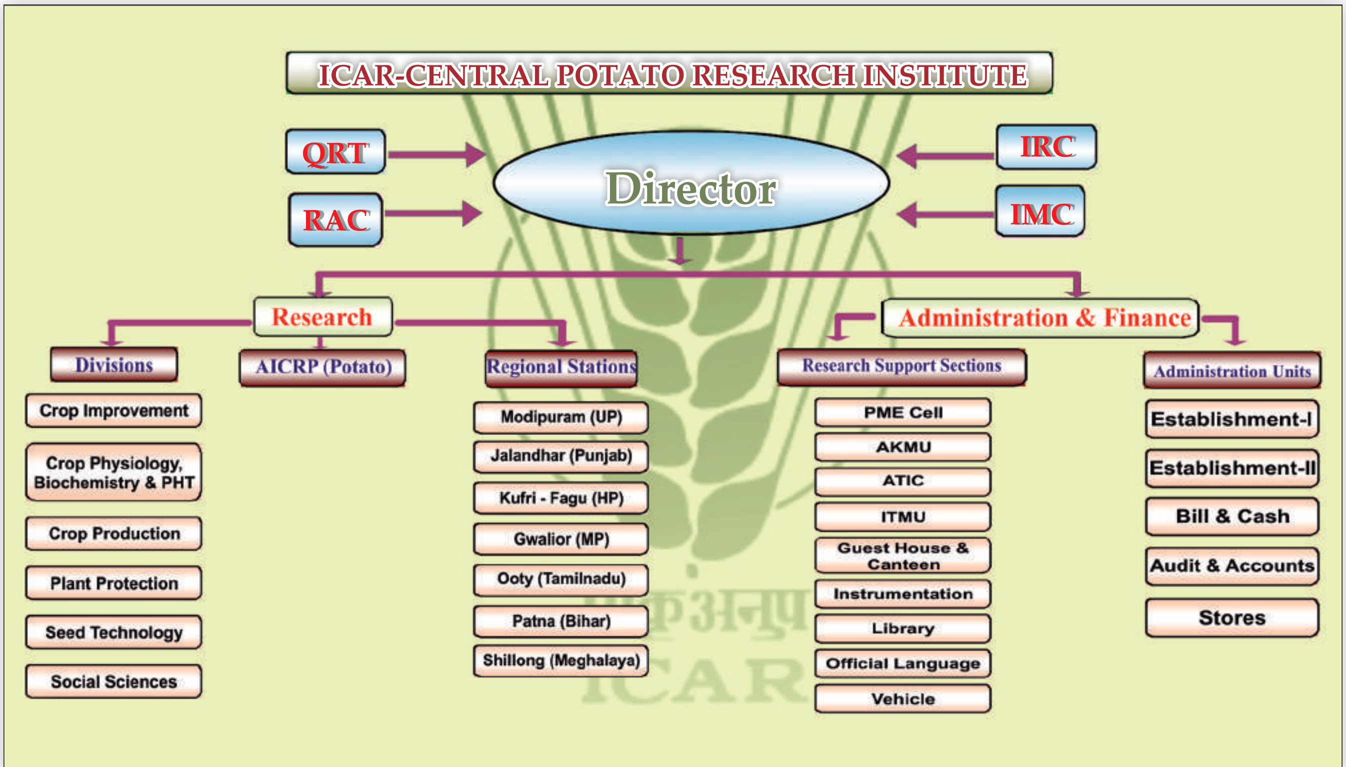
FACILITIES

The institute created state-of-the-art laboratories for conducting basic and strategic research in the field of biotechnology, genetics and plant breeding, plant protection, soil science and agronomy, plant physiology, biochemistry, and post-harvest technology. The 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 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 in ICAR-CPRI, Shimla, CPRI, RS, Modipuram, CPRI, RS, Patna, and CPRI, RS, Shillong for soil less disease free seed potato production. A BPD Unit has been established at CPRI RS, 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, Shilong

EXECUTIVE SUMMARY

DIVISION OF CROP IMPROVEMENT

Management and enhancement of potato germplasm is the basic programme of the division for collection, conservation, evaluation and documentation of germplasm. During the year, 181 accessions were imported from CIP, Lima, 20 from the USA, 19 from the Netherlands, 9 from UK, 7 from Chile, 6 from Canada and 2 from Australia. Presently > 4500 accessions of cultivated and wild species belonging to 30 countries are conserved at the institute in field genebanks, *in vitro* repository and TPS forms. These collections were evaluated for several important biotic and abiotic stresses, keeping quality, processing attributes and adaptability to various thermo-photoperiods, and promising accessions were identified documented and used in breeding.

In Breeding programme, three new potato varieties Kufri Ganga, Kufri Neelkanth and Kufri Lima were notified; and three varieties PS/06-88 (Kufri Manik) SM/00-42 (Kufri Karan) and OS/01-497 (Kufri Sahyadri) for table purpose and MP/4-578 (Kufri FryoM) for French fry were recommended for release. Eight advanced stage hybrids J/11-30, J/11-174, MS/13-391, PS/12-10, PS/13-45 (table); MP/11-30, MP/12-126 (chips), HT/12-751 (heat stress) were identified. Advanced hybrids MS/12-2116, MS/13-527, MCIP/12-185 (table), MP/9-45, MP/9-73 (chips) and WS/07-113 (drought tolerance) were introduced into AICRP for multi-location testing. Standardized optimum NPK requirements (kg/ha) for varieties/advanced hybrids namely MS/8-1148 (240N, 40P, 150K), Kufri Neelkanth (240N, 30P, 120K), and MP/06-39 (240N, 40P, 100K). Plant spacing (60 x 25 cm2) was found optimum for Kufri Ganga and Kufri Mohan. Promising genotypes were identified based on gene-specific markers for late blight and PCN resistance, and other multiple traits (glycol-alkaloids content, canopy temperature as a reliable water deficit stress indicator, tuber yield, processing attributes and nutritional components). The ploidy level of 75 genotypes was analysed and diploids were hybridized with *sli* gene donor for introgressing self-compatibility and 3176 hybrid TPS of 6 crosses were developed.

In Biotechnology programme, genome sequence of androgenic dihaploid potato C-13 was analysed. In which 30241 genes, 1.12 million SNPs and 48145 indels were identified. Genome-wide methylome analysis for tuber shape variation in potato cv. Kufri Bahar showed higher cytosine methylation in variant tuber than the original. Genes and microRNAs were identified in potato under low nitrogen stress. Aeroponics-based precision phenotyping enables identification of NUE efficient genotypes based on key traits and genes involved in improving NUE in potato under low N supply. Two SSR markers (STIKA and STU6SNRN) were developed for identification of Indian potato varieties. Diagnostic SSR markers were identified to distinguish somatic hybrids' progenies and parents, and for nutritionally superior potato. Advanced stage interspecific hybrid MSH/14-07 (48.65 t/ha) for higher yield, and MSH/14-112, MSH/14-113, MSH/14-115 and MSH/14-122 for higher tuber dry matter content (21-24%) were selected. Besides, research on enhancing earliness by CDF1.2 gene, CRISPR cas mediated editing of chlorophyll synthesis gene, in-silico identification of meiosis specific *MiMe* genes, activation tagging, investigating microbial communities in the potato rhizospheric soils, and potato transgenics for thermotolerance, late blight resistance, StSWEET promoter element, and biofortification of with zinc were completed.

DIVISION OF CROP PRODUCTION

In Integrated nutrient and water management program, a decision support system NRPPP (Nutrient Recommendation for Potato Production in Punjab) was developed using QUEFTS Model for Punjab. Field experiments were carried out to validate and calibrate QUEFTS model for NPK recommendation. Experiments were carried for omission plot study, split and foliar application of potassium, boron and molybdenum, optimizing phosphorous dose etc. with the objective of precise nutrient application. Investigation for developing variety specific water and nutrient management schedule under limited water availability and nitrogen requirement of newly released potato varieties under drip irrigation were performed.

Yield gap analysis showed wider total yield gap (TYG) in Meghalaya (17 t/ha) and Bihar (15.2 t/ha). Good Agricultural Practices (GAP) for quality potato production was developed as per control points and their compliances framed by quality council of India. Different potato varieties and biochemical traits viz, phenols, flavoniods, reducing sugars etc. were studied under organic production system. Potato based cropping systems were studied at Gwalior and Ooty. Potato productive, soil health, disease and pest incidence were studied in long term plant nutritional studies. Mechanization program focused on damage assessment during mechanical operations, conveyor for potato loading-unloading, minituber size grading system etc. ICAR-CPRI net house and handheld tool for weeding/ intercultural operations were developed.

Infocrop model was used to study agronomic management practices in Uttar Pradesh showed increasing fertilizers rate and irrigation frequency are likely to increase the yield over farmers' practice. Experiments were carried to understand consequences of water levels and mulching on potato under drip and sprinkler irrigation, identification of climate resilient potato cultivars under elevated CO_2 and temperature and transcriptome analysis. Potential impact of climate change on late blight, arrival and build-up of aphid population were studied under changing climatic parameters along with study of climate analogues. Vulnerability assessment in Uttar Pradesh emphasized on policy interventions and implementation of suitable adaptation strategies.

DIVISION OF PLANT PROTECTION

During 2018-19, late blight was appeared in early November 2018 in Hoshiarpur and again in February 2019 in whole of Punjab. Isolates of *Phytophthora infestans* were observed sensitive to new molecules (cymoxanil, dimethomorph and fenamidone). Developed loop-mediated isothermal amplification (LAMP) assay for detection of PVA, PVY, PSTVd, and determination of viruliferous nature of aphids for detection of PVA and PVY; dipstick kit for detection of PVY, PVM, PVA and PVS using commercial antibodies; validated LAMP assay for detection of *P. infestans* in host tissues; validated PCR protocol for detection of Phytoplasma and identified *Candidatus Phytoplasma ziziphi* and *Ca. Phytoplasma fragaria* associated with potato. Studied whitefly-mediated transmission of ToLCNDV-potato and results revealed that Asia II 5 genotypic group of whitefly could transmit this virus with 100% efficiency and ToLCNDV-potato is a monocyclic or simple interest disease. The Indo-Blightcast model was used to predict the appearance of late blight across the agro-ecologies and it predicted late blight accurately across the country. Application of dimethomorph (0.1%) and fluopicolide 62.5 + propamocarb hydrochlorid 625 SC @ 0.3% was found effective against late blight. Application of phosphorous acid reduced blight severity considerably and reduction was more in susceptible (53.75%) than moderately resistant (41.18%) cultivar. Scheduling fungicide application for management of late blight using Indo-Blightcast resulted in saving of three sprays compared to calendar based strategy. Application of Zn as foliar and soil application resulted in inhibition of ToLCNDV-potato DNA replication. Mixing of nano clay with dsRNA formulation further improved its efficacy against late blight. Bacterial endophytes found effective against late blight, common scab and bacterial wilt were characterized for plant growth promotion activities and some of them exhibited siderophore production, nitrogen fixation and phosphorous solubilisation activities. These endophytes were identified as *Stenotrophomonas*, *Pseudomonas*, *Bacillus*, *Acinetobacter*, *Klebsiella*, *Pantoea*, *Chryseobacterium*, *Janibacter* and *Enterobacter*.

In Entomology programme, aphids, whitefly, leafhoppers and mites were monitored at Modipuram, Jalandhar and Gwalior. At Jalandhar, the arrival of *Myzus persicae* was delayed almost one week as compared to the previous year and *Aphis* spp. remained above the critical level throughout the cropping season; and whitefly, *Bemisia tabaci* remained above economic threshold till the 2nd week of November. At Modipuram, *M. persicae* crossed the critical level in first week of January, whereas whitefly remained high (32/05 plants) on early potato crop (cv. Kufri Pukhraj). At Gwalior, the incidence of whitefly reached its peak in second week of December. Both floating and hoop supported Polyopropylene row covers were effective for insect vector exclusion and thereby in reduction of virus disease incidence. Potassium silicate was able to suppress the adult whitefly up to 62 % at Modipuram and Jalandhar like other insecticides. Nanma @ 1.0% and Imidacloprid 17.8 SL @ 0.04 % could provide sustained reduction up to 9 days after treatment while Aavya @ 0.4% had no appreciable knockdown or residual toxicity against whitefly. Fipronil 0.3G @ 25Kg/ha, and Cartap hydrochloride 4G @ 25 Kg/ha were found as effective as Phorate 10 G @15 Kg/ha as soil incorporated insecticides. Gene prediction revealed 22,021 genes in *Aulacorthum solani*. Cent-percent cyst disintegration was recorded in PCN treatments with NaOCl @ 2.0% after 10 min. Genomic DNA of *G. rostochiensis* female, collected from Ooty (GrO) and Shimla (GrS) indicated that GrO population is close to Australian and European populations while GrS is close to Chinese, Japanese, Italian, Canadian and some European populations. Validation of LAMP assay for the identification of potato cyst nematode *(Globodera species)* from soil samples indicated that target DNA could be detected up to the dilution of 1 pg/µl. Study on the effect of different cropping system on PCN population indicated that minimum reproduction factor was recorded in Dazomet @ 40 g/m^2 treated plots followed by plots planted with Solanum sismbrifolium, after 1st year.

DIVISION OF CROP PHYSIOLOGY, BIOCHEMISTRY AND POST-HARVEST TECHNOLOGY

Post-harvest losses in potatoes were estimated in cvs. Kufri Chipsona-3 and Kufri Pukhraj 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. Chitosan coating (0.1%, 0.25% and 0.5%) before storage was found to reduce weight loss and *Fusarium* infestation in stored potatoes, without affecting processing traits. Study showed that tubers with better peel thickness have better keeping traits. An *in vitro* method for estimation of glycaemic index was developed, which has low cost and better precision. Potato varieties having lower resistant starch contribute a higher rate of starch hydrolysis which ultimately increases glycaemic index. Free glutamate content can be selected as an indicator of potato taste while developing different products. Studies on estimation of ten phenols in flesh and peel of popular potato varieties showed significant varietal differences, which could be associated with nutraceutical properties and disease resistance of varieties. Prebiotic activity of resistant starch showed that it is good for the growth of Lactobacillus paracasei CD4. Metformin was determined from potato flesh, peel and sprout using LC-MS. Concentration of metformin in potato sprout was higher than the concentration reported in peel and flesh, which may be utilized for extraction of metformin to prepare formulations for diabetics. Key genes responsible for the delayed dormancy/sprouting and storage, and carotenoids pathways were identified. To enhance the palatability of microwaved chips (low oil), oil was applied on the surface of potato slices before microwaving. As far the colour, fat content and overall acceptability scores are considered, for development of low fat potato chips, two oil coatings is recommended. Under waste utilization, possibility of synthesizing silver nanoparticles from both peel and potato juice extract was succeeded. Three novel potato products viz. Potato daliya and semolina, potato halwa premix and Lactose free potato burfi were developed and processed for their commercialization.

DIVISION OF SEED TECHNOLOGY

A total production of 29891.35 qtls nucleus and breeder seed was achieved from an area of 148.749 ha. Out of which, 24528.13 qtls production from 123.692 ha was through conventional and 5363.22 qtls from 25.057 ha through hi-tech seed production systems respectively. The percentage of nucleus and breeder seed from conventional system was 82.06 and 17.94 through hi-tech system. During 2017-18, total 20893.36 qtls breeder seed was supplied to various government and private agencies, from plains. During 2018, a total production of 808.64 qtls of seed was achieved from 5.0 ha area in Kufri/Fagu. A total 222 virus-free in vitro culture tubes of basic seed material of 19 varieties were supplied to 19 different seed producing organizations in India and a revenue of ₹ 11,10,000/- has been generated. As per the MoU for breeder seed production, the healthy aeroponic minitubers of varities viz., Kufri Himalini (13000 no.), Kufri Khyati (2500 no.) were supplied to West Bengal State Seed Co-operation Ltd., West Bengal for further multiplication at their farm and a revenue of ₹ 1, 55,000 was generated.

True potato seed (TPS) as a source of plant material for minituber production through aeroponics was evaluated for the first time and 100 tubers/plant was recorded. It could serve the purpose of accelerated breeding. The results revealed that the hardening of microplants by gradually acclimatizing the microplants to the natural climatic conditions can harness the full potential of plants for minituber production under aeroponics.

Cultivars Kufri Himalini and Kufri Girdhari tubers harvested after 90 days of planting had maximum dormancy period of 105 and 180 days respectively whereas in Kufri Swarna tubers harvested after 105 days of planting had maximum dormancy period of 90 days. Cultivar Kufri Girdhari had minimum dormancy when the haulm killing was done 75 days after planting other cultivars it was 120 days after planting. Cultivar, Kufri Girdhari in B5 medium (266 mg) resulted in maximum fresh weight. Cultivar, Kufri Jyoti in B5 medium (10.2%) recorded maximum dry matter content. Post-harvest handling of aeroponic minitubers of variety Kufri Girdhari showed the reduced biomass loss due to shrinkage and better sprout emergence was observed at 24°C/80-100% RH (10 days).

DIVISION OF SOCIAL SCIENCES

A survey was conducted in West Bengal for assessing the cost and income of potato production. Study revealed that on an average, the total cost of potato cultivation (Cost C) was found to be ₹ 1,65,410/- per ha. Overall, the net income was ₹ 44,346.0/- per ha with the B:C ratio of 1:27. The results of Economic Surplus model for measuring the benefits in India revealed that the total cost of R&D of Kufri Pukhraj was Rs. 12.1 crore. The Net Present Value (NPV) of the benefits of Kufri Pukhraj R&D was ₹ 10974.5 crore and 4215.5 crore at 5 and 8 per cent discount rate respectively and the IRR of the net benefit was 43 %. Studies on Seed Replacement Rate (SRR) revealed that the SRR for improved varieties was 100 percent and 91.8 percent in West Bengal and Uttar Pradesh, respectively and the SRR for certified seeds was 40.3 and 30.0 in West Bengal and Uttar Pradesh, respectively.

The study on varietal adoption patterns showed that Kufri Jyoti (52%) was the most popular variety in West Bengal, which was followed by Kufri Chandramukhi (18%) and Kufri Pukhraj (16.2%). In Gujarat, the most popular varieties were Lady Rosetta (40.5%) and Kufri Pukhraj (33.3%). A study conducted to investigate consumers' preferences for potatoes revealed that in Bihar, the ranks of attributes in order of importance were: skin color > tuber size > shape > skin smoothness > taste > cooking time > shelf life> flesh color = texture >eye's depth >aroma. In Punjab, the ranks of attributes were: tuber size > cooking time=taste shape > aroma > skin color > shelf life > skin smoothness > texture > flesh color >eye's depth. A survey in West Bengal revealed that overall; about 31 percent of potato seeds were farm saved seeds and seeds obtained from friends or other farmers and about 27.3 percent of the seed were obtained from local markets/ seed traders. For popularization of technologies developed by the institute, 528 FLDs (425 in Bihar, 35 in UP, 30 in Meghalaya, 20 in Himachal Pradesh, 10 in Madhya Pradesh and 8 in Punjab) were laid out. The institute also conducted 29 national and international training programmes at the headquarter and also at regional stations. Many exhibitions, fairs, celebration of important days, chat shows, etc were also organized by the Division. Expert scientists from different discipline of ICAR-CPRI, Shimla participated in 8 live phone-in programmes on Doordarshan Shimla. Under HRD Cell, 20 scientists, 21 technical officers, 8 administrative officers and 30 skilled supporting staffs were sent to participate in various training programmes.

RESEARCH PROGRAMMES

Institute Research Programmes, PIs and Co-PIs

Sl. No.	Programmes Name (Code No.)	PIs and Co-PIs
1.	Management and enhancement of potato germplasm HORTCPRICIL201500100129	**PI: Dr. Vinod Kumar. Co-PIs:** Drs. Vinay Bhardwaj, Ashwani Kumar Sharma, Jagesh Kumar Tiwari, Dalamu, G Vanishree, Tanuja Buckseth, Raj Kumar, Ratna Preeti Kaur, SK Luthra, Shambhu Kumar, Ashiv Mehta, Name Singh, Bandana, S Roy, 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
2.	Breeding to evolve trait specific varieties for productivity, quality and resistance to biotic and abiotic stresses HORTCPRICIL201500200130	**PI: Dr. SK Luthra. Co-PIs:** Drs. VK Gupta, Raj Kumar, Ashwani Kumar Sharma, RP Kaur, Shambhu Kumar, Mehi Lal, Sanjay Rawal, Vinay Bhardwarj, Bandana, Ashiv Mehta, 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, Susheel 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 Kumar Tiwari, Nishant chourasia
3.	Genetic enhancement of potato through molecular and genomic tools. HORTCPRICIL201500300131	**PI: Dr. Jagesh Kumar Tiwari. Co-PIs:** Drs. VK Dua, Som Dutt, VU Patil, S Sundaresha, Vinay Bhardwaj, Hemant Kardile, Brajesh Singh, Shashi Rawat, Ashiv Mehta, 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
4.	Impact, adaptation and management strategies for climate resilient potato production. HORTCPRICIL201500300139	**PI: Dr. VK Dua. Co-PIs:** Drs. Devendra Kumar, Jagdev Sharma Shashi Rawat, Sanjay Rawal, SP Singh, Sanjeev Sharma, Mehi Lal, Kamlesh Malik, Anuj Bhatnagar, VK Gupta, Vinay Sagar, Som Dutt, 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 Kharumnuid, Preeti Singh
5.	Integrated nutrient and water management for improved productivity of potato HORTCPRICIL500500133	**PI: Dr. Manoj Kumar, Co-PIs:** 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

Sl. No.	Programmes Name (Code No.)	PIs and Co-PIs
6.	Biology, epidemiology, modeling and management of insect pests, vectors and cyst nematodes of potato. HORTCPRICIL201500600134	**PI: Dr. (Mrs.) Kamlesh Malik, Co-PIs:** Drs. Anuj Bhatnagar, Aarti Bairwa, Baswaraj Raigond, Ravinder Kumar, S Sundaresha, Jagesh Kumar 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
7.	Re-defining epidemiological parameters and management approaches for potato pathogens. HORTCPRICIL201500800135	**PI: Dr. Sanjeev Sharma. Co-PIs:** Drs. Vinay Sagar, Baswaraj R, S. Sundaresha, Ravinder Kumar, S Roy, 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
8.	Post harvest management and nutritional enhancement of potatoes. HORTCPRICIL201500800136	**PI: Dr. Brajesh Singh. Co-PIs:** Drs. Ashiv Mehta, Jagdev Sharma, SK Luthra, Vinay Bhardwaj, Vinay Sagar, Som Dutt, Pinky Raigond, Baswaraj Raigond, Bandana, S Sundares ha, 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
9.	Resource optimization in potato based cropping system. HORTCPRICIL201500900137	**PI: Dr. Sanjay Rawal. Co-PIs:** 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
10.	Assessment of potato technologies and its transfer to stakeholders for improving potato production HORTCPRICIL201501000138	**PI: Dr. NK Pandey. Co-PIs:** Drs. RK Singh, Pynbiangland Kharumnuid, Ashok Chauhan
11.	Production of nucleus and breeder seed of important notified varieties of potato. HORTCPRICIL201501100132	**PI: Dr. RK Singh. Co-PIs:** Drs. Devendra Kumar, Tanuja Buckseth, Ashwani Kumar, Vinay Singh, Dhruv Kumar, Prince, Ratna Preeti Kaur, S Roy, 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

DIVISION OF CROP IMPROVEMENT

PROGRAMME: MANAGEMENT AND ENHANCEMENT OF POTATO GERMPLASM

Genetic resources of a crop are the basic raw material required for its genetic improvement. ICAR-CPRI, Shimla is designated as the National Active Germplasm Repository for potato and it maintains potato germplasm. The main activities are to import, conserve and evaluate potato germplasm for important biotic and abiotic stresses and document the information for research use.

Collection

A total of 181 accessions were imported from CIP, Lima, 20 from the USA, 19 from the Netherlands, 9 from UK, 7 from Chile, 6 from Canada and 2 from Australia. Presently more than 4500 accessions of cultivated and wild potato species, obtained from 30 countries, are conserved at the institute (Table 1).

Conservation

Field conservation: A total of 1522 Tuberosum accessions, 741 Andigena accessions and 66 indigenous potatoes were maintained in fields at Jalandhar. Nearly 1325 Tuberosum accessions and 90 indigenous samples were maintained in fields at Kufri. Besides, pollen of four potato varieties namely Kufri Anand, Kufri Ashoka, Kufri Jawahar and Kufri Sutlej were cryo-preserved in liquid nitrogen for future use. Ten dihaploids of Indian commercial varieties were maintained in glasshouses at Shimla. In wild species, 360 clones of 123 accessions representing 42 *Solanum* species were multiplied for maintenance breeding whereas, 294 accessions of 70 species were maintained in TPS form. In total, 486 accessions (both in tuber and TPS forms) of 125 species were conserved at ICAR-CPRI, Shimla.

***In vitro* conservation:** Nearly 2700 Tuberosum accessions were maintained in *in vitro* form. Minitubers of 207 accessions from *in vitro* repository were produced and added to the germplasm collection maintained under field conditions at Kufri. Mericlones of different hybrids and varieties were developed and tested for their freedom from all viruses. During this year, 3 advanced hybrids /varieties namely Kufri Karan (SM/00-42), Kufri Manik (PS/06-88) and Kurfi FriyoM (MP/04-578) were found free from all viruses.

Table 1: Potato germplasm holding at ICAR-CPRI, Shimla

Material	No. of accessions				No. of donor countries
	Tuber	*In vitro*	True potato 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	-	2840	30
b) Andigena	723	77	-	762	5
c) Wild/semi-cultivated spp.	123 (12 speices)	130 (29 species)	294 (70 species)	540 (125 species)	5
Total germplasm				**4502**	

Evaluation

A large number of accessions were evaluated for various biotic and abiotic stresses and also for adaptability and physcio-biochemical traits; and promising accessions are listed in Table 2.

Wild Potato Species

SSR profiling of wild potato species: SSR profiling of 22 wild species depicted in (Fig. 1) was performed using SSR markers and allelic profile is shown here (Fig. 2).

Table 2: Evaluation of potato germplasm

Character	Location	No. of accessions evaluated	Promising accessions
Adaptability	Kufri	140	CP Nos. 3974, 4000, 4042, 4107, 4174, 4191 and 4221
	Jalandhar (Spring)	100	CP Nos. 4393 and 4405
	Modipuram (Autumn: early) (Autumn: main)	145	CP Nos. 4423, 4492, 4503, 4504, MCIP/12-185, MS/10-1529, MS/14-243, MS/9-723 and MSH/14-129
		105	CP Nos. 4492, 4501, 4504, 4512, 4518, JW96 and Kufri Sadabahar
PSTVd	Shimla	100	32 accessions (infected)
Leaf hopper and Mites	Modipuram	145	CP Nos. 4404, 4423, 4492, 4499, 4502, 4504, 4512, 4516, MCIP/12-185, MCIP/14-202, MS/10-1529 MS/13-527, MS/14-243, MSP/15-44, Phuwla White and Red Flesh (< 15% infection)
Cyst nematodes	Ooty	51	CP Nos. 1137, 1330, 1533, 4350, 4388, 4502 and 4510
Keeping quality	Jalandhar	99	Best keeper: CP No. 4441 Good keeper: CP Nos. 1442, 1476, 1490, 1546, 1555, 2017, 3242, 3448, 4446, 4452, 4455, 4458, 4459, 4469 and 4472
Chipping	Jalandhar	99	CP Nos. 1963 and 4447
Vitamin C	Modipuram	72	CP Nos. 2179, 2062, 2124, 2101, 2181, 2143, 2282, 2191 and 2178 (> 32 mg/100 g fr.wt.)
Zinc	Shimla	74	Memphis, NJ130, Bhura Alu, Desi No.1 and JG-1 (> 25 ppm)
Iron	Shimla	74	Sagita, Lal Jyoti, JG-2, Dehati Aloo and JG-22 (> 37 ppm)
Protein content	Shimla	100	CP Nos. 3203, 1690, 1871, 3245 and JEX/A 763 (> 1.0% soluble protein)
Water use efficiency	Modipuram	26	CP Nos. 2148, 3359, 3464 and 3599 (equal yield with control cv. Kufri Bahar)
Foliage maturity (early)	Patna	380	CP Nos.1450, 1470, 1566, 1702, 1727, 1778, 1876, 1878, 1881, 1890, 1907, 1916, 1930, 1940, 1985, 1997, 1998, 2002, 2006, 2370, 2419, 2423, 3179, 3265, 3269, 3360, 3774 and 4242

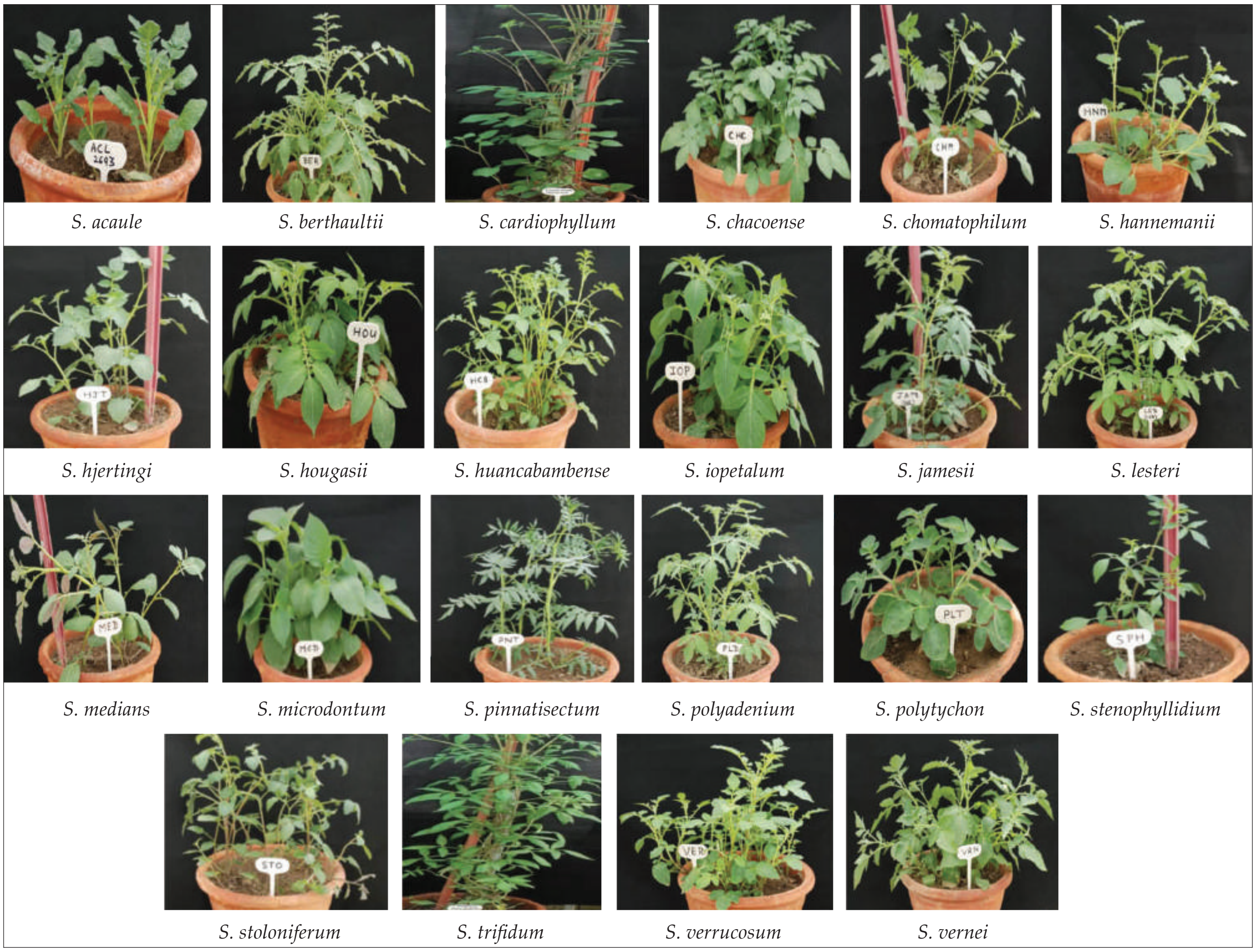


Fig. 1: Twenty-two wild *Solanum* species of potato used in SSR study and late blight testing.

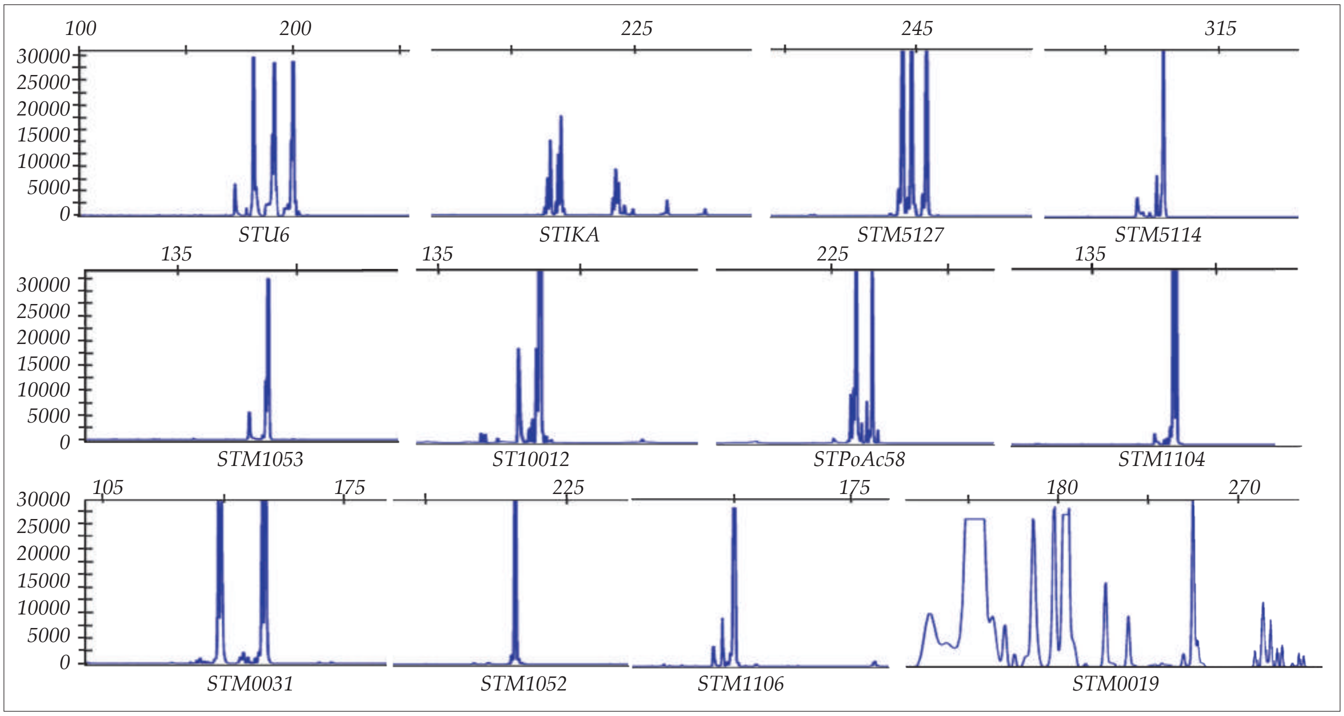


Fig. 2: SSR allelic profile of selected wild species *Solanum berthaultii* (PI 498096)

Screening for late blight resistance: In order to diversify the resistance source in potato breeding programmes, 63 accessions of 18 species were evaluated for late blight resistance under natural disease condition at Kufri. Five accessions (2837-0, 2895-01, 3125-0, 3125-02 and 3125-03) showed immune reaction (0 AUDPC), seven accessions showed below 100 AUDPC and 20 accessions were in between 100-500 AUDPC. Rest of the accessions observed >500 AUDPC. In another lot, 82 accessions of 22 species were screened earlier for late blight resistance in controlled chamber, in which most accessions were highly resistant (60) followed by resistant (5), moderately resistant (13) and susceptible (5). Highly resistant species have been listed in Table 3.

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.

Table 3: Screening of wild potato species for foliage resistance to late blight by whole plant assay method

Wild species	No. of accessions	Accessions (Highly resistant)
S. berthaultii	3	BER25, BER57 and BER96
S. cardiophyllum	5	CPH25, CPH26, CPH62, CPH63 and CPH87
S. hougasii	1	HOU27
S. huancabambense	2	HCB06 and HCB19
S. iopetalum	1	IOP59
S. jamesii	4	JAM07, JAM49, JAM77 and JAM89
S. lesteri	4	LES29, LES34, LES37 and LES88
S. microdontum	2	MCD24 and MCD85
S. pinnatisectum	8	PNT11, PNT12, PNT31, PNT40, PNT41, PNT42, PNT43 and PNT44
S. polyadenium	15	PLD13, PLD14, PLD37, PLD38, PLD42, PLD43, PLD45, PLD46, PLD47, PLD48, PLD49, PLD63, PLD80, PLDCIP14 and PLDCIP24
S. polytrichon	2	PLT18, PLT62
S. stoloniferum	2	STO40 and STO61
S. trifidum	7	TRF22, TRF35, TRF37, TRF39, TRF41, TRF42 and TRF64
S. verrucosum	4	VER55, VER58, VER59 and VER60

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

Research activity 1: Breeding for table potato varieties

Hybridization and selection: In all 548851 true potato seeds (TPS) of 207 crosses were generated at Modipuram, Jalandhar and Patna stations. A total of 99636 seedlings were raised from 239177 TPS (226 crosses) and 7908 clones were selected. In initial clonal stages (F_1C_1, F_1C_2 and F_1C_3), 13542 clones were evaluated at 60/75/90 days and 2130 promising clones were selected for further trials.

Advanced stage trials: In all, 127 advanced stage hybrids were evaluated in 16 yield trials at 60/75/90 days at Jalandhar, Modipuram and Patna, and 40 promising hybrids were selected. In nine preliminary yield trials, 25 promising hybrids namely J/13-60, J/13-72, J/13-85, J/13-97, J/13-100, J/13-123, J/13-135, J/13-173, J/13-175, J/13-195, J/13-200 (Jalandhar), MS/15-758, MS/15-1001, MS/15-1422, MS/14-1495, MS/14-1505, MP/12-543-white, MS/13-527, MS/14-505, MS/14-1381-red (Modipuram) and PS/14-10, PS/14-19 & PS/14-33-red, PS/14-09, PS/14-32-white (Patna) were selected from 87 hybrids. In four confirmatory yield trials, 10 promising hybrids namely J/12-1, J/12-10, J/12-31, J/12-54, J/12-60, J/12-120, J/12-146 (Jalandhar), MS/14-243 (Modipuram), PS/13-45 red and PS/13-34 white (Patna) were selected from 24 hybrids. In three final yield trials, five advanced hybrids namely J/11-30, J/11-174 Jalandhar), MS/13-391 (Modipuram), PS/12-04 and PS/12-10 (Patna) were selected from 16 hybrids.

Identified promising advanced stage hybrids: Based on consistent good performance over the years, six hybrids namely J/11-30, J/11-174, MS/13-391, PS/12-04, PS/12-10 and PS/13-45 were identified (Fig. 1).

J/11-30 (Kufri Frysona × MS/94-1118): The hybrid with tuber yield of 25 and 36 t/ha gave 7% and 9% higher total tuber yield over control Kufri Khyati (23 and 33 t/ha) at 60 and 75 days harvests, respectively (Table 1). It produces white oblong tubers with shallow eyes and cream flesh colour with tuber dry matter of 18%.

J/11-174 (CP3170 × CP3770): The hybrid with tuber yield of 27 and 39 t/ha gave 23% and 24% higher total tuber yield over control Kufri Khyati (21 and 31 t/ha) at 60 and 75 days harvests, respectively (Table 1). It produces white ovoid tubers with shallow eye and white-cream glesh colour with tuber dry matter of 15%.

MS/13-391 (Kufri Gaurav × 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) (Table 2). 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 to late blight as compared to Kufri Bahar.

PS/12-10 (JEX/A-98-103 × CP2340): The hybrid with total tuber yield of 31 and 35 t/ha showed advantage of 8% and 9% at 75 and 90 days over Kufri Pukhraj (29 and 32 t/ha). The hybrid (Table 3) produces white round tubers with medium eyes and light yellow flesh having 19% tuber dry matter, good keeping quality and moderate level of resistance to late blight.

PS/13-45 (CP2366 x CP2340): The hybrid with tuber yield of 27 and 34 t/ha showed advantage of 6% and 7% at 75 and 90 days over Kufri Lalit (25 and 31 t/ha). The hybrid (Table 3) produces red round tubers with medium eyes and yellow flesh with red ring in cortex having 19% tuber dry matter, good keeping quality and moderate level of resistance to late blight.

J/11-30 *J/11-174* *MS/13-391* *PS/12-10* *PS/13-45*

Fig. 1: Advanced stage potato hybrids identified at Jalandhar, Modipuram and Patna

Table 1: Promising advanced stage hybrid identified at Jalandhar

Genotypes	Total tuber yield (t/ha)							
	2016-17		2017-2018		2018-2019		Average	
	60 days	75 days	60 days	75 days	60 days	75 days	60 days	75 days
J/11-30	31.10	39.30	18.50	34.60	26.10	33.80	25.20	35.90
Kufri Pukhraj	28.10	36.30	13.90	23.60	24.90	35.80	22.30	31.90
Kufri Khyati	28.80	37.30	14.30	24.10	26.10	37.00	23.10	32.80
CD (0.05)	1.60	2.60	0.90	1.70	2.90	2.70		
J/11-174	30.20	41.80	18.40	33.30	30.90	42.90	26.50	39.30
Kufri Pukhraj	24.90	32.50	13.90	23.60	24.90	35.80	21.20	30.60
Kufri Khyati	24.40	33.20	14.30	24.10	26.10	37.00	21.60	31.40
CD (0.05)	2.40	2..6	0.90	1.70	2.90	2.70		

Table 2: Promising advanced stage hybrid identified at Modipuram

Genotypes	Total tuber yield (t/ha)							
	2016-17		2017-2018		2018-2019		Average	
	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days
MS/13-391	37.24	46.67	41.99	50.25	34.86	49.79	38.03	48.90
Kufri Bahar	28.6	35.96	37.92	45.4	32.99	44.4	33.17	41.92
Kufri Pukhraj	38.6	43.75	43.79	47.65	36.12	50.14	39.50	47.18
C.D. 5%	1.7	1.74	2.19	1.84	1.56	1.69		

Table 3: Promising advanced stage hybrid identified at Patna

Genotypes	Total tuber yield (t/ha)							
	2016-17		2017-2018		2018-2019		Average	
	75 days	90 days	75 days	90 days	75 days	90 days	75 days	90 days
PS/12-10	29.89	35.12	30.87	35.82	31.50	34.84	30.75	35.26
Kufri Ashoka	22.13	--	25.08	28.39	26.46	28.99	24.56	28.69
Kufri Pukhraj	28.37	34.84	28.21	31.86	29.09	30.58	28.56	32.43
PS/13-45	26.35	--	25.21	33.96	29.49	34.04	27.02	34.00
Kufri Lalit	24.56	29.08	23.38	32.34	28.50	32.27	25.48	31.23
Kufri Lalima	20.12	24.53	21.87	27.91	27.20	29.88	23.06	27.44
CD (0.05)	2.07	2.05	4.36	4.07	2.61	2.86		

MS/12-2116 *MS/13-527* *MCIP/12-185*

Fig. 2: Advanced stage hybrids introduced in AICRP for multi-location testing

Advanced hybrids introduced in AICRP

Introduced advanced stage hybrids MS/12-2116, MS/13-527 and MCIP/12-185 (Fig. 2) in AICRP for multi-location testing.

MS/12-2116 (Kufri Surya × CP2340): The hybrid with total tuber yield of 38 t/ha (75 days) and 47 t/ha (90 days) showed superiority of 12% and 25% over Kufri Bahar (37 and 38 t/ha). The hybrid produces attractive white-cream, ovoid tubers with shallow eyes and cream flesh. The hybrid possesses 19% tuber dry matter at 90 days and very good keeping quality.

MS/13-527 (MP/5-816 × Kufri Gaurav): The hybrid with total tuber yield of 30 t/ha (75 days) and 39 t/ha (90 days) showed superiority of 5% over Kufri Lalima and Kufri Sindhuri (37 t/ha at 90 days). The hybrid produces attractive dark red, round-ovoid tubers with medium eyes and cream flesh. The hybrid possesses 18% tuber dry matter at 90 days, very good keeping quality and high resistance to late blight as compared to Kufri Bahar.

MCIP/12-185 (CP4047 × Kufri Pukhraj): The hybrid with total tuber yield of 37 t/ha (75 days) and 49 t/ha (90 days) showed superiority of 4% and 18% over Kufri Bahar (35 and 42 t/ha). The hybrid produces attractive white-cream, ovoid tubers with shallow eyes and cream flesh. The hybrid possesses 18% tuber dry matter at 90 days and very good keeping quality. MCIP12-185 showed resistance to late blight under field and through detached leaf test.

Recommendation of new variety: Medium maturing advanced stage hybrid PS/06-88 (Fig. 3) was recommended for release in 36th group meeting of ACIRP (Potato) held during 08-11 September, 2018 at SDAU, Sardar krushinagar, Gujarat for eastern plains. It produces red round tubers with medium deep eyes and yellow flesh. PS/06-88 produces nearly 25-30 t/ha tuber yield and possess good keeping quality, nearly 19% tuber dry matter and is moderately resistant to late blight.

Notification of new potato varieties: New improved potato varieties namely Kufri Ganga, Kufri Neelkanth and Kufri Lima (Fig.4) were notified by Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops, New Delhi vide No.3-69/2018-SD'IV Dated: 20th December, 2018 for cultivation in north Indian plains.

Fig. 3: Tubers of PS/06-88

Optimizing agro-techniques for Kufri Neelkanth: The variety responded up to 240 kg nitrogen (29.5 & 31.4 t/ha), 30 kg phosphorous (27.8 & 31.5 t/ha) and 120 kg potassium (26.8 & 30.2 t/ha) per hectare for marketable and total tuber yield, respectively. The spacing of 60 x 25 cm was optimum for higher marketable (37.2 t/ha) and net marketable yield (33.8 t/ha) with 20% less seed (3.33 t/ha) as compared to conventional spacing of 60 x 20 cm, which had 36.3 and 32.1 t/ha of marketable and net tuber yield, respectively, where 4.17 t/ha of seed tubers of 50 g mean tuber weight was used.

Optimizing agro-technology for Kufri Ganga: The two year (2017-18 and 2018-19) results at 90 days crop duration revealed that spacing of 60 x 25 cm was optimum for higher marketable (42.9 t/ha) and net marketable yield (39.6 t/ha) with 20% less seed (3.33 t/ha) in comparison to conventional spacing of 60 x 20 cm, which recorded 42.1 and 37.9 t/ha of marketable and net tuber yield, respectively.

Kufri Ganga *Kufri Neelkanth* *Kufri Lima*

Fig. 4: Tubers of new potato varieties

Optimizing agro-techniques for advanced stage hybrid MS/8-1148: The results of 90 days crop duration, indicated response of hybrid up to 240 kg nitrogen (37.4 & 43.2 t/ha), 40 kg phosphorous (38.8 & 43.0 t/ha) and 150 kg potassium (37.4 & 43.2 t/ha) per hectare for marketable and total tuber yield, respectively. Tuber dry matter content varied between 15-18 and dose of 240 N- 40 P_2O_5-150 K_2O kg/ha recorded 17% tuber dry matter.

Evaluation for late blight resistance at Modipuram: Among advanced hybrids, the minimum AUDPC was recorded in CP4510 (40) followed by MP/14-730 (48), MSH/14-122 (83), MCIP/14-202 (85), MP/12-118 (138), MS/13-527 (157), MSH/14-113 (170), MP/14-707 (295), MCIP/13-64 (385), MSH/14-112 (389), MS/15-1001 (445) and MS/15-1572 (472) as compared to Kufri Bahar (943). Among the hybrids, lowest rAUDPC was recorded in MSH/14-122 (0.055) and highest was in MS/14-1063 (0.590) as against Kufri Bahar (0.628). Under laboratory condition, by detach leaf method, one hybrid MCIP/14-202 was found resistant (R) and 14 advanced stage hybrids namely CP4510, MCIP/13-64, MCIP/14-211, MP/12-118, MP/14-707, MP/14-730, MP/14-854, MS/13-527, MS/14-505, MSH/14-7, MSH/14-112, MSH/14-113, MSH/14-122 and MSH/14-123 were found moderately resistant and remaining 40 were susceptible.

Research activity 2: Breeding for processing varieties

Hybridization and selection: In total, 101392 TPS of 73 crosses were produced at Kufri/Modipuram. A total of 101392 TPS of 73 crosses were raised, 22036 seedlings were transplanted and 1092 clones were selected. A total of 927 clones of F_1C_1, 152 clones in F_1C_2 and 22 clones in F_1C_3 generation were evaluated and 237, 56 and 8 clones respectively were selected based on tuber characters and chip colour.

Advanced stage trials at Modipuram: In F_1C_4 stage, 7 genotypes namely MP/14-169, MP/14-171, MP/14-332, MP/14-427, MP/14-632, MP/14-1003 and MP/14-1029 were selected from 11 hybrids. In F_1C_5 and F_1C_6 stage, 14 hybrids along with 6 control varieties were evaluated at 75, 90 and 110 days in two trials and on the basis of total tuber yield, processing grade yield, chip colour and dry matter, 10 genotypes namely MP/11-30, MP/11-126, MP/11-112, MP/12-105, MP/12-223 MP/13-602, MP/13-662, MP/13-669, MP/13-1040 and MP/13-1045 were selected for chips/French fries.

Advanced stage trials at Burdwan (West Bengal): Among the 10 hybrids evaluated along with 4 control varieties at 95 days, MP/11-30 (59 t/ha), MP/9-73 (55 t/ha) and MP/9-45 (53 t/ha) were found superior on the basis of quality and tuber yield for chips than their respective controls.

Identification of advanced hybrid for AICRP

MP/11-30 (Kufri Chipsona-3xHT/97-727): Based on last three years performance, MP/11-30 produced 42% higher processing (37 t/ha) and 20% higher total tuber yield (42 t/ha) than Kufri Frysona (26 and 35 t/ha). MP/11-30 produces attractive white-cream, ovoid-oblong tubers with shallow medium eyes and white-cream flesh. The hybrids possess 20% tuber dry matter and acceptable fry colour score (4.0).

MP/12-126 (CP 4047 x MP/99-322): Based on last three years performance, MP/12-126 produced 9% higher mean processing (37 t/ha) and 5% higher total tuber yield (41 t/ha) than control Kufri Chipsona-3 (34 t/ha and 39 t/ha). MP/12-126 produces attractive white-cream, ovoid-oblong tubers with shallow medium eyes and white-cream flesh. The hybrids possess 20% tuber dry matter and acceptable chip colour score (3.6).

Advanced stage hybrid introduced into AICRP

MP/9-45 (Kufri Himsona x CP 1371): Based on last three years performance, MP/9-45 (Fig. 5) for chips has been introduced into AICRP for multi-location trials. It produced 8 % higher mean processing (30 t/ha) and 9 % higher total (36 t/ha) tuber yields than Atlantic (28 and 32 t/ha). It produces attractive white cream, ovoid tubers with shallow medium eyes & white cream flesh. The hybrids possess 21% dry matter and acceptable chip colour score (3.3).

MP/9-73 (MP/97-921 x HT/97-727): Based on last three years performance, MP/9-73 (Fig. 6) for chips has been introduced into AICRP for multi-location trials. MP/9-73 produced 13% higher mean processing (30 t/ha) and 4 % higher total (36 t/ha) tuber yields than Kufri Chipsona-1 (25 and 33 t/ha). MP/9-73 is earlier in foliage senescence (70%) than Kufri Chipsona-3 (60%) and Kufri Chipsona-4 (65%).

It produces attractive white cream, ovoid tubers with shallow medium eyes & white cream flesh. The hybrids possess 22% tuber dry matter and superior or at par chip colour score (3.5) than Atlantic, Kufri Chipsona-3 and Kufri Chipsona-4.

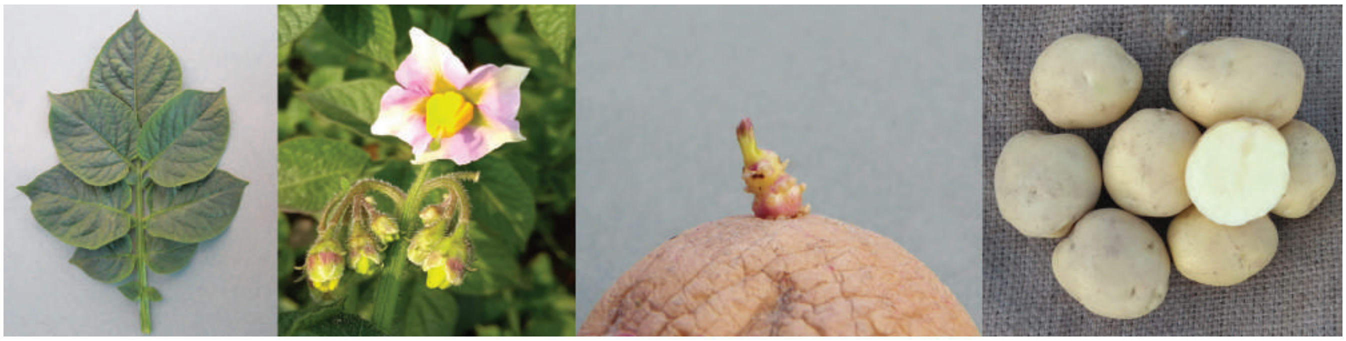


Fig. 5: Leaf, flower, sprouts and tubers of MP/9-45

Fig. 6: Leaf, flower, sprouts and tubers of MP/9-73

Recommendation of new varieties: Medium maturing French fry advanced stage hybrid MP/4-578 (Fig. 7) was recommended for release in 36th group meeting of ACIRP (Potato) held during 08-11 September, 2018 at SDAU, Sardar Krushinagar, Gujarat for cultivation in North western and central plains. It produces white oblong tubers with shallow eyes and white flesh colour. Hybrid MP/4-578 produces nearly 30-35 t/ha tuber yield and possess good keeping quality, nearly 20-21% tuber dry matter and is field resistant to late blight and potato virus Y.

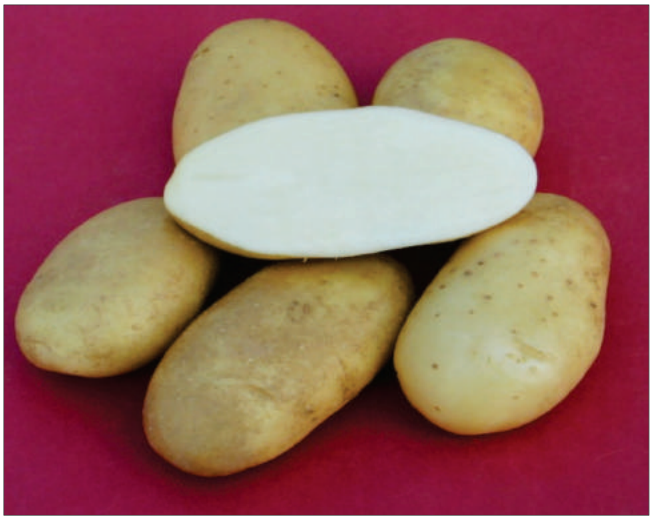


Fig. 7: Tubers of MP/4-578

Processing quality of advanced hybrids at Jalandhar: Among the seven processing hybrid evaluated along with six controls at 90 days, except for MP/9-45 (19.84%), tuber dry matter of all hybrids was more than 21% and MP/12-105 (24%) recorded highest tuber dry matter. Chip colour score of MP/12-223 was within acceptable range, however, French fry colour of all hybrids except MP/11-112 was within acceptable range. Bio-yield point (at which the probe punctures through the skin), hardness and firmness (average hardness during probe travel) of MP/12-70 was highest. Whereas, flesh firmness (plateau of the force after the bio-yield point) of MP/12-105 was maximum. Similarly, chips crispiness and toughness (work done or total force used during first bite/compression) was highest for MP/12-105.

Processing quality of genotypes during storage at 10-12^{o}C with CIPC during 2017-18: Among the 13 genotypes, except MP/10-172, all hybrids recorded more than 21% dry matter during storage. After 180 days of storage only MP/11-30 recoded acceptable chip colour score whereas fry colour score of all hybrids were within the acceptable range. Highest chips crispiness and fracturability were recorded in MP/9-45.

Optimizing agro-techniques of advanced stage hybrid MP/06-39: The hybrid responded significantly up to 240 kg N/ha having marketable (36.8 t/ha) and total tuber yield (41.2 t/ha). Phosphorous application up to 40 kg P_2O_5/ha was sufficient as hybrid had marketable (36.9 t/ha) and total tuber yield (40.7 t/ha). The hybrid attained sustainable marketable (33.3 t/ha) and total (38.7 t/ha) tuber yield at 100 kg K_2O/ha. Comparable tuber dry matter content (21.72%) and best chip colour score (3.6) was observed with 240 N-40 P_2O_5-100 K_2O kg/ha level.

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

Hybridization and selection: In all, 160645 TPS were obtained from the 109 crosses attempted at Shimla, Ooty and Shillong involving late blight and potato cyst nematode resistant parents.

Seedling stage: A total of 14898 seedlings derived from 91540 TPS of 41 crosses were screened and at harvest, 1898 clones were selected at Kufri and Ooty. In initial clonal stages (F_1C_1 to F_1C_4), 1787 clones were evaluated and 778 clones were selected at Kufri, Ooty and Shillong.

Advanced stage trials at Shimla, Ooty and Shillong: Five F_1C_5 advanced stage hybrids were evaluated along with controls. SM/08-04 yielded significantly higher compared to controls and also showed resistant reaction to late blight disease. In F_1C_6 stage, among the seven advanced stage hybrids evaluated, SM/03-25, SM/09-91 and SM/08-11 showed yield superiority over best control, Kufri Girdhari. In F_1C_7 stage (10 advanced stage hybrids, 2 trials), three hybrids namely SM/11-120, SM/08-11 and SM/10-139 yielded significantly higher than the best check Kufri Himalini. The hybrid, SM/11-120 is highly resistant to late blight and both species of potato cyst nematodes. At Ootacamund, 9 hybrid were selected from the 30 evaluated in 5 trials. At Shillong, seven promising advanced hybrids were selected based on the tuber characteristics, dry matter, AUDPC and yield from the 13 evaluated in one trial.

Evaluation at Modipuram: Among the 22 late blight resistant hybrids (2 trials) evaluated, hybrids SM/13-122, VMT 3-1, SM/08-21, SM/10-253, SM/13-150 and SM/13-129 yielded significantly higher than Kufri Bahar. A red fleshed hybrid SM/13-172 performed significantly better than Kufri Jyoti, statistically at par to Kufri Bahar. Thirty advanced hybrids along with seven varieties were evaluated for late blight screening. All hybrids showed less Area under Disease Progress Curve (AUDPC) in comparison to highly susceptible control variety Kufri Bahar. Minimum AUDPC was recorded in hybrid SM/13-172 (10).

PCN screening at Kufri: A total of 22 hybrids with standard checks Kufri Jyoti, Kufri Girdhari and Kufri Himalini were screened against both the species potato cyst nematodes at Kufri and one hybrid (SM/11-120) was immune, one highly resistant (HR) (SM/09-121) and five were found moderately resistant (MR) to both the species of *Globodera*.

Recommendation of new varieties: New Potato varieties namely Kufri Karan and Kufri Sahyadri (Fig. 8) were recommended for release.

Fig. 8 (a): Tubers of new potato variety (Kufri Karan)

Kufri Karan (SM/00-42) a medium maturing late blight resistant hybrid was recommended for release in 36th Annual Group Meeting on AICRP (P). It possesses resistance to multiple diseases viz., late blight, apical leaf curl virus, potato virus Y, potato virus S, potato leaf roll virus, potato virus A, potato virus M with moderate resistance to potato cyst nematode. It produces nearly 30 tons/ha yield and is recommended for Indian hills and Plateau region.

Fig. 8 (b): Tubers of new potato variety (Kufri Sahyadri)

Kufri Sahyadri recommended for Tamil Nadu hills during 36th Annual Meeting of AICRP (P) is highly resistant to both the species of potato cyst nematode with average yield of 32 t/ha.

Molecular Breeding

Hybridization: A total of 16210 hybrid TPS were obtained from 8 crosses to pyramid multiple resistance genes in a common genotypic background for late blight (*R1* and *R3a*), PVY (*Ryadg, Rysto*) and potato cyst nematodes (*H1, HC_QRL* and *Gro1-4*) resistance using molecular assisted selection.

Characterization of parental lines for late blight resistance genes: Fifty-two parental lines were screened phenotypically under field condition and genotypically using gene specific markers (R1AS, CosA, R2, cLET5E4, GP 185 and R31380). Field screening results showed that 40.38% lines were highly resistant, 15.38% were resistant, 38.46% were moderately resistant and 5.88% were susceptible to late blight. In molecular validation 3 lines showed positive response for R1AS, 3 for CosA, 29 for R2, 51 for cLET5E4, 46 for GP 185 and 34 for R3 1380. Among these CP2328, CP2340 and CP1669 showed the presence of five markers (R1AS, CosA, cLET5E4 and GP 185). Based on phenotypic (highly resistant/resistant) and genotypic (presence of two genes) data, 10 promising accessions viz., CP1843, CP2066, CP2258, CP2417, OS/13-519, SM/00-191, SM/00-43, SM/01-07, Kufri Girdhari and CP2427 identified.

Characterization of parental lines for PCN resistance genes: Eighty-six parental lines were screened for eight PCN resistance linked molecular markers for identification of resistant genotypes. The genotypes CP4052, CP4057, CP4075 and Ivory russet were positive for highest number of molecular markers (7), while HR/9-5, CP4087, CP2418, CP3173 were positive for six markers. The marker SPUD 1636 was only found in Atlantic and Herculea and TG 432 was found in three genotypes viz., CP3711, HR/9-5 and CP4311.

Characterization of advanced stage hybrids for multiple resistance: Forty advanced stage hybrids were screened for R genes/R gene linked markers (Fig. 9) for resistance to late blight, PVY and PCN. Among the hybrids, SM/11-120, SM/10-178, SM/10-255, SM/09-161, SM/13-172, SM/13-169 were promising for PCN resistance based on number of genes/markers present in them. Most of the advanced hybrids were having one or the other late blight *(R1* and *R3)* and PVY *(Ryadg)* resistance gene.

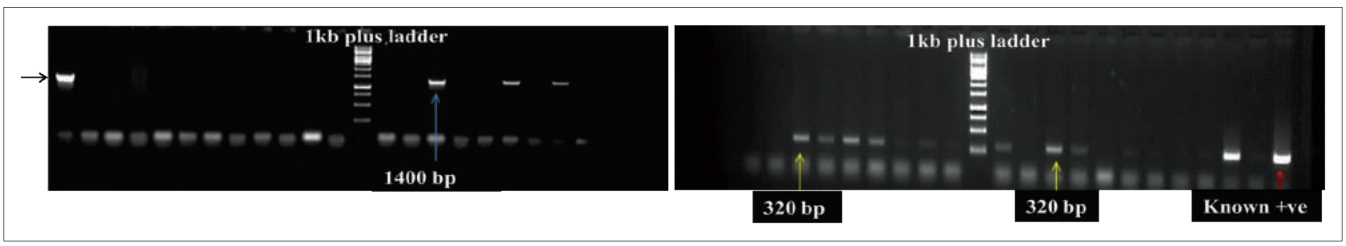


Fig. 9: Hybrids possessing R1 (AS) (1400bp) marker and Ryadg (320 bp) marker/gene

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

Breeding for heat tolerance

Hybridization and selection: A total of 175195 TPS were obtained from 68 crosses, 9580 seedlings were raised from 53054 TPS (51 crosses) and 488 clones were selected. A total of 317 clones were also selected from single tubers derived from 6 crosses screened under heated glass house (35-38^{0}C day and 22-24^{0}C night). In all 568 clones of F_1C_1, F_1C_2& F_1C_3 were multiplied and evaluated at Modipuram in winter crop and 38 clones were selected. In F_1C_3, clones HT/16-240 and HT/16-113 (35 t/ha) were top yielder as compared to Kufri Surya (27 t/ha) and Kufri Pukhraj (37 t/ha).

Advanced stage trials under early crop season at Modipuram: Five hybrids namely, HT/14-101, HT/12-834 (13 t/ha), HT/12-116, HT/12-751, HT/12-43 (12 t/ha) were found promising as compared to controls Kufri Surya and Kufri Lima (11 t/ha).

Advance stage trials at Bhubaneswar and Pune: Six advanced stage hybrids were evaluated along with control varieties at 90 DAP at Bhubaneshwar (Rabi crop) and Pune (Kharif crop). At Bhubaneswar significantly higher total tuber yield was obtained in the advanced hybrid HT/12-751 (22 t /ha) followed by HT/12-830 and HT/12-834 (19 t/ha) as compared and best control Kufri Surya (17 t/ha). At Pune significantly higher total tuber yield was obtained in advanced hybrids *viz*., HT/12-43 and HT/12-834 (17 t/ha) as compared to best control Kufri Surya (17 t/ha).

Analysis of glycol-alkaloids in heat-tolerant genotypes at Shimla: Total 41 samples from early season harvest from Gujarat, Modipuram (UP) and Pune (Maharashtra) were analysed for glyco-alkaloids in whole tubers (unpeeled). The results showed wide variation for the trait and, thus, regular monitoring of glycol-alkaloids is equally important in breeding for heat tolerance.

Identification advanced stage hybrid: Based on four years performance (2015-16 to 2018-19) during early planting season of at Modipuram, advanced stage hybrid HT/12-751 (ASP-1 x HT/4-935) was identified. It produced 7% and 10% higher marketable and total tuber yields, respectively compared to best control Kufri Surya. It produces white-cream, ovoid tubers with shallow eyes and yellow flesh (Fig. 10). HT/12-751 possesses 17% tuber dry matter, long dormancy period and very good keeping quality.

Fig. 10: Tubers of HT/12-751

Breeding for drought tolerance

Hybridization and selection: In all 4750 seedlings were raised from 28500 TPS (8 crosses) and 203 clones were selected. Total 236 clones of F1C1, F_1C_2, F_1C_3 & F_1C_4 were multiplied and evaluated at Modipuram in winter crop and 176 clones were selected at harvest.

Advanced stage hybrid trials: A total of 17 hybrids were evaluated under water stress and well-watered conditions along with control Kufri Bahar, Kufri Mohan and Kufri Pukhraj. Total irrigations were five in control and four in water stress strip. Considering the root pulling force, stay-green trait and other associated traits viz. total tuber yield, tuber dry matter under stress, attractive tuber shape and tuber uniformity five hybrids were selected namely WS/09-609, WS/11-367, WS/12-110, WS/13-135 and WS/13-192,.

Stay green trait as adaptive attribute under water stress: Hybrids WS/12-110, WS/13-135 and WS/13-192 stayed green at 85 DAP and shown lowest foliage senescence (< 4% yellow) with better total tuber yield under stress as against moderate (20-30% yellowness) in control. Stay green trait helped in capitalizing the favorable period of moisture availability (last watering to optimize harvest operations) during terminal end of crop maturity.

Advanced hybrid introduced into AICRP: Based on three years performance under water deficit regime during 2015-16 to 2017-18 at Modipuram, hybrid WS/07-113 (CP1748 x LT-1) was introduced into AICRP. It produced 14% higher tuber yield at Modipuram over the control Kufri Bahar. It recorded higher Stress Tolerance Index (STI) due to higher Pn rate, compact canopy and also highest mean WUE (1.35 q tuber/ha-mm) as against Kufri Bahar (1.26 q tuber/ha-mm) across the years of evaluation. It possesses white-cream, oval tubers, shallow to medium eyes and cream flesh (Fig. 11). The hybrid has > 19% dry matter, long dormancy period and very good keeping quality in country store.

Evaluation of advanced hybrids for higher yield & water use efficiency: Five advanced stage hybrids along with Kufri Bahar and Kufri Pukhraj were tested at three soil moisture regimes viz. 0.20-0.25, 0.40-0.45 & 0.60-0.65 bars/atm. The total water (including effective rainfall) was applied viz. 300, 250 & 200 mm under wet, moist & semi-dry regime, respectively during 92 days crop. Results showed that WS/09-609 produced significantly higher total tuber yield (36.6 t/ha including 7-8% tuber cracking) than Kufri Bahar (36.4 t/ha) followed by advanced hybrid WS/11-367 (35.7 t/ha) (Table 4). The total tuber numbers produced by control varieties were statistically at par with the tubers produced by WS/09-609.

Fig. 11: Leaf, flowers, tubers and sprout of WS/07-113

Table 4: Tuber yield and WUE of different advance WS genotypes as influenced by irrigation levels

Genotype.	Total yield			Mean	Water use efficiency			Mean
	Wet	Moist	Semi-dry		Wet	Moist	Semi-dry	
WS/07-113	33.7	30.8	28.8	31.1	1.123	1.232	1.440	1.265
WS/09-605	36.0	34.4	33.9	34.8 Cr	1.200	1.376	1.695	1.435
WS/09-609	36.8	36.7	36.2	36.6 Cr	1.227	1.468	1.810	1.502
WS/11-367	36.4	35.2	35.4	35.7	1.213	1.408	1.770	1.464
WS/11-344	35.6	33.8	33.6	34.3 Cr	1.153	1.352	1.730	1.412
Kufri Bahar	37.9	37.2	34.2	36.4	1.263	1.488	1.710	1.487
Kufri Pukhraj	41.3	39.3	38.5	39.7	1.373	1.572	1.930	1.625
Average	36.4	35.3	35.2	–	1.212	1.413	1.760	–
LSD at 5%	(I) NS	(G)2.3	(I x G)NS		–	–	–	

Wet =0.20-0.25 bars, Moist =0.40-0.45 bars, Semi-dry =0.60-0.65 bars, Cr = Cracking in tubers, I= Irrigation, G= Genotype

Canopy temperature, a reliable water deficit stress indicator: Infrared imaging, canopy temperature (CTemp) provides information on water status, water use and level of stress condition besides it indicates the actual energy released by a plant. Analysis of CTemp in potato under water deficit stress was undertaken at ICAR-NIASM, Baramati (MH) using Plant Phenomics facility. Kufri Jyoti and Kufri Chipsona-3 were grown in plastic pots in greenhouse at 27±5°C.

Plants at 45 DAP were subjected to 10 days of water treatments i.e. Control (100% of FC, field capacity), stress 1 (50% of FC) and stress 2 (severe stress). The water level (respective FC) of each treatment was maintained by LemnaTec automated weighing and watering system.

CTemp, analysed using Infrared imaging (VarioCAM® High Definition), was progressively increased as intensity of water stress increased in both genotypes and it was significantly higher in Kufri Chipsona 3 than Kufri Jyoti (Fig. 12). Results suggest that Kufri Jyoti has ability to keep CTemp lower under severe stress. Thus, CTemp can be a reliable indicator in screening drought tolerant genotypes in potato.

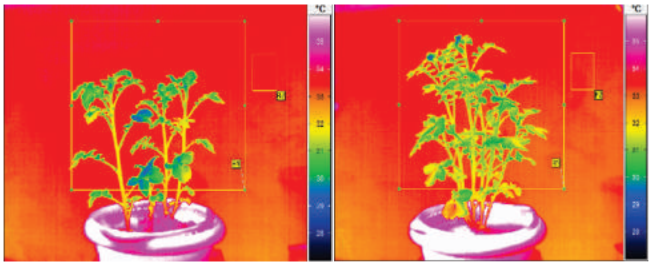


Fig. 12 (a): Infra-red images of Kufri Jyoti & Kufri Chipsona-3 and canopy temperature under water stress levels

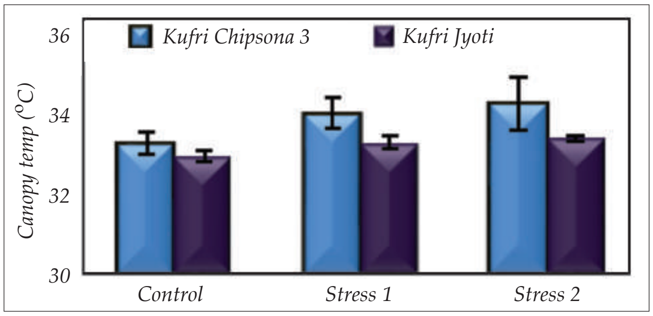


Fig. 12 (b): Canopy temperature under water stress levels

Effect of deficit irrigation on root parameters: Root length density (RLD), the length of roots per unit volume of soil, is one of the important parameters required to understand plant performance under water stress. Pot culture studies showed that RLD was higher in Kufri Surya, Kufri Badshah and hybrid HT/7-1329 under deficit irrigation (DI) during 35 to 45 DAP as compared to full irrigation (FI) in control. Root surface area (RSA) was also increased in Kufri Surya, Kufri Badshah and declined in hybrids under deficit irrigation (Fig. 13).

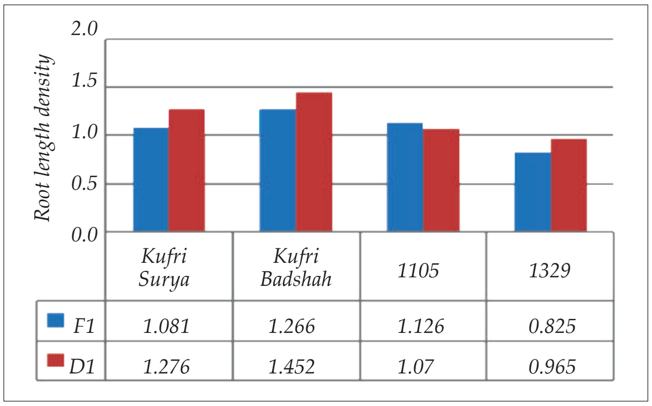


Fig. 13: (a) Root length density as affected by water stress

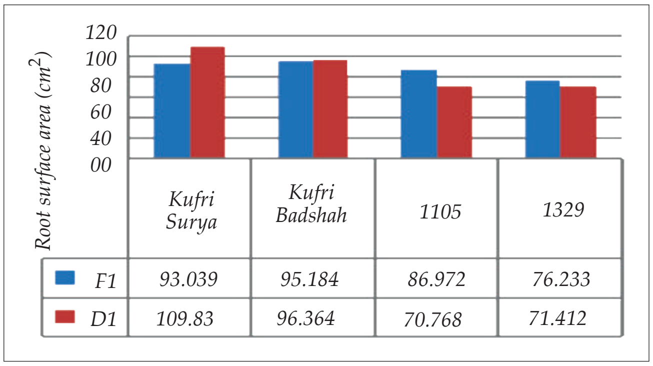


Fig. 13 (b): Root surface area as effected by water stress

Research activities 5 & 6: Development of nutritio-nally superior varieties & Breeding for enhanced micronutrient content in potato

Hybridization and selection: A total of 30000 TPS (18 crosses) were generated, 3760 seedlings were raised from 9653 TPS of 14 crosses, 193 clones were selected. In F_1C_1 stage 72 clones of 12 families were evaluated at 90 days in short row trial and 21 promising clones were selected from 7 families. In F_1C_2 stage 36 clones of 6 families were evaluated in duplicate row trial at 90 days and based on tuber attributes and nutritional components, 8 promising clones namely MSP/17-07 (yellow skin), MSP/17-89, MSP/17-147, MSP/17-212, MSP/17-341, MSP/17-345, MSP/17-532, MSP/17-537 (pink or purple skin) were selected.

F_1C_3 stage: Hybrids MSP/16-150, MSP/16-300, MSP/16-307 and MSP/16-375 produced high total tuber yield or remained at par with control Kufri Bahar. The result of mean phytonutrient profiling of last two years (2016-17 and 2017-18) indicated range of anthocyanin content in tuber flesh from 0.47 to 1.10 mg/100g FW depicted by MSP/16-272 and MSP/16-362, respectively (Fig. 14). The carotenoids content varied from 134 to 609 ug/100 g FW exhibited by MSP/16-298 and MSP/16-272, respectively (Fig. 15). The Iron content varied from 24 to 41 ppm DW basis in clones MSP/16-307 and MSP/16-004, respectively, while zinc content ranged between 14 to 24 ppm DW in MSP/16-150 and MSP/16-004, respectively (Fig. 16).

F_1C_4 stage: Six clones of cross Bareilly Red x CP3770 were evaluated in replicated yield trial at 90 days and based on low degeneration rate, tuber attributes and nutritional components, one promising clones namely MSP/15-60 was retained (Fig. 17). MSP/15-60 is medium maturing, produced 38 t/ha total tube yield with nearly 27 tubers/plant. This clone can be suitable for production of baby potatoes. The nutritional profiling of last three years (2015-16, 2016-17 and 2017-18) on 9 F_1C_4 clones revealed range of anthocyanin content in tuber flesh from 0.24 to 1.58 mg/100g FW depicted by MSP/15-48 and MSP/15-51, respectively.

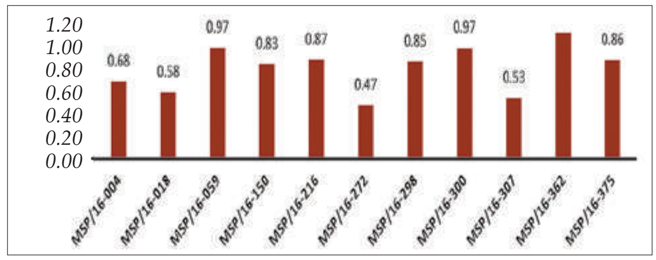


Fig. 14: Anthocyanin (mg/100g FW) content over 2016-17 & 2017-18

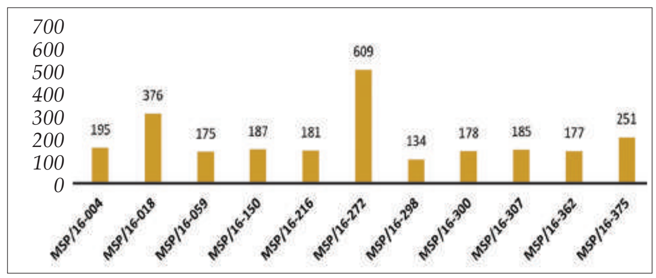


Fig. 15: Carotenoid content (ug/100g FW) over 2016-17 & 2017-18

The carotenoids content varied from 381 to 1099 ug/100 g FW exhibited by MSP/15-56 and MSP/15-64, respectively. The Iron content varied from 28 to 35 ppm DW basis in clones MSP/15-26 and MSP/16-51, respectively, while, zinc content ranged between 16 to 23 ppm DW in MSP/15-56 and MSP/16-12, respectively. The results revealed highest mean anthocyanin and iron content in clone MSP/15-51. Flavouring compounds (AMP: Adenosine 5′-monophosphate, GMP: glutamic acid, aspartic acid, guanosine 5′-monophosphate) in microwaved tubers ranged from 3.12 (MSP/15-44) -7.22 (MSP/15-56) µg/g FW defining that clones with higher values would tastes better and have higher organoleptic scores.

Nutrient profile of potato germplasm: Various germplasm were evaluated for micronutrients content such as anthocyanin from 0.11 (CP4406) to 1.66 (Kala Aloo) mg/100g FW in tuber flesh; carotenoids between 18 (CP4496) to 576 (Kala Aloo) ug/100g FW; phenols between 10 (CP4393) to 80 (JEX/A-122) mg/ 100g FW) and iron from 17 (CP4406) to 27 (JEX/A-122) ppm DW. Other mineral elements *viz.*, copper content (ppm DW) in tuber flesh ranged between 8 (CP4510) to 13 (CP4406), while manganese content (ppm DW) varied from 11 ppm (CP4510) to 27 ppm (CP4498).

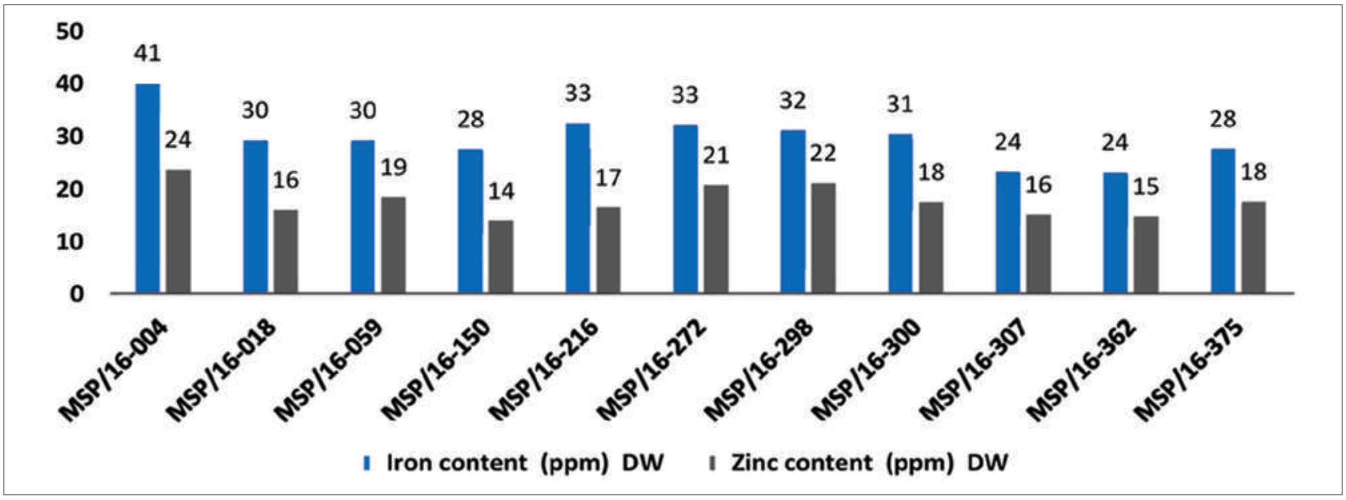


Fig. 16: Iron and zinc content (ppm DW) over 2016-17 & 2017-18

Fig. 17: Tubers of MSP/15-60

On overall basis, Kala Aloo showed highest content of anthocyanin and carotenoids, whereas JEX/A-122 showed highest values for phenols and zinc in tuber flesh.

Molecular profiling of breeding population: A total of 110 lines including 108 segregating progenies MSP/17-136 to 243 developed from MP/4-816 and CP4242 were analysed using 60 simple sequence repeat (SSR) markers.

Only one distinct SSR marker (STI0003) was identified as distinct and polymorphic marker on 3% agarose gel which could able to differentiate the parents and progenies (Fig. 18).

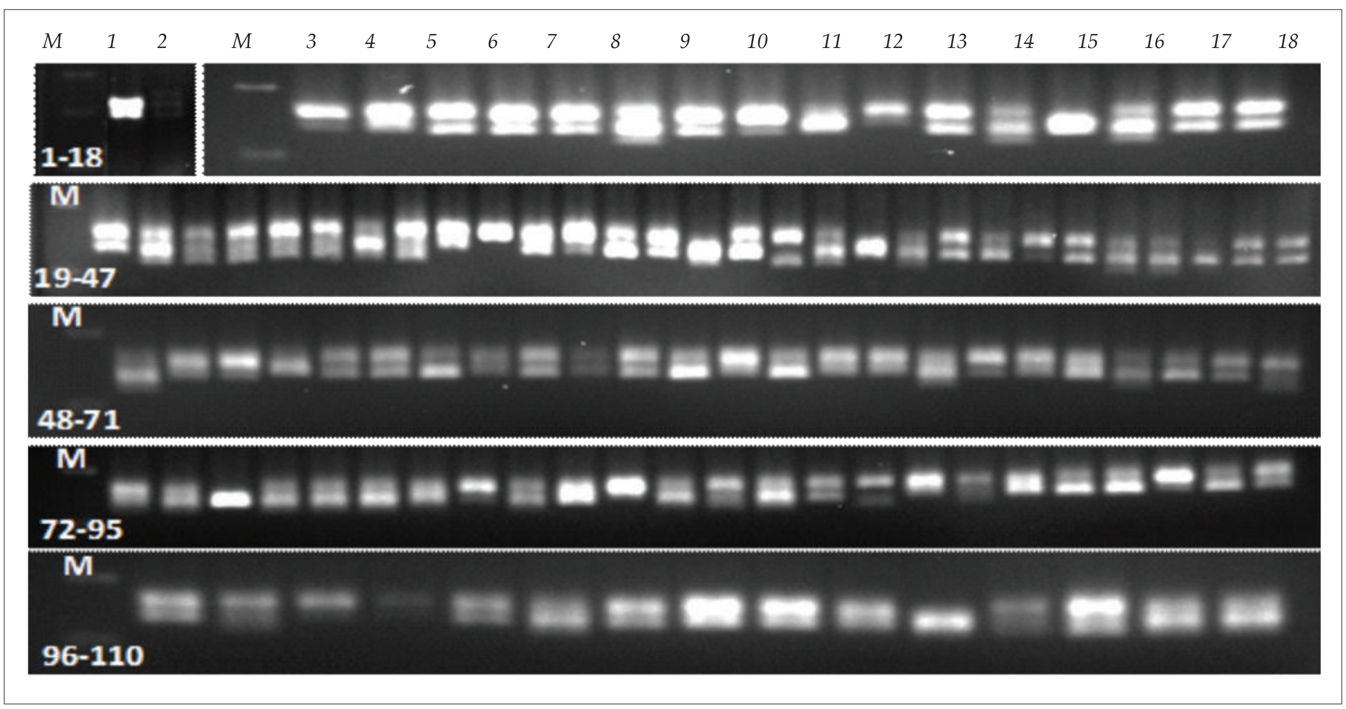


Fig. 18: Gel profile of parents and 108 progenies and parents analysed by SSR marker (STI0003). Gel images: M = DNA ladder 50 bp; 1 = MP/4-816; 2 = CP4242; 3-110: MSP/17-136 to 243

Late blight reaction at Kufri: Clones MSP/15-44 and MSP/15-56 were resistant against late blight (AUDPC < 250) while MSP/15-26, MSP/15-51, MSP/15-60 and MSP/15-64 were susceptible (AUDPC > 650) compared to controls Kufri Girdhari (highly resistant), Kufri Jyoti (susceptible) and Kufri Himalini (resistant).

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

Hybridization and selection: A total of 33344 seedlings were raised from 57202 TPS of 86 crosses and 6390 clones were selected. In F_1C_1 stage 2560 clones, in F_1C_2 stage 265 clones and in F_1C_3 stage 50 clones were selected. Evaluation in replicated yield trial: Twelve advanced stage hybrids namely N/14-133, N/14-150, N/14-151, N/14-181, N/14-254, N/14-256, N/14-59, N/14-63, N/14-75, N/14-79, N/14-85 and N/14-230 were selected out of 48 hybrids evaluated at 90 days. All these hybrids gave significantly higher yield than controls except N/14-63 which produced at par yield with controls and had 19% tuber dry matter.

In three confirmatory yield trials, two hybrids namely N/13-49 and N/13-91 were selected on account of significantly high yield as compared to control out of 14 hybrids evaluated at 90 days.

Research activity 8: Diploid potato breeding

Screening of new germplasm: Fifty diploid accessions belonging to eight cultivated species were raised in glasshouse for tuber multiplication and ploidy confirmation (Fig. 19). Besides, 25 accessions of different wild species were also subjected to ploidy analysis. Based on FACS analysis, 23 accessions from cultivated species and 15 accessions of wild species were found diploid. Confirmed diploids cultivated species were hybridized with *sli* gene donor for introgressing self-compatibility and six successful crosses out of eleven attempted resulted in 3,176 hybrid TPS. Six accessions of 23 identified diploids produced tubers and showed self-incompatibility. Ten accessions producing flowers were analysed for pollen viability and results showed sterility to partial fertility.

Multiplication and generation advancement of diploid populations: Three diploid populations TPS received from USDA was raised in glasshouse and plants were analysed to confirm the ploidy as well as self-compatibility. Tubers were obtained in 4, 3 and 4 plants in DM × M18, DM x M6 and USW4 x M6 populations, respectively.

All plants were self-compatible and selfing of flowers in all the three populations resulted in 3819, 4387 and 10 seeds. Pollen viability analyses showed that DM x M18 and DM x M6 were fully fertile while USW4 x M6 was partially fertile (Fig. 20).

Fig. 19: Diploid accessions for multiplication and evaluation a) Diploid accessions identified from gene bank, b) plants of three diploid populations c) selfed berries in diploid population plants

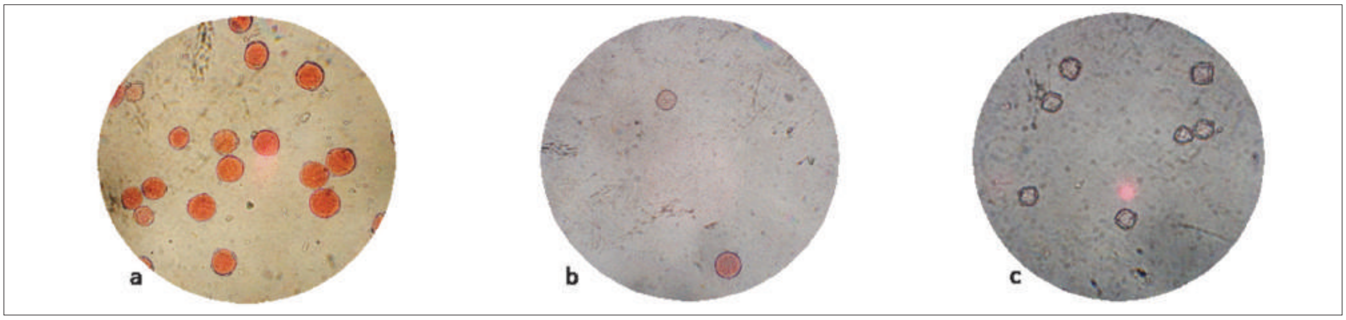


Fig. 20: Pollen viability analysis of diploid accessions a) Fertile b) Partially fertile c) Sterile

PROGRAMME: GENETIC ENHANCEMENT OF POTATO THROUGH MOLECULAR AND GENOMIC TOOLS

Genome sequence analysis of dihaploid potato C-13: Dihaploid C-13, developed earlier by anther culture from cv. Kufri Chipsona-2, was used for genome resequencing to analyze variations at sequence level with respect to the potato genome. A total of 344.794 million reads (paired end & short reads) of very high quality data was generated using Illumina technology.

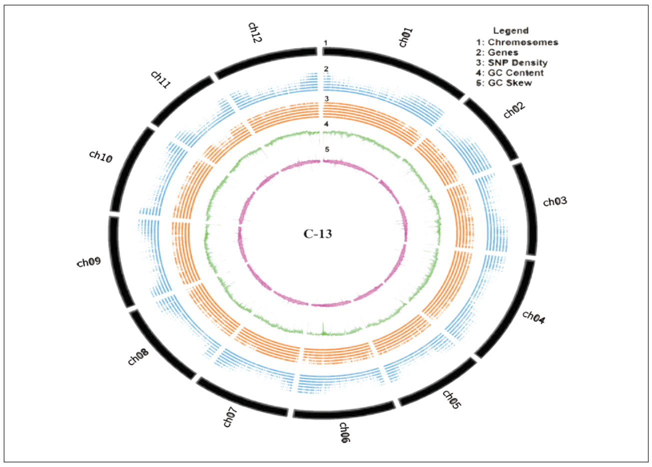


Fig. 1: A circos plot shows pictorial distribution of SNPs in *S. tuberosum* dihaploid potato C-13

Genome sequence analysis resulted in 80.68% reference assembly with the potato genome. Overall, 30241 genes were identified in C-13 genome, of which 15538 genes were characterized by the gene ontology (GO) terms. A total of 1,122,388 SNPs (single nucleotide polymorphisms) and 48,145 indels (insertion/deletions) were detected in C-13. In both SNPs and indels, homozygous (65.78% and 90.16%) were observed higher than heterozygous (34.22% and 9.84%), respectively. C-13 genome is presented in a circos plot showing pictorial distribution of SNPs on the potato chromosomes (Fig. 1) and GO terms in Fig. 2.

Genome-wide methylome analysis for tuber shape variation in potato cv. Kufri Bahar: We analysed genome-wide DNA methylation pattern by whole genome bisulfite sequencing for potato tuber shape variation in tissue culture-derived variant plant (M2, elongated tuber shape) and original mother plant (M1, round tuber shape- as control). Sequence analysis showed ~ 38% methylated cytosines in the samples, of which total methylation ratio (M2/M1 = 1.15) was higher in M2 including CpG (1.19), CHG (1.20) and CHH (1.08) contexts. Differential methylation regions (DMRs) analysis revealed maximum methylation on chromosome 5, CHG context and downstream region, and higher hypo-methylation than hyper-methylation (Fig. 3).

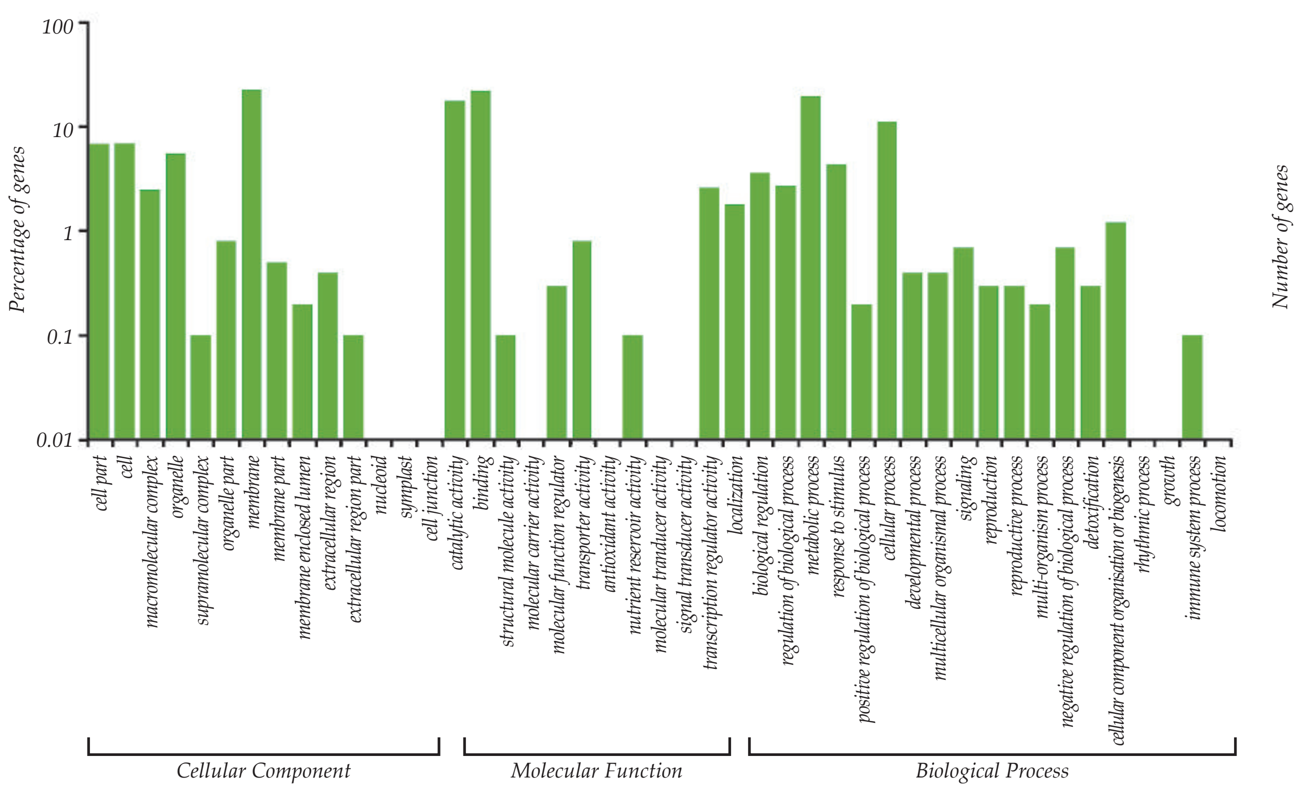
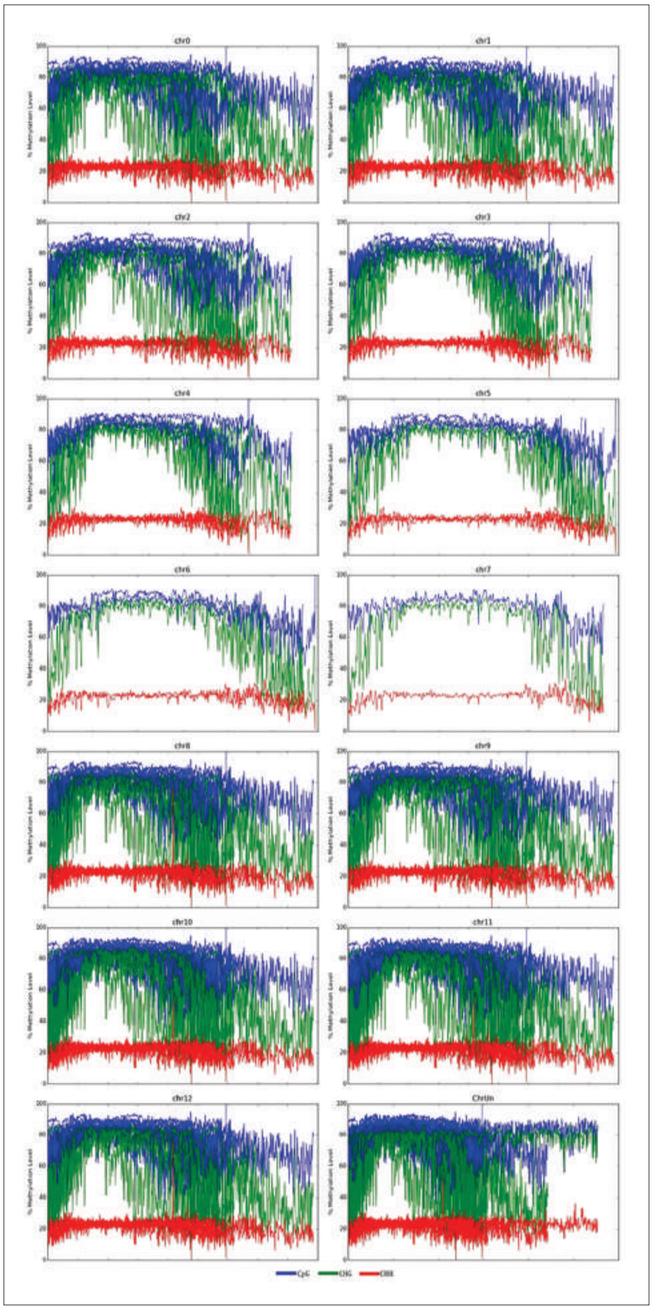


Fig. 2: Gene Ontology (GO) characterization of C-13 genes in three main GO terms.

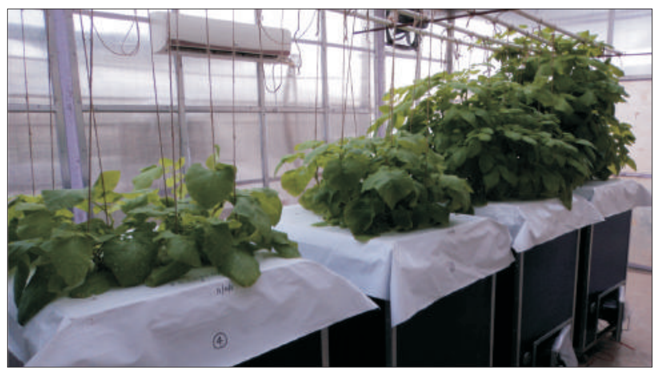


Original *De-shaped*

Fig. 3: Methylome profiling of Kufri Bahar for tuber shape variation (Original *vs.* de-shaped tuber)

Precision phenotyping of contrasting potato varieties in a novel aeroponics system for improving nitrogen use efficiency:

Precision phenotyping of two distinct potato varieties (Kufri Gaurav: N efficient, and Kufri Jyoti: N inefficient) was done in aeroponics supplied with low N (0.75 mM NO3-) and high N (7.5 mM NO3-). Plant biomass, root traits, total chlorophyll content and plant N were increased with increasing N supply, whereas higher NUE parameters namely NUE, agronomic NUE (AgNUE), N uptake efficiency (NUpE), harvest index (HI), and N harvest index (NHI) were observed at low N. An NUE efficient cv. Kufri Gaurav showed higher tuber dry weight, fresh tuber yield, tuber number per plant, early start of tuber harvesting, root traits, stolon traits, NUE parameters and higher amino acids (aspartic acid and asparagine) content at low N supply. Higher expression of NR, NIR and AS genes was observed in the leaf tissues of Kufri Gaurav at high N. Thus, aeroponics-based precision phenotyping enables identification of NUE efficient genotypes based on key traits and genes involved in improving NUE in potato (Fig. 4).



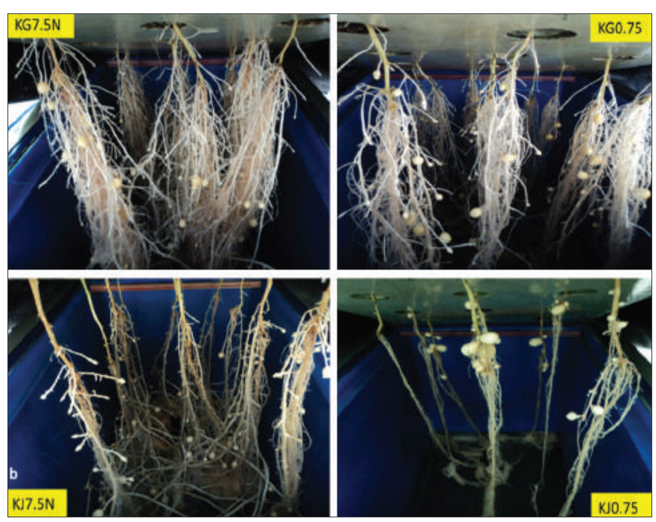


Fig. 4 (a): Growth of potato aeroponics with different nitrogen doses phenotype and root biomass.

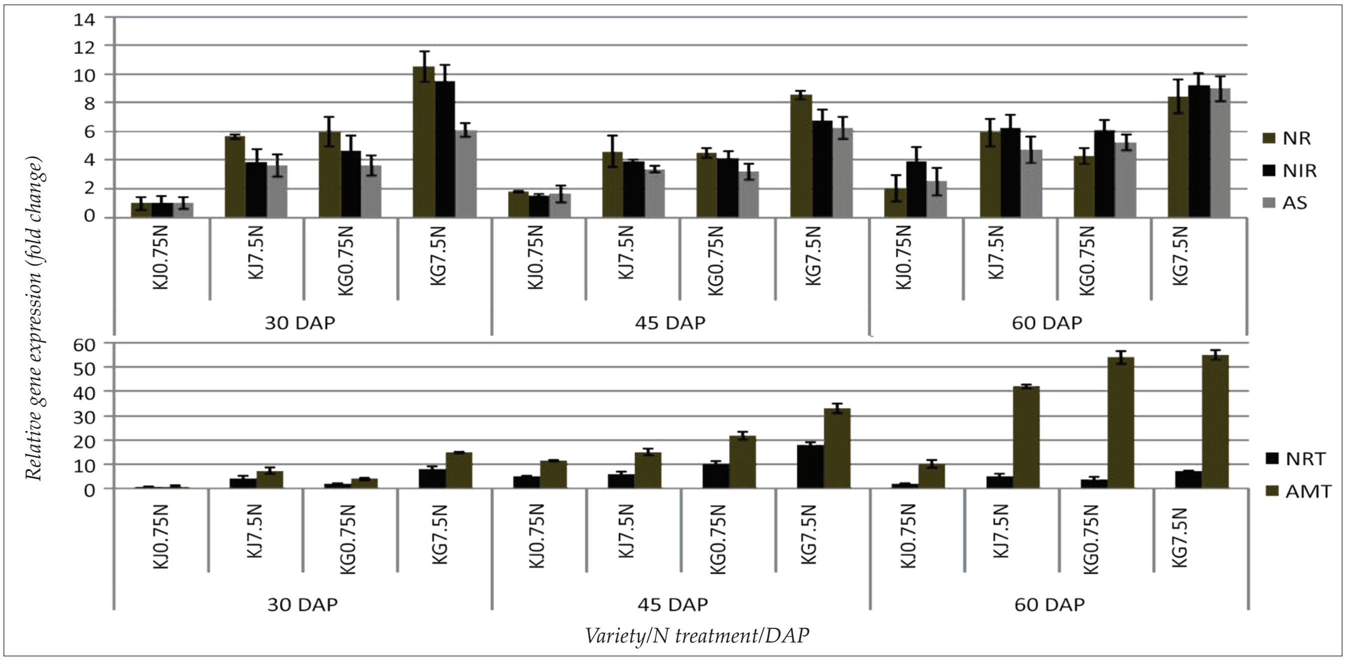


Fig. 4 (b): Gene expression of potato plants grown in aeroponics with different nitrogen doses

Performance of potato varieties in aeroponics to analyze genes involved in nitrogen use efficiency: The available potato varieties (54 nos.) developed by ICAR-CPRI were evaluated in aeroponics controlled conditions with a single nutrient solution comprising macro/micro nutrients and all varieties performed excellent except a few. The composition of aeroponic nutrient solution was developed at the institute (Patent applied: 201911011277). The tuber yield and plant biomass data showed excellent results during October to February crop season in Shimla. Further, plant samples were collected to analyse genes governing nitrogen use efficiency in potato varieties.

Small RNA sequencing to identify regulatory elements under low nitrogen stress in potato: Potato variety Kufri Jyoti (KJ), N inefficient, was grown in aeroponics with two nitrogen treatments (high N and low N) under controlled conditions. Shoot and root samples were analyzed by small RNA sequencing to identify microRNAs involved in N stress in potato.

Field evaluation of NUE mapping population: A total of selected 116 clones (F_1C_4) from the cross (Kufri Jyoti × Kufri Gaurav) were evaluated in 90 days replicated field trial under low nitrogen (50 kg N/ha) regime along with the parents. Variation in leaf pattern was well noted and about nine clones had > 200g/plant leaf FW.

There was great variability in tuber yield. Majority of the clones were found as low yielder, nevertheless 11 lines achieved >480 g/plant tuber FW. Data on leaf FW, number of tubers and their relation with tuber yield suggested that clones having around 200g as leaf FW with 12 to 14 tubers/plant were good yielder under low N.

Development of simple sequence repeat (SSR) markers set for identification of Indian potato varieties: Total of 155 SSR alleles of 12 markers were scored in 48 varieties with alleles per locus varied from 4 (STM1053) to 35 (STIKA), and polymorphic information content (PIC) ranged between 0.53 (STM1053) to 0.92 (STIKA). Total of 1492 absolute alleles frequencies were detected in the varieties ranging from 19 (Kufri Arun or Kufri Sadabahar) to 45 (Kufri Kundan) with marker-wise allele frequencies were maximum in STIKA (273) and minimum in STM5127 (73) or STM1053 (73). A set of minimum two-markers-set (STIKA and STU6SNRN) was developed for varietal identification up to similarity coefficient 0.89. These newly developed SSR markers sets of Indian potato varieties have potential roles in varietal identification, genetic fidelity testing, DUS and molecular characterizations (Fig. 5).

SSR fingerprinting of Somatic hybrid progenies with FAM labelled SSR marker: Somatic hybrids progenies [MSH/17-16: Kufri Garima × Card 10; MSH/17-25: Kufri Garima × P10; and MSH/17-27: Kufri Jyoti × Card 16] were analyzed by 60 SSR markers. A diagnostic marker (STI0001) was identified to distinguish the progenies and parents (Fig. 6).

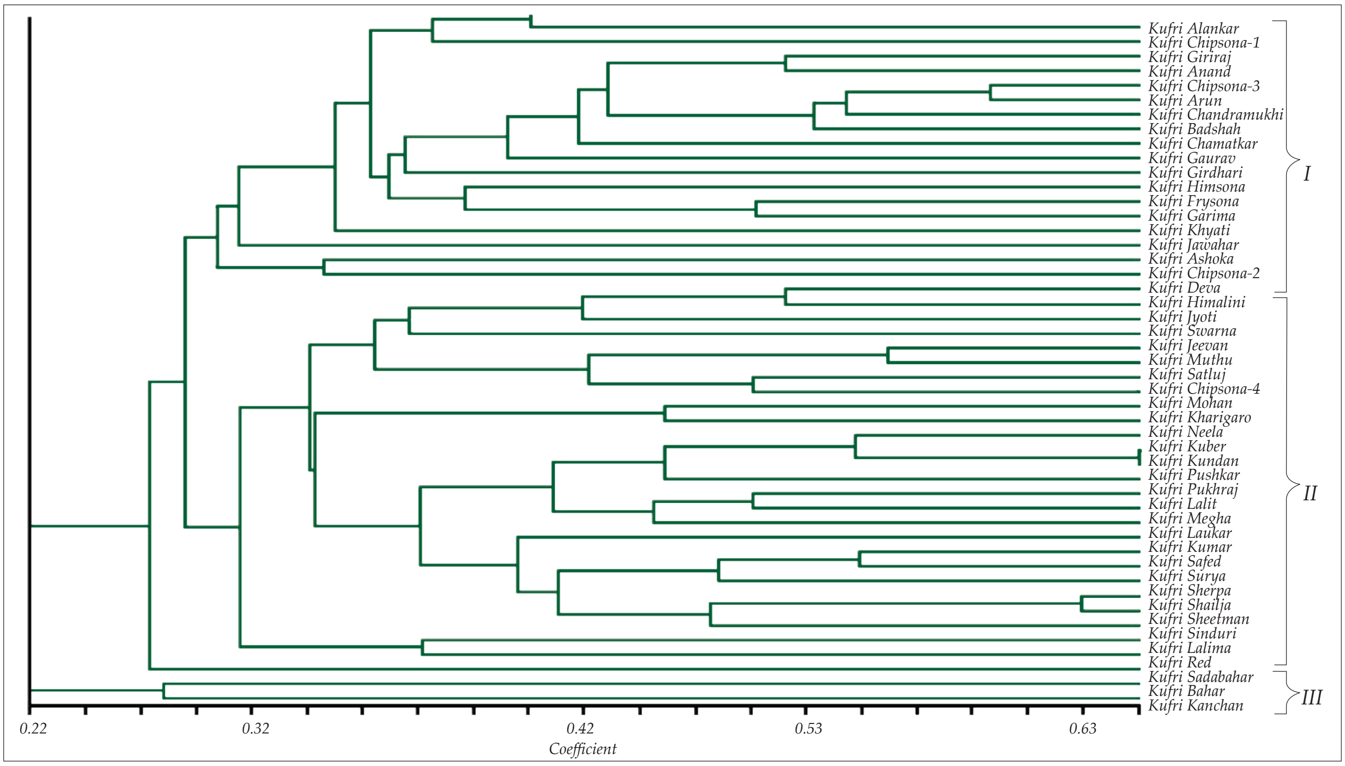


Fig. 5: Fingerprinting of potato varieties using SSR markers

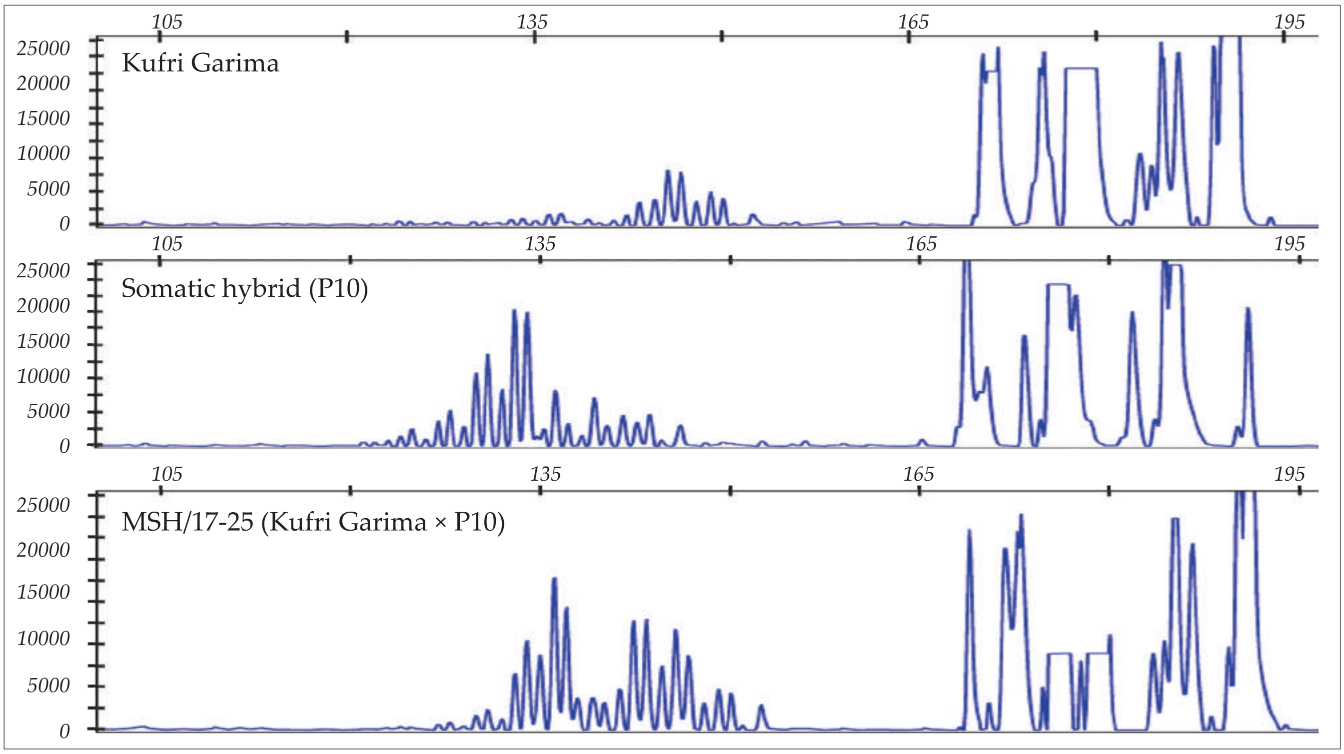


Fig. 6: Molecular profile of somatic hybrid progenies using diagnostic SSR marker (STI0001).

Genetic improvement of somatic hybrids:

i) Replicated yield trials: Three advanced stage hybrids MSH/14-7, MSH/14-129 and MSH/14-131 evaluated at 75 and 90 DAP in replicated yield trial. At harvest, advanced stage hybrid, MS/14-07 (48.65 t/ha) produced significantly high tuber yield than Kufri Bahar (40.04 t/ha) at 90 days (Fig. 7). *ii) Evaluation under early crop:* Of 8 clones evaluated under early crop at 75 day, MSH/14-07 (261 g/plant) and MSH/14-129 (277 g/plant) showed tolerance to hopper/mite and produced significantly high yield than heat tolerant variety

Kufri Surya (188 g/plant). *iii) Evaluation of elite clones of cross P8 x Kufri Jyoti under main crop:* MSH/14-113 (508 g/plant), MSH/14-115 (406 g/plant), MSH/14-122 (374 g/plant) and MSH/14-123 (474 g/plant) produced at par tuber yield with Kufri Bahar (437 g/plant) at 90 DAP. Clones namely MSH/14-112, MSH/14-113, MSH/14-115 and MSH/14-122 produced significantly high tuber dry matter (21-24%) as compared to Kufri Bahar (20%). *iv) Evaluation of progenies of somatic hybrids for late blight resistance:* All the advanced hybrids possessed less AUDPC than the susceptible variety Kufri Bahar. Specifically MSH/14-113 and MSH/14-122 showed high level of late blight resistance.

CDF1.2 is candidate gene for enhancing earliness in potato cultivars: The short-day photoperiod promotes tuberization in potato, whereas long-day and high-temperatures inhibit or delay tuberization. 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. Based on this concept, we over expressed the CDF1.2 gene in late maturing cv. Kufri Girdhari.

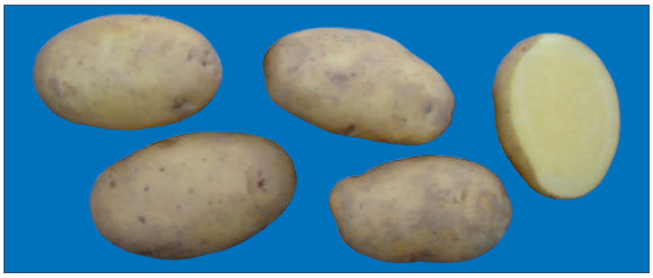


Fig. 7: Tuber of advanced somatic hybrid progeny MSH/14-07

Out of 95 transformed lines, 55 were found nptII PCR positive and these positive lines were subjected to phenotyping for tuberisation. When analysed phenotypicaly for maturity and early tuberization, 25 of the transformed lines were tuberising 13 days early and senescence phenotype in comparsion to the non transgenic Kufri Girdhari (Fig. 8).

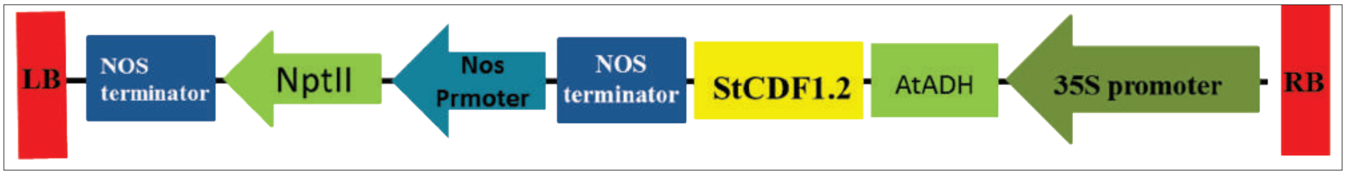


Fig. 8: T-DNA map of StCDF1.2 in pRI101AN

CRISPR/Cas mediated editing of chlorophyll synthesis gene Phytoene Desaturase (PDS), a proof of concept for genome editing in potato:

CRISPR/Cas system is an important tools for elucidating genetic controls and crop improvement. We attempted use of CRISPR/Cas methodology in tetraploid potato Kufri Chipsona-1 by targeting the chlorophyll synthesis gene PDS (Phytoene desaturase). To construct genome editing module for PDS gene, we designed a specific and off target 3 gRNA from for exon region of the PDS gene.

A 20 bp gRNA sequence was selected by using the gRNA designer (CCTop) and confirmed by manual analysis. The 20-bp sequence had tri-nucleotide PAM sequence i.e., 5′-AGG-3′ on its 3′ end. We designed multiplex editing of all the 3 gRNA using potato glycine tRNA for the simultaneous expression of all 3 gRNA under the control of AtU6 promoter.

This construct was used for genetic transformation of potato using intermodal stem cuttings for efficient stable transformation. More than 80% of the putative transformants shoot lines exhibited mutant phenotypes i.e. bleached phenotype (Albinism). Mutant shoot lines selected for molecular analysis, results indicate the PDS gene is functionally disrupted in Kufri Chipsona-1 and clearly demonstrate that CRISPR/Cas9 can be used to edit genes at high frequency within the potato genome for various traits (Fig. 9).

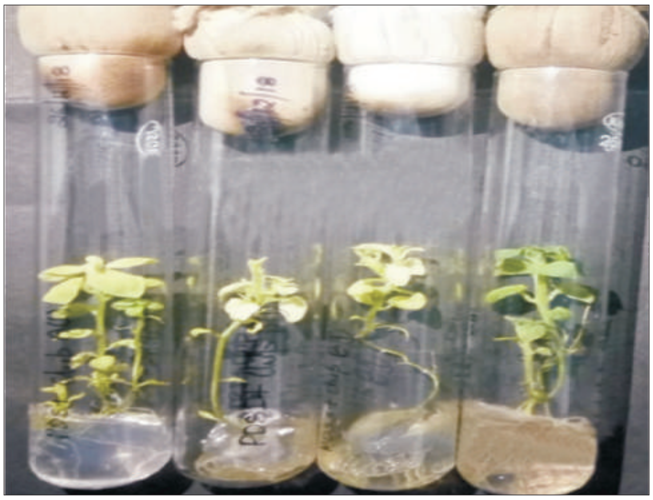


Fig. 9: Kufri chipsona1 PDS mutated line showing bleached phenotype

In-silico identification of meiosis specific *MiMe* genes (OSD1, SPO11-1 and REC8) and molecular characterisation: The meiosis genes were mined from the Arabidopsis information resource (TAIR) for OSD1 (NM_115648.5), SPO-11-1 (NM_112156.2) and REC8 (NM_180442.2). Total RNA isolated from anther and carpel of Kufri Jyoti. The PCR specific 768bp of StOSD1, StSP011-1 (1068bp) and Rec8 (526bp for T-1 and 635 bp for T-2) fragments were isolated and cloned into pTZ576/T vector. Amongst 20 recombinant clones, five clones were Sanger sequenced. The results indicated that there was 98% sequence identity with existing potato gene sequence. Four CRISPR/Cas9 construct were designed and will be synthesized in future: Two gRNA were selected for each gene based on online gRNA finder software CCTOP and the CRISPR/Cas9 construct designs were developed for all 3 MiMe genes. Each deisgn consisted *Bsa*I restriction site followed by Arabidopsis GlyGCC-68 (pre-tRNAGly) (Fig. 10).

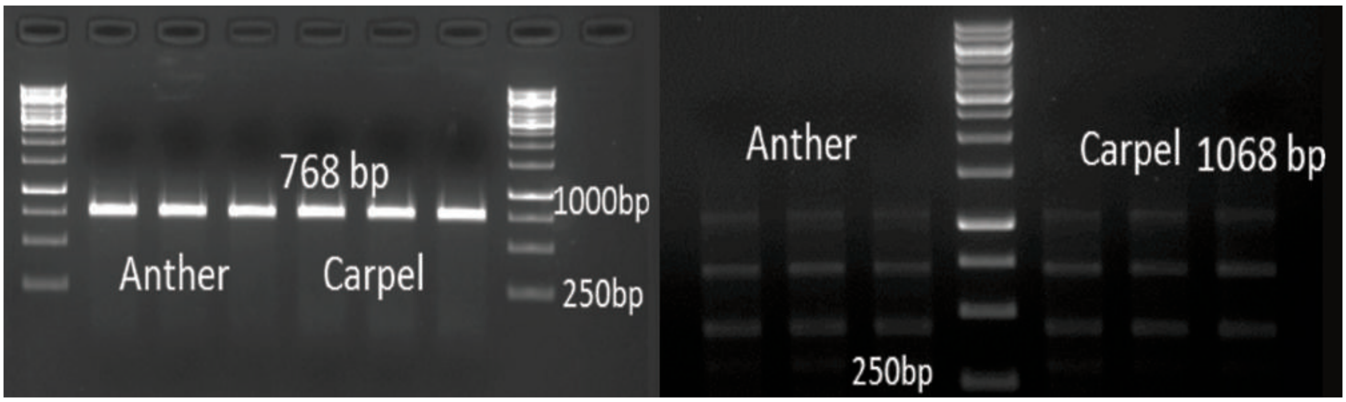
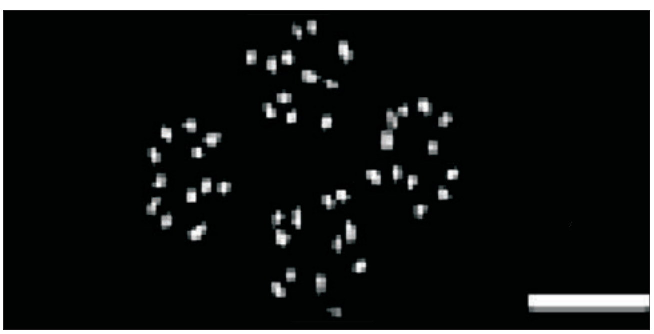


Fig. 10: Semi-quantitative PCR analysis of StOSD-1 (A) and StSPO11-1 (B) transcript expression from anther and carpel of Kufri Jyoti



Acid spread with DAPI staining

Fig. 11: Standardization experiment showing elophase II of diploid potato showing 12 sister chromatids at either of the four poles resulting in tetrad of microspores

Standardizing the cytological procedures to study meiosis of *MiMe* clones: Conventional squash techniques doesn't show the morphology and counts chromosomes clearly and thus we have standardized the acid spread technique that gives a better information (Fig. 11).

Activation tagging in potato, a tool for generating functional genetic resources in potato: The generation of functional genetic resources and understanding the traits of its alleles will be useful for successful breeding programme. The activation tagging approach is used to produce functional mutants of potato having improved phytonutrients, thereby leading to affirmative impact on human health. The vector pSKI015 was procured from addgene plasmid repository (www.addgene.org). PCR amplification and restriction digestion confirmed a intact 4 copies of 35s enhancer element and Bar gene region and reconfirmed by PCR cycling. Then, this vector was used for genetic transformation of Kufri Jyoti and Kufri Chipsona and one of the diploid clone for generating large number putative transformants. The positive transformants was selected based on hpt and Bar gene specifc PCR and found 28 positive lines and these lines will be subjected to phytonutrients and other valuable characters (Fig. 12).

Understanding the soil health status through metagenomics: Soil is probably the most complex and heterogeneous microbial habitat on earth. We studied the microbial communities present in the potato rhizospheric soils using whole metagenome sequencing (indirect molecular approach). Preliminary analysis reveals the presence of the four major kingdoms i.e. Archea, Bacteria, Eukaryota and viruses. The abundance count and percentage values in each kingdom is given in Table 1, and the resolution up to species level is shown in Fig. 13.

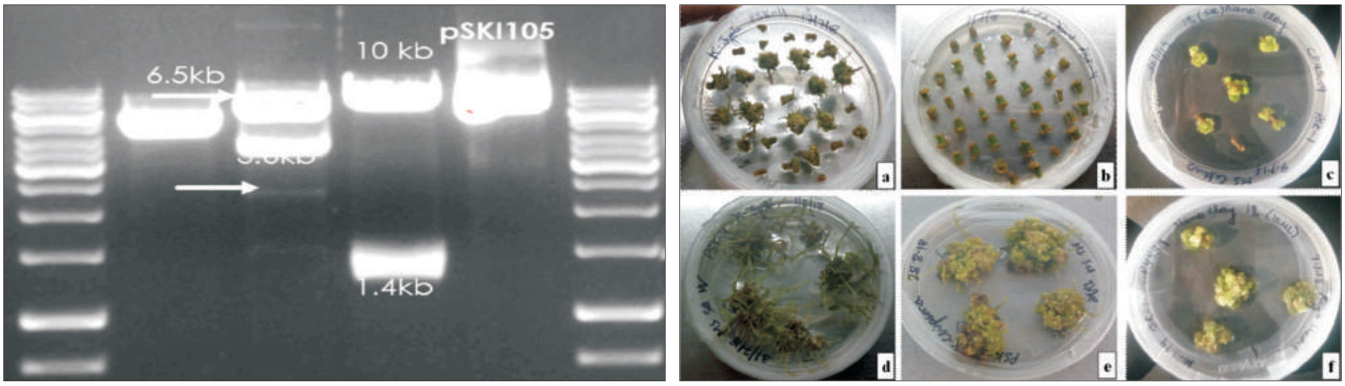


Fig. 12: Restriction digestion of vector pSKI015 using restriction enzymes BamHI, NotI and KpnI yielded 3.637Kb and 6.501Kb band (1-3) and KpnI yielded 1.309Kb and 7.417Kb bands (4) and Callus induction/shoot regeneration

Table 1. Kingdom level abundance statistics

Kingdoms	Abundance count	% value
Archaea	6637	2.00
Bacteria	210152	63.35
Eukaryota	758	0.23
Viruses	49	0.01

The mode of interaction of these micro-organisms with potato plant can be understood using the transcriptomics approach and the same is underway to get more insight about the effect of soil microbiota on potato crop.

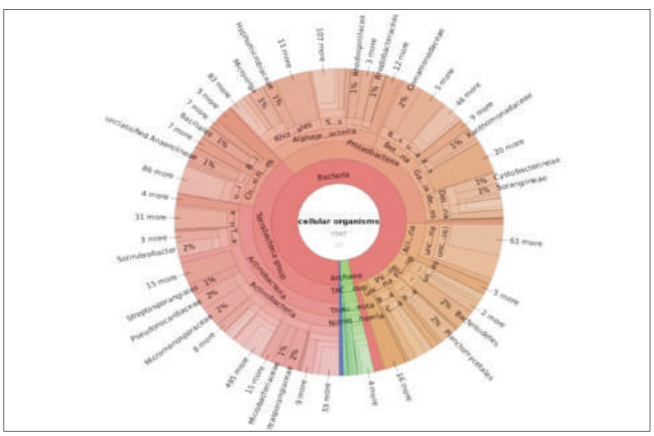


Fig. 13: Krona graph showing the microbial diversity (Kingdom to species level) present in the potato hizospheric soil

Potato transgenics for thermotolerance: Heat stress has severe effect on potato cultivation affecting the tuberization and the bulking process. Being a signaling molecule it is hypothesized that annexins might play important role in tuberization under heat stress condition.

Expression profiles of these genes in contrasting genotypes under heat stress conditions reveals strong up-regulation StAnn1 indicating the key signaling molecule under heat stress conditions.

By considering its importance the StAnn1 was cloned from the heat tolerant potato cultivar, Kufri Surya and overexpressed in the heat susceptible potato variety Kufri Chandramukhi (Fig. 14).

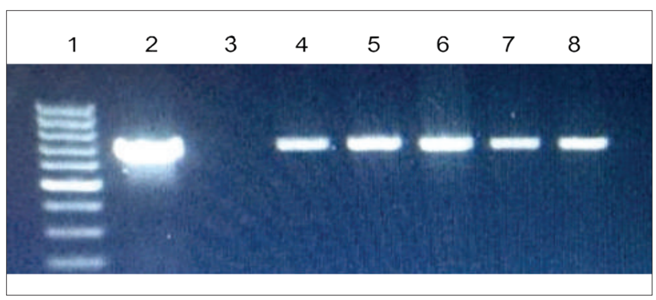


Fig. 14: Putative transgenics of Kufri Chandramukhi expressing the thermo-tolerant AtAnn1 from Kufri Surya. 1: 50 bp ruler, 2: +ve control, 3: -ve control, 4-8: Putative transgenics.

Cloning and sequencing of the StSWEET promoter element from Kufri Girdhari and Kufri Bahar: SWEET transporters are critical to the crop yield and pathogen susceptibility. Expression of these genes was analyzed under late blight conditions in potato and out of 37 SWEET genes in potato 6 genes namely StSWEET10, 14, 18, 29, 31 and 32 were found to be responsive to the late blight. The promoter elements of these genes were cloned and sequenced from the LB resistant cultivar, Kufri Girdhari and LB Susceptible cultivar, Kufri Bahar. Sequence level variation was observed in these promoters elements. These elements along with the RXLR effectors from *P. infestans* will be used to predict the effector binding sites in SWEET promoters.

Development of high temperature tolerant potato: Apart from synthesis of proteins, translation initiation factors play various other important roles in plants. The work was carried out on translation initiation factor eIF(iso)4E gene in potato in response to high temperature. The eIF(iso)4E gene exhibited differential expression when exposed to high temperatures. Complete coding sequence (CDS) of eIF(iso)4E gene was cloned and sequenced. Open Reading Frame (ORF) of the cloned eIF(iso)4E gene contained 603 nucleotides encoding 200 amino acids. The cloned eIF(iso)4E gene sequence showed allelic variations for two nucleotides when compared with the most identical sequence (99 % identity) of eIF(iso)4E available in NCBI GenBank. Comparison with the second most identical sequence (98 % identity) of eIF(iso)4E available in GenBank revealed the allelic variations for 10 nucleotides.

Biofortification of potato with zinc, Cloning of zinc transporter gene (StZnTrp1): NCBI databases search revealed availability of 11full length cDNA sequences of zinc transporter in potato genome. Of these, complete coding sequence (CDS) of one zinc transporter gene (StZn Trp1) from Solanum tuberosum L. cultivar Kufri Chandramukhi was cloned and sequenced. The ORF consisted of 987 nucleotides encoding a protein having 328 amino acids. The deduced protein was predicted to have molecular weight of 35.2 kD and isoelectric point of 5.67. The cloned StZn Trp1gene sequence showed allelic variations for eight nucleotides when compared with the most identical sequence of zinc transporter gene available in NCBI GenBank.

C-13 S. pinnatisectum Somatic hybrid S. cardiophyllum C-13 Somatic hybrid C-13 S. etuberosum Somatic hybrid

❑❑❑

DIVISION OF CROP PRODUCTION

PROGRAMME: INTEGRATED NUTRIENT AND WATER MANAGEMENT FOR IMPROVED PRODUCTIVITY OF POTATO

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

Experiments based on QUEFTS Model: Fertilizers account for a major component of total production cost of any crop, more so in case of potato where the uptake efficiency of applied nutrients is quite low. The under-application of fertilizers results in low economic return whereas over-application increases production costs along with severe environmental hazards. Thus, judicious and precise fertilizer application is anticipated. Models, represented physically or mathematically, are the replica of the system and QUEFTS is one of them. This model encompasses various components of soil fertility and has facility to understand nutrient interactions. Moreover, it provides diagnostic tool to analyses experimental data and helps in making precise fertilizers recommendations. It is a site-specific nutrient management approach, which describes the quantitative evaluation of the native soil fertility, using yield and NPK uptake trials. QUEFTS has been calibrated and validated for NPK fertilizers management in rice, wheat, maize, cassava, elephant foot yam and sweet potato. At ICAR-CPRI, this model is calibrated for potato.

A decision support system NRPPP (Nutrient Recommendation for Potato Production in Punjab) was been developed as per the output derived from QUEFTS Model for Punjab. The model requires inputs viz., date of planting, district and available NPK value. In case, the user is not having the NPK status of their field, he can choose the other option where the tool takes the default value for the particular district and give recommendations accordingly. The tool is user friendly and helps the growers to decide the application rate of NPK nutrients for a fixed target yield ranging from 25-45 t/ha based on their inputs. Further, the model facilitates drop down list, where the user can manually select the desired value. The DSS was developed using ASP.NET (C#) technology and database for the same has been designed using SQL Server (Fig. 1).

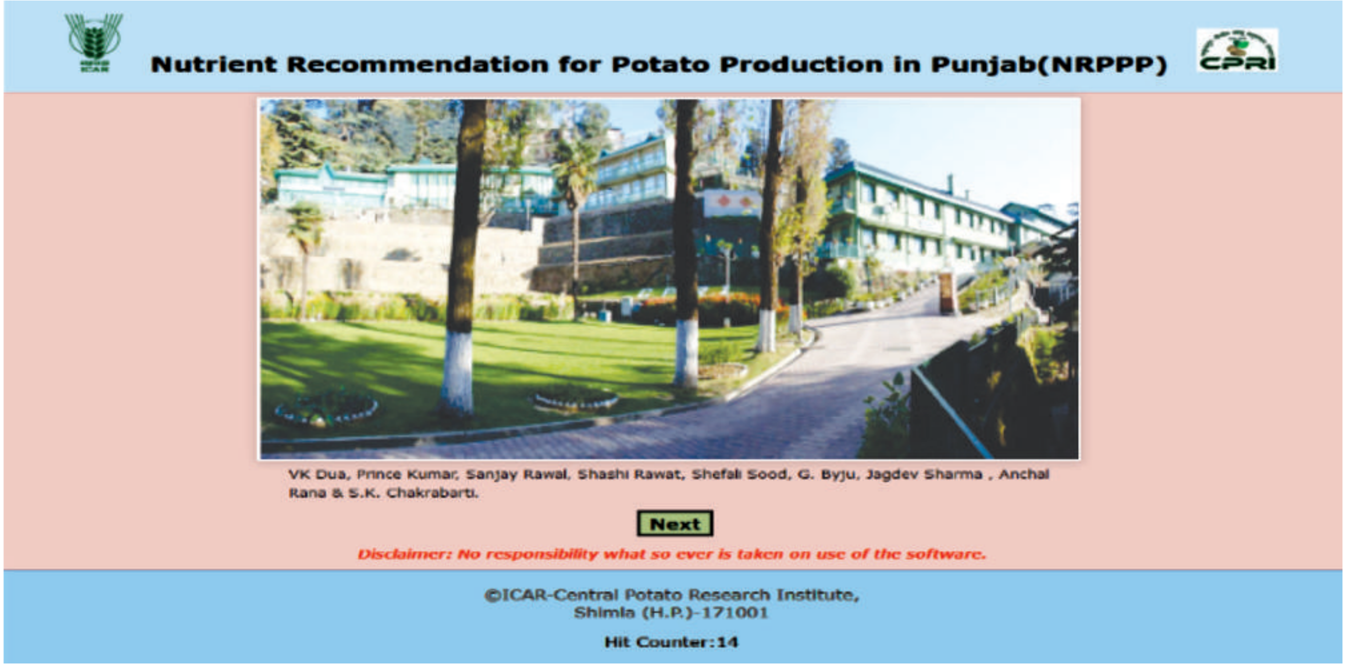
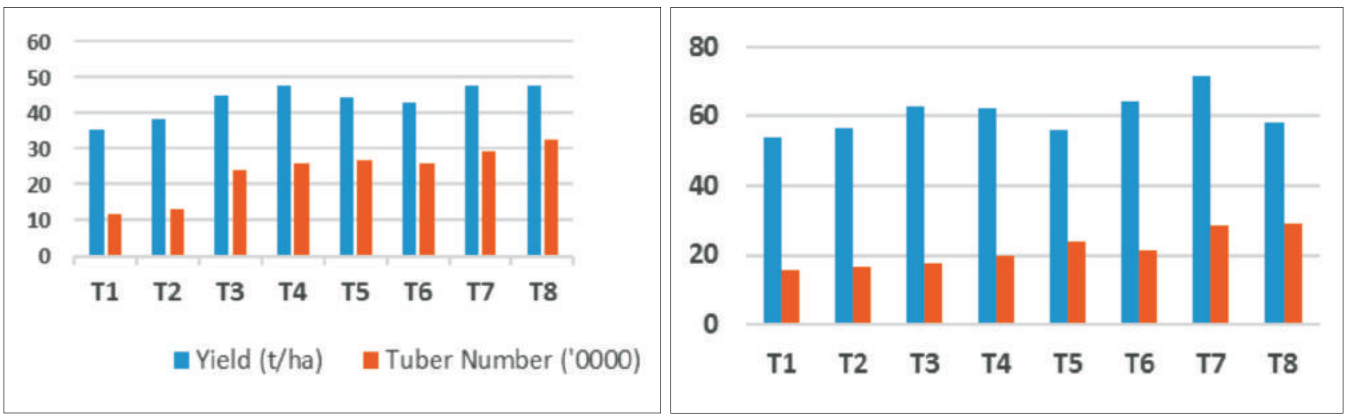


Fig. 1: Nutrient Recommendation for Potato Production in Punjab (NRPPP)

Validation and calibration of QUEFTS model: For Precise nutrient recommendations, a decision support system using QUEFTS model is developed for nutrients requirements in Uttar Pradesh and Punjab. However, this model needs to be periodically validated and tested. Also, the data needs to be generated for further fine-tuning of this model. Keeping this in view, the experiments were conducted at Jalandhar, Gwalior, Modipuram and Patna. Experiments were laid out in such a way that, the QUEFTS model be calibrated with the already available data as well as further information can be generated to enhance its precision.

At Modipuram, in potato cultivar Kufri Garima, the highest yield was obtained with 25% higher NPK than the QUEFTS recommendation (Fig. 2). However, at Jalandhar, Kufri Pukhraj, results showed that the application of NPK based upon QUEFTS model gave the yield at par with that of 125% higher application of NPK. Further, yield obtained with 100% NPK application as per QUEFTS model was also at par with the yield obtained with 125% of recommended NPK. Similarly, at Patna in variety Kufri Pukhraj, application of NPK based upon QUEFTS model resulted in higher yield, which was about 32% higher than the 75% application (Fig. 2). It showed that, the model is performing satisfactorily for giving NPK application recommendation at Jalandhar and Patna.

At Gwalior, application of NPK based upon QUEFTS model produced equivalent yield than application of 125% higher NPK (Fig. 3). In field experimentation, the QUEFTS model is validated and it can be concluded that, QUEFTS model can be used satisfactorily for NPK recommendation at Jalandhar, Gwalior and Patna and needs to be fine-tuned for Modipuram.



(a) *(b)*

Fig. 2: Effect of NPK application as per QUEFTS model on yield and tuber number of Kufri Garima (a) and Kufri Pukhraj (b)

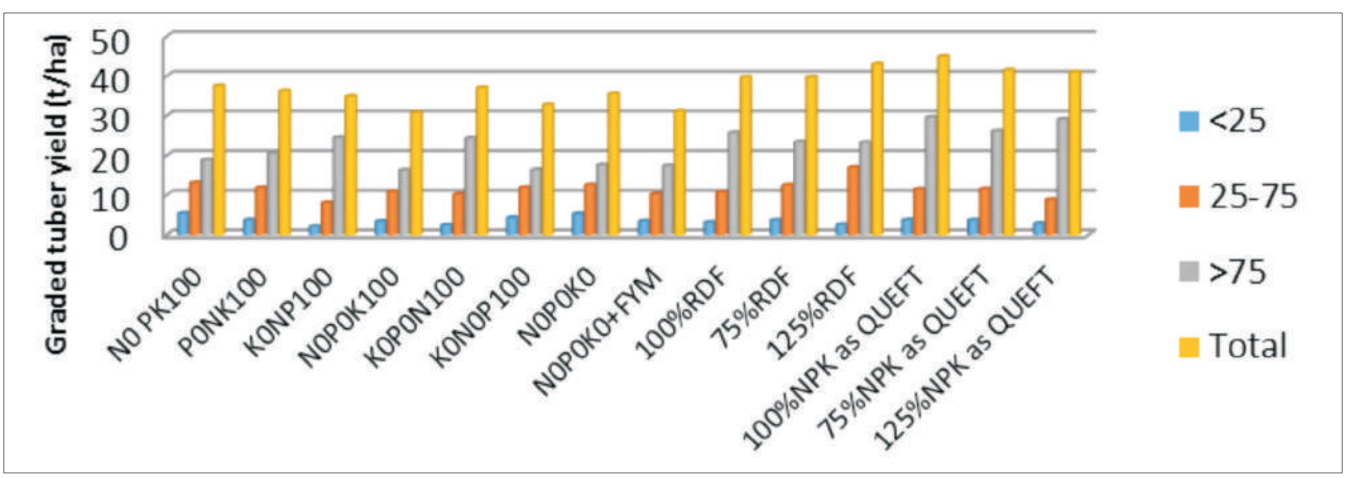


Fig. 3: Effect of NPK application based on QUEFTS model on graded and total tuber yields at Gwalior

Omission plot experiments: For site specific nutrient application and to assess the nutrient supplying capacity of the soil, an experiment was conducted using Kufri Jyoti at CPRS Jalandhar without adding FYM on a green manured field. Highest yield (31.81 t/ha) was obtained when recommended NPK dose was increased to 150% signifying the need for revision of N dose in the absence of FYM application. Omission of N in all the treatment combinations reduced the tuber and above ground biomass yield significantly. Omission of P and K did not affect the tuber yield significantly.

At Modipuram (Kufri Garima) and Patna (Kufri Pukhraj and Kufri Khyati) omission of N resulted in higher yield reductions. Omission of P did not have any significant effect on yield at these locations (Table 1).

Effect of split and foliar application of potassium on potato yield: In order to improve potassium use efficiency, an experiment on split and foliar application was conducted at Jalandhar and Modipuram with variety Kufri Pukhraj. At Jalandhar, omission or delayed application of K (100 % at 25 DAP) reduced the tuber and above ground biomass yield significantly (Table 2 and Fig. 4). Tissue potassium concentration was also significantly lower in these two treatments at 30 DAP. Foliar applications of 1% K in the form of MOP were also found promising in saving 25% dose of potassium. No significant difference was observed between two and three foliar applications of potassium. At Modipuram, the treatment where 75 % of recommended K was applied as basal and 25% at 25 DAP proved superior over rest of the treatments.

Table 1. Experiment using nutrient omission plot technique at Modipuram and Patna

Treatments	Modipuram	Patna	
WS/07-113	Kufri Garima (t/ha)	Kufri Khyati (t/ha)	Kufri Pukhraj (t/ha)
Minus N	16.18	15.20	11.96
Minus P	22.17	17.04	19.32
Minus K	23.41	20.09	17.46
Minus NK	14.16	12.19	14.07
Minus NP	16.42	11.94	11.03
Minus PK	20.29	21.69	19.55
Minus NPK	11.64	12.83	12.49
NPK 100% recommended	25.91	24.44	21.12
LSD (p=0.05)	2.65	--	--

Table 2. Effect of Split and foliar application of K on tuber yield (t/ha) of Kufri Pukhraj

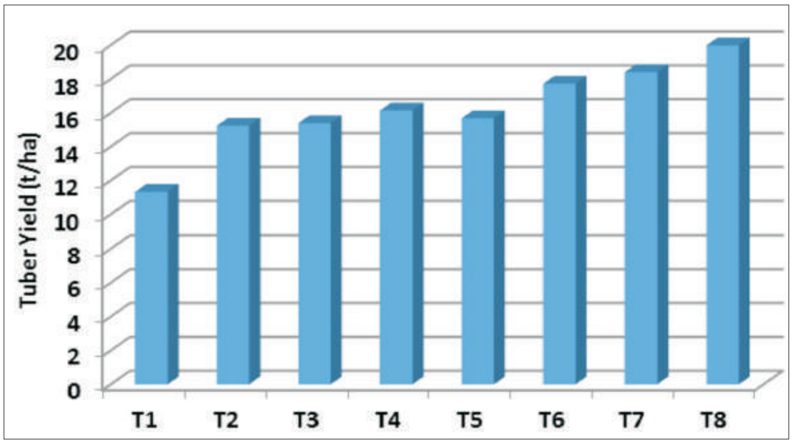
Treatment	Application schedule	Jalandhar	Modipuram
T1	Control (zero K)	28.13	30.04
T2	100% RFD of K application basal	36.23	33.43
T3	100% at 25 DAP at earthing up	30.02	32.18
T4	50% at planting and 50% at earthing up	33.59	33.09
T5	75% at planting and 25% at earthing up	32.99	35.28
T6	75% at planting and 25% at earthing up + two foliar sprays at 25 and 50 DAP	33.68	33.54
T7	75% at planting and 25% at earthing up + two foliar sprays at 25 and 40 and 55 DAP	33.80	35.17
	LSD (p=0.05)	3.33	3.09

Fig. 4. Effect of potassium dose applied at planting (LHS) and 25 days after planting (RHS)

Optimization of phosphorus dose in potato: Invariably P is applied at the higher rate than its uptake due to its low use efficiency. Regular applications of P over the years results in its buildup in soil, which further resulted into adverse effect on dynamics of other nutrients particularly secondary and micro nutrients. Therefore, experiments were undertaken in soils having high available P. At Patna omission of P did not cause any reduction in yield of variety Kufri Khyati in a green manured field although variations in tuber number were observed.

At Shillong, an experiment was conducted using rock phosphate as P source during 2018-summer season with potato var. Kufri Himalini. Highest yield was obtained in the treatment of 100% of recommended P through rock phosphate along with PSB (20.00 t/ha) followed by 75% of recommended P + PSB (18.41 t/ha) and 50 % of recommended P + PSB (17.73 t/ha). The lowest yield was obtained when no P was applied (Fig. 5).

In acidic soil of Ooty, an experiment was conducted to evaluate different methods for increasing the availability of phosphorus using lime, PSB and FYM. The trial was conducted during the summer season with cultivar Kufri Girdhari and during autumn season with cultivar Kufri Swarna. The results showed that, the cultivar Kufri Girdhari recorded maximum tuber yield with 50% P+Lime (14.76 t/ha) followed by 25% P+ PSB+lime (13.46 t/ha) and 50% P+ PSB+lime (13.48 t/ha) compared to control (5.83 t/ha). Kufri Swarna also recorded maximum tuber yield with 50% P+lime (8.01 t/ha) followed by 50% P+ PSB+lime (7.37 t/ha), 75% P+ PSB+lime (7.15 t/ha) and 50% P+PSB (7.02 t/ha) as compared to control (5.15 t/ha) (Fig 6). Better response P in limed plot was possibly due to pH balancing act which might has resulted in less fixation of the nutrient.



T1: 0 P (Control),

T2: 0 P + PSB,

T3: 25% of recommended P,

T4: 25% of recommended P + PSB,

T5: 50 % of recommended P,

T6: 50 % of recommended P + PSB,

T7: 75% of recommended P + PSB,

T8: 100% of recommended P + PSB.

Fig. 5. Effect of rock phosphate on potato tuber yield.

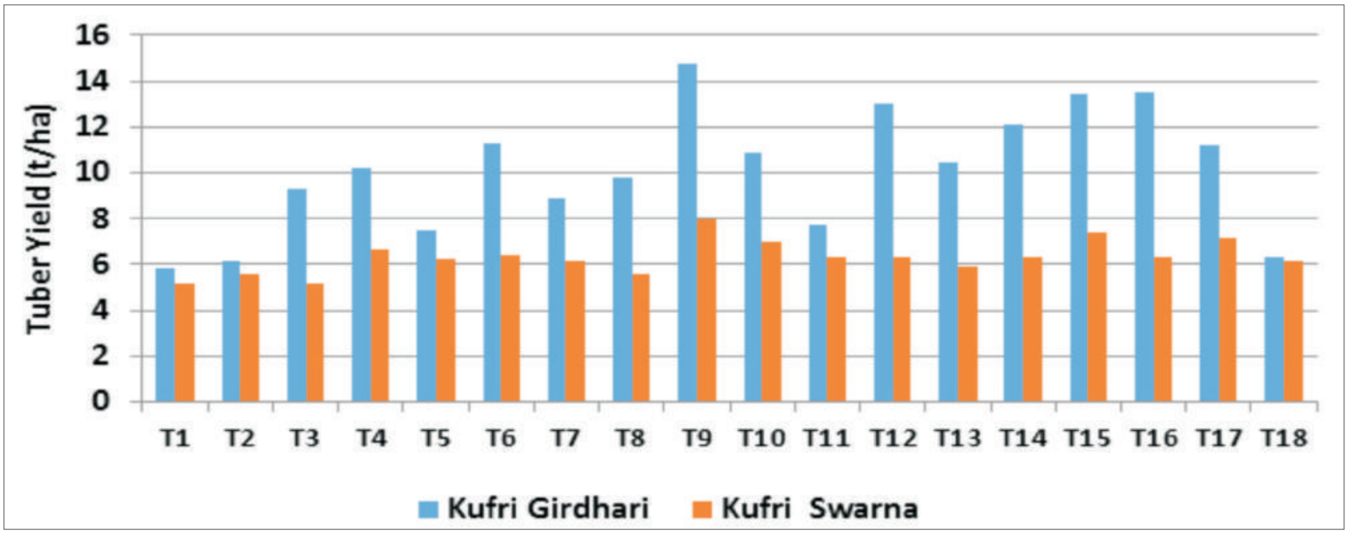


Fig. 6: Effect of different phosphorus optimizing methods on potato yield

Experiments on beneficial and micronutrients: For reducing frost injury, an exploratory trial using foliar applications of potassium silicate was conducted at Jalandhar. Two foliar applications of potassium silicate (3 ml/liter) at 30 and 60 days reduced the late season frost injury to foliage. However, effect of potassium silicate sprays on tuber yield of Kufri Pukhraj was not significant.

Response of potato cultivars to foliar application of boron and molybdenum: A field experiment was conducted at Shillong using cultivars Kufri Himalini and Kufri Girdhari. Among the treatments, boron @ 1-1.5 g/L and ammonium molybdate @ 0.25g/L recorded maximum yield (12.29 t/ha, 12.22 t/ha and 13.07 t/ha). The cultivar Kufri Girdhari recorded highest yield with 1.0g/L sodium borate (15.03 t/ha) and ammonium molybdate 0.25 g/L (15.09 t/ha), whereas, Kufri Himalini recorded maximum yield with the application of ammonium molybdate 0.25g/L (11.06 t/ha) (Fig. 7).

Developing variety specific water and nutrient management schedule under limited water availability: Field experiments were conducted at Modipuram, with six potato cultivars at three moisture regimes viz. irrigation given at 2.5, 2.0 and 1.5 IW:CPE (cumulative pan evaporation) under furrow irrigation, and three fertility levels i.e. 75, 100 and 125 kg K_2O/ha. The tuber yield obtained was in the order of Kufri Khyati > Kufri Pukhraj > Kufri Anand > Kufri Garima > Kufri Sadabahar > Kufri Bahar (Table 3). The irrigation applied at 2.5 IW:CPE ratio produced significantly higher total yield (42.8 t/ha) followed by yield at 2.0 IW:CPE ratio (40.8 t/ha).

The effect of potash was significant on total tuber yield (Table 4). The higher fertility 125 kg K_2O/ha produced highest tuber yield (42.2 t/ha) however, it was statistically at par with the produce of 100 kg K_2O/ha (41.1 t/ha).

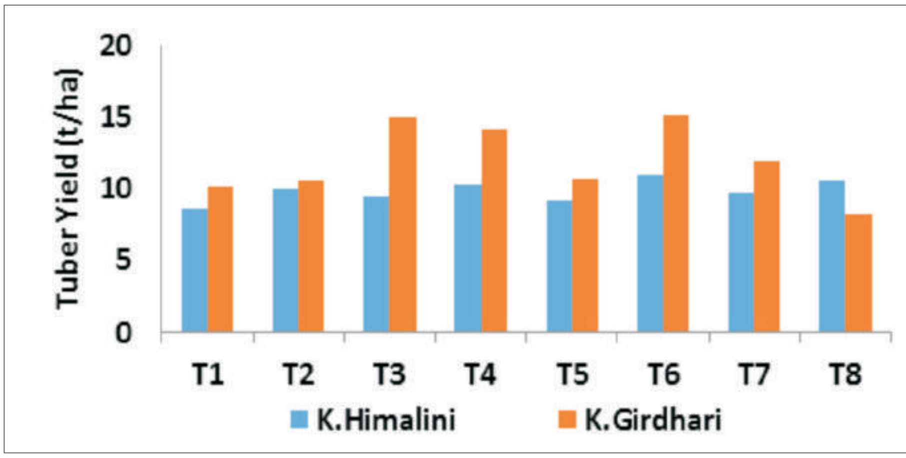


Fig. 7: Effect of foliar application of boron and molybdenum on potato cultivars

Table 3. Productivity and tuber numbers of different potato varieties as influenced by irrigation levels

Treat-ment	Total yield (t ha^{-1})							Tuber numbers (thous.ha^{-1})						
	Kufri Bahar	Kufri Pukhraj	Kufri Khyati	Kufri Garima	Kufri Sadabahar	Kufri Anand	Mean	Kufri Bahar	Kufri Pukhraj	Kufri Khyati	Kufri Garima	Kufri Sadabahar	Kufri Anand	Mean
T1	38.4	48.7	49.6	39.3	39.3	41.5	42.8	595	733	645	711	710	764	694
T2	34.5	42.7	49.8	38.8	38.9	40.3	40.8	539	709	616	647	648	761	653
T3	35.0	45.5	46.6	35.5	35.4	40.0	39.7	508	662	625	534	534	769	606
Average	36.0	45.6	48.7	37.9	37.8	40.6	-	547	701	629	631	631	765	-
LSD at 5%	Variety (V)=1.6; Irrigation (I) =1.1; Interaction (V x I) =NS							Variety (V)=38; Irrigation (I)= 27; Interaction (V x I)=NS						
T1: Irrigation at 2.5 IW:CPE ratio, T2: Irrigation at 2.0 IW:CPE ratio, T3: Irrigation at 1.5 IW:CPE ratio														

Table 4. Productivity and tuber numbers of different potato varieties as influenced by levels of potash

Treat-ment	Total yield (t ha^{-1})							Tuber numbers (000' ha^{-1})						
	Kufri Bahar	Kufri Pukhraj	Kufri Khyati	Kufri Garima	Kufri Sadabahar	Kufri Anand	Mean	Kufri Bahar	Kufri Pukhraj	Kufri Khyati	Kufri Garima	Kufri Sadabahar	Kufri Anand	Mean
75 kg K2O/ha	33.8	44.0	46.9	37.8	37.8	39.7	40.0	522	688	642	633	632	784	650
100 kg K2O/ha	36.9	46.4	48.3	37.3	37.5	40.1	41.1	558	738	609	636	637	716	649
125 kg K2O/ha	37.2	46.4	50.8	38.4	38.4	41.9	42.2	562	679	635	623	624	794	653
Average	36.0	45.6	48.7	37.9	37.8	40.6	-	547	701	629	631	631	765	-
LSD at 5%	Variety (V) = 1.6; Potash (K) = 1.1; Interaction (V x K)= NS							Variety (V)= 38; Potash (K)=27;Interaction (V x K)=NS						
T1: Irrigation at 2.5 IW:CPE ratio, T2: Irrigation at 2.0 IW:CPE ratio, T3: Irrigation at 1.5 IW:CPE ratio														

Table 5. Effect of NK fertility levels on tuber yield and numbers of potato variety Kufri Mohan

Treatment (% RFD)	Total yield (t ha^{-1})				Tuber numbers (thous.ha^{-1})			
	Large (>75 g)	Medium (25-75 g)	Small (< 25 g)	Total	Large (>75 g)	Medium (25-75 g)	Small (< 25 g)	Total
75 % of NK ha-1	20.8	21.8	1.7	44.3	155	378	130	660
100 % of NK ha-1	40.2	14.6	2.0	56.8	273	254	139	666
125 % of NK ha-1	39.4	19.6	1.7	60.7	234	373	245	852
LSD at 5%	5.0	1.9	NS	3.9	53	54	48	61

Table 6: Effect of NK drip-fertigation on productivity and tuber number of processing potato varieties

Treatment (% RFD)	Potato yield (t/ha)		Mean	Tuber numbers		
	Kufri Chipsona-1	Kufri Frysona		Kufri Chipsona-1	Kufri Frysona	Mean
75 % NK through fertigation	26.8	28.3	27.6	606	634	620
100 % NK through fertigation	33.3	39.7	36.5	654	684	669
125 % NK through fertigation	45.7	50.0	47.8	755	788	772
150 % NK through fertigation	49.4	52.4	50.9	849	786	817
Mean	38.8	42.6	-	716	723	-
LSD at 5%	Variety=2.2; Fertigation=3.1; Interaction (VxF)=NS			Variety =NS; Fertigation = 89; Interaction (VxF) =NS		

Nitrogen requirement of newly released potato variety under drip fertigation: A trial was laid out at Modipuram, with three levels of NK nutrients viz. 75, 100 & 125% of the recommended NK dose for direct soil application through drip-fertigation in newly released variety Kufri Mohan. The total yield was maximum (60.7 t/ha) with 125% recommended NK fertigation (1/3 NK applied as basal and 2/3 dose applied through drip-fertigation) in comparison to other treatments, but, statistically it was also found at par with 100% recommended NK fertigation which gave a yield of 56.8 t/ha (Table 5).

In another trial, four levels of N+K (75, 100, 125 and 150 % of the recommended dose for direct soil application) were applied through drip-fertigation in main plots and two potato varieties viz. Kufri Chipsona-1 and Kufri Frysona in sub plots were tried to work out NK requirement with drip fertigation. The var. Kufri Frysona produced significantly higher yield (42.6 t/ha) in comparison to Kufri Chipsona-1 (38.8 t/ha) (Table 6).

The total tuber yield was maximum (50.9 t/ha) with 150% recommended NK drip-fertigation (1/3 NK applied as basal and 2/3 doses given through drip-fertigation) against other treatments, but, statistically it was at par with 125% recommended NK fertility (47.8 t/ha).

PROGRAMME: RESOURCE OPTIMIZATION IN POTATO BASED CROPPING SYSTEM

In this research programme, investigations were made for yield gap analysis in Bihar and Meghalaya, development of Indian good agricultural practices (GAP) for production of potatoes and agro-technologies for organic potato production, efficient potato based cropping systems in West-central plains and Nilgiris, long term experiment, metagenomics studies and fabricating useful farm machines, affordable net houses and tools for potato cultivation and handling. The main findings are presented below:

Yield gap analysis for potato crop in different agro-ecological regions

Analysis of yield gap of potato in Bihar and Meghalaya: Existence of yield gap in horticultural crops is a major issue in India where actual yields are far below the potential yields. A survey for analyzing the yield gap of potato was conducted in district Vaishali and Saran (Bihar) and East Khasi Hills, Ri Bhoi and West Khasi Hills (Meghalaya). Total yield gap (TYG) was computed for cv. Kufri Sindhuri (Bihar) and Kufri Himalini (Meghalaya). It was observed that there were significant differences in productivity of potato crop at farmers' fields in comparison to demonstrations and potential yields in both the states. In Bihar, TYG was 15.2 t/ha (YGI=5.9 t/ha and YGII=9.3 t/ha) which was about 43.4%. TYG in Meghalaya was even larger 17t/ha (YGI=4.5 t/ha and YGII=12.5 t/ha) which was about 48.6% (Fig. 1).

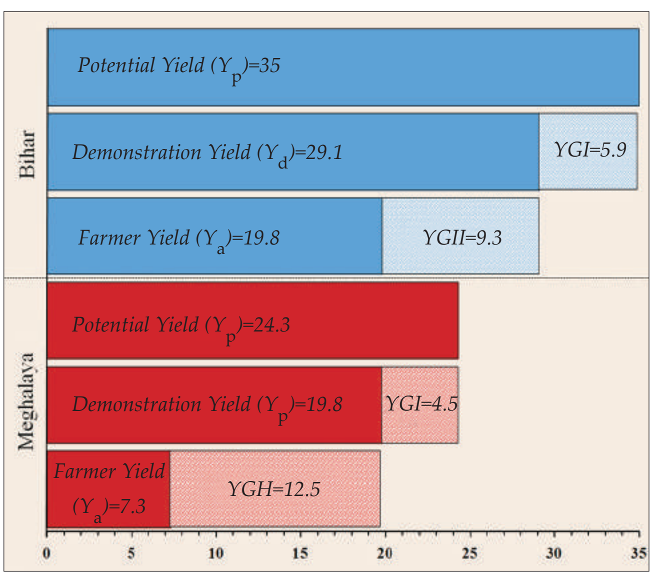


Fig. 1: Potato yields (t/ha) and yield gaps (t/ha)

The reasons for wide yield gaps in Bihar was that large potato area (38.6%) is still under susceptible and low-yielding local potato varieties like Bhura Aloo, Lal Gulab and C-1 etc. Further farmers use farm saved seeds for a long period of time and plant potato late due to water logging condition in the study areas. In Meghalaya, yield gap could be due to less or no use of fertilizers and pesticides by majority of farmers and they are growing low yielding highly susceptible local varieties or old cv. Kufri Jyoti which has become highly susceptible to late blight. They also use own seed for longer period due to non-availability of quality seeds.

Indian good agricultural practices (GAP) for production of potato crop

Developing Indian GAP: Good Agricultural Practices (GAP) are required for organized marketing of potato crop, better farm profits and sustaining productivity by conserving the farm site and environment. Document for Indian GAP for production of potato crop has been developed to aware the different potato stake holders about this farm certification scheme which include control points and their compliances for IndGAP certification developed by Quality Council of India (QCI).

Optimizing date of planting for potato cultivars in Nilgiris: A field experiment was conducted during summer season with four cultivars (Kufri Girdhari, Kufri Himalini, Kufri Jyoti and Kufri Swarna) and six different dates of planting starting from 27.04.2018 to 01.06.2018 at seven days' interval to find out the suitable planting date (Fig. 2).

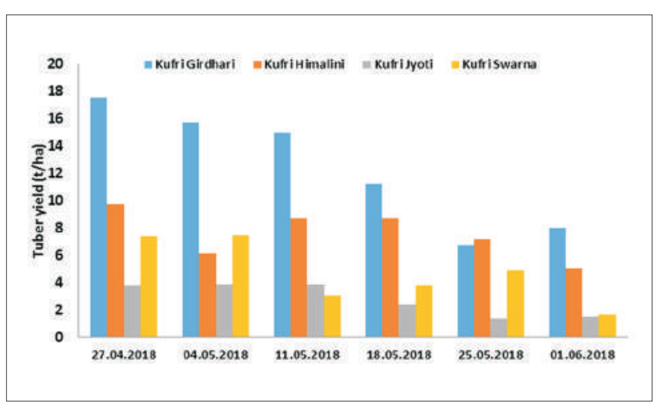


Fig. 2: Effect of different planting dates on potato yield

Crop planted on 27.04.2018 recorded highest tuber yield (9.63 t/ha) followed by 04.05.2018 (8.29 t/ha). Cultivars Kufri Girdhari (17.6 t/ha), Kufri Himalini (9.76 t/ha) and Kufri Swarna (7.40 t/ha) planted on 27.04.2018 recorded maximum yield, whereas, cv. Kufri Jyoti had highest tuber yield during first three dates of planting.

Organic potato production technology development

Performance of potato varieties in organic farming systems: At Modipuram, ten varieties were evaluated in organic farming (CPRI technology) and zero budget organic farming. Yield maintenance of all the genotypes was comparable in both the systems. Variety Kufri Mohan, Kufri Garima and Kufri Khyati recorded total tuber yield of 20.6, 19.8 and 19.8 t/ha, respectively in organic farming (CPRI), while their yields were 22.0, 18.2 and 16.2 t/ha, respectively in zero budget organic farming. Processing varieties Kufri Chipsona-1 and Kufri Chipsona-3 attained 11.2 & 12.6 and 14.9 & 16.8 t/ha in organic farming (CPRI) and zero budget organic farming, respectively (Fig. 3).

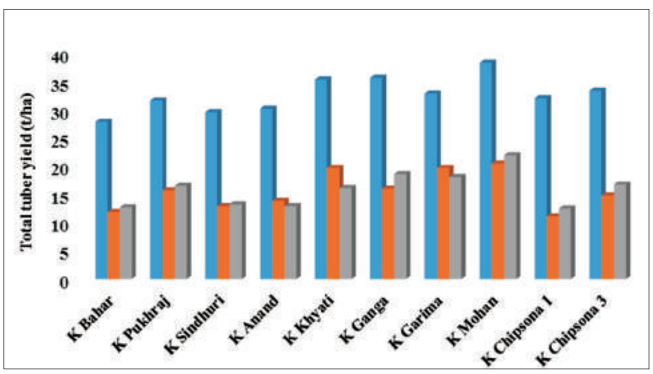


Fig. 3: Total tuber yield (t/ha) of potato varieties in organic farming systems

Disease and pest management: Foliar spray of Agrispray (horticulture mineral oil) @ 5 ml/l was found very effective for the control of white fly in organic farming plots in comparison to control. A field experiment was conducted to develop management strategies for late blight through organic based/ restricted used chemicals with two cultivars (Kufri Bahar and Kufri Mohan). Treatments were T1: Copper oxychlorde @ 0.2%, T2: Copper hydroxide @ 0.2%, T3: Bacillus subtillus-0.25%, T4: Trichderma viridae @ 2.0%, T5: Neem giri fermented @ 1.0%, T6: Neem oil @7.0, T7: Pseudomonas fluorescence @ 1% a market product and T8: Control. Copper hydroxide @ 0.2% and copper oxychlorde @ 0.2% showed less disease severity of 56.67% and 61.67%, respectively against control (93.33%) on cv. Kufri Bahar. Alike in Kufri Mohan, copper hydroxide @ 0.2% and copper oxychlorde @ 0.2% also recorded lower disease severity of 33.33% and 36.67% against control having disease severity of 85.00% (Fig. 4). It was also observed that higher concentration of neem oil reduced this parameter.

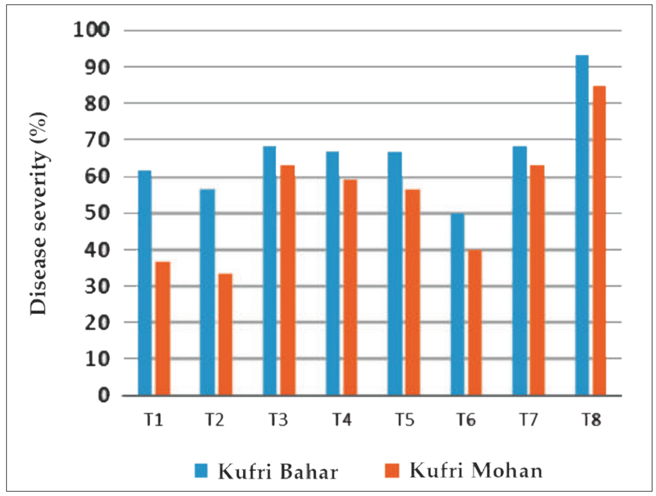


Fig. 4: Effect of organic based/ restricted used chemicals on disease severity of late blight

Comparison of biochemical traits in inorganic and organic potatoes

Flavonoids were found to be maximum in cv. Kufri Chipsona-1 (20.87 mg/ 100g fresh weight) followed by Kufri Chipsona-3 (20.00) and Kufri Sindhuri (18.97) in organic potatoes. In inorganic potatoes, cv. Kufri Chipsona-1 (16.05) accumulated more flavonoids followed by Kufri Sindhuri (15.89), Kufri Chipsona-3 (15.73) and Kufri. Bahar (15.57) as depicted in Fig. 5.

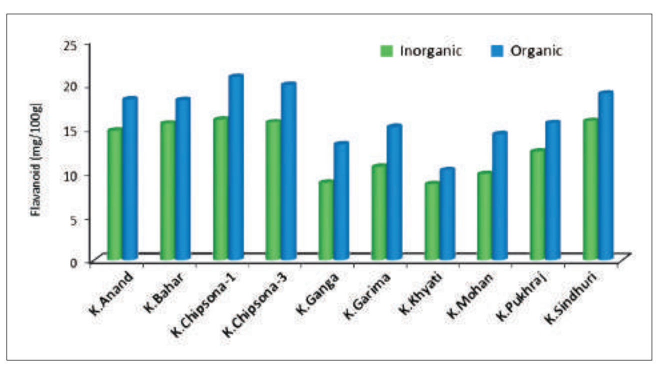


Fig. 5: Flavonoids content in inorganic and organic potatoes

Like flavonoids, more phenols were registered in organic potatoes in comparison with inorganic ones (Fig. 6). These were observed maximum in

Kufri Chipsona-1 (55.29 mg/ 100g fresh weight) followed by Kufri Khyati (14.87) in organic potatoes. While in inorganic potatoes, cv. Kufri Chipsona-1 (53.83) exhibited higher content followed by Kufri Anand (50.72).

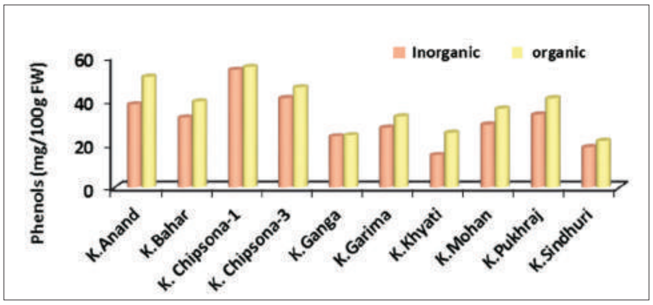


Fig. 6: Phenols content in inorganic and organic potatoes

In general, tuber dry matter content (%) was marginally better in organic potatoes over inorganic one (Fig. 7). It varied in inorganic samples between 15.06 to 20.03% in Kufri Ganga and Kufri. Chipsona-3, respectively. Maximum tuber dry matter content in organic potatoes was observed in processing cv. Kufri Chipsona-1 (19.60%) and Kufri Chipsona-3 (19.13%).

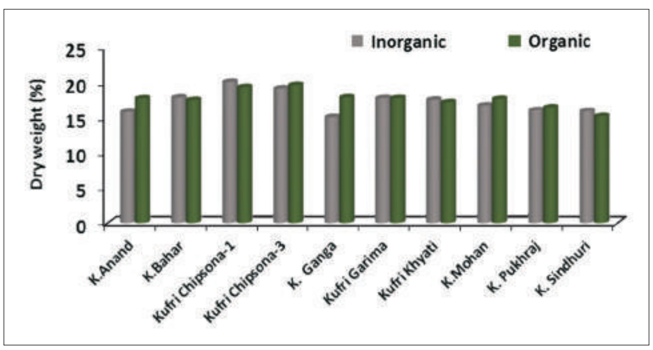


Fig. 7: Difference in tuber dry matter content of inorganic and organic potatoes

Reducing sugars is one of the most important parameters from processing point of view. It should be below 150mg/ 100g fresh tuber weight for suitability of potato processing.

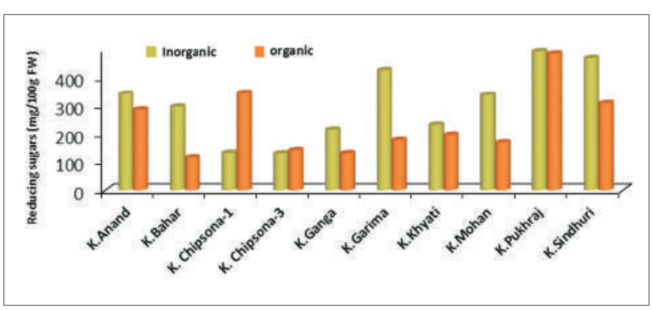


Fig. 8: Reducing sugars in inorganic and organic potatoes

In general, inorganic potatoes had lower reducing sugars (Fig. 8). Variety Kufri Pukhraj (490.23) retained maximum reducing sugars among all the varieties. In organic potatoes, this trait varied from 131.73 to 482.00 in Kufri Ganga and Kufri Pukhraj, respectively.

Sucrose content is an indicator of chemical maturity. In general, this parameter was higher in organic potatoes over inorganic one. Processing varieties Kufri Chipsona-1 and Kufri Chipsona-3 recorded less than 100 mg sucrose content in inorganic and organic tubers (Fig. 9).

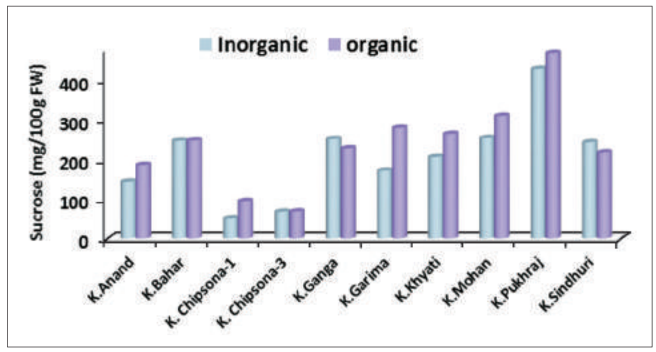


Fig. 9: Sucrose content in inorganic and organic potatoes

Development of potato based cropping systems for different agro-ecologies

Evaluation of potato based cropping systems at Gwalior: In three potato based systems, i.e. maize-potato, cowpea-potato and maize+cowpea-potato, planting of potatoes was done after three crops of *kharif* season *viz.* maize, cowpea and maize+ cowpea, respectively. Highest maize equivalent yield (31.0 t/ha) was recorded in maize+ cowpea-potato sequence. Lowest maize equivalent yield (25.0 t/ha) was found in cowpea- potato system (Figs. 10 & 11).

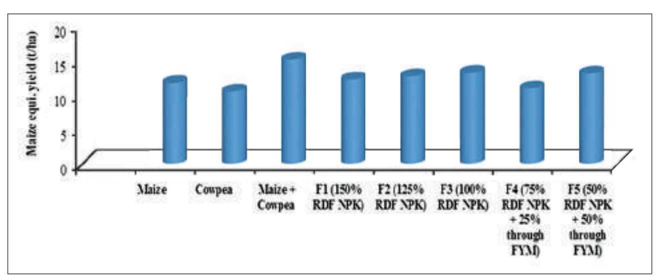


Fig. 10: Maize equivalent yield (t/ha) as affected by cropping system and fertility levels

This was due to lower yield of cowpea as compared to maize. Among different fertility treatments, application of 150% recommended dose of NPK in all the crops gave highest potato equivalent yield (52.4 t/ha), which was significantly higher over other treatments. Other levels of 125% NPK (48.1 t/ha), 75% NPK+ 25% FYM (48.4 t/ha) and 100% NPK (44.4 t/ha) followed the trail (Table 1).

Table 1: Potato equivalent yield as influenced by cropping system and fertility levels

Cropping system	Tuber equivalent Yield (t/ha)
Maize- Potato	27.8
Maize+ Cowpea- Potato	31.0
Cowpea- Potato	25.0
CD(P=0.05)	2.70
Fertility level	
150% RDF NPK	52.4
125% RDF NPK	48.1
100% RDF NPK	44.4
75% RDF NPK+ 25% FYM	48.4
50% RDF NPK+ 50% FYM	39.7
CD(P=0.05)	1.90

Fig. 11: Maize+ cowpea inter-cropping

Evaluation of different potato based cropping system in Nilgiri: At Ooty, potato cultivar Kufri Jyoti was planted as main crop in summer season, and potato and other crops viz., cabbage, carrot and garlic were planted subsequently in autumn season. Yield of potato crop in summer ranged from 5.46-11.4 t/ha, while in autumn it was 6.30-9.35 t/ha. Highest potato equivalent yield (PEY) was obtained from potato-garlic sequence (37.7 t/ha), whereas PEY of crop sequences potato-cabbage (23.4 t/ha) and potato-carrot (23.1 t/ha) was found at par (Fig. 12).

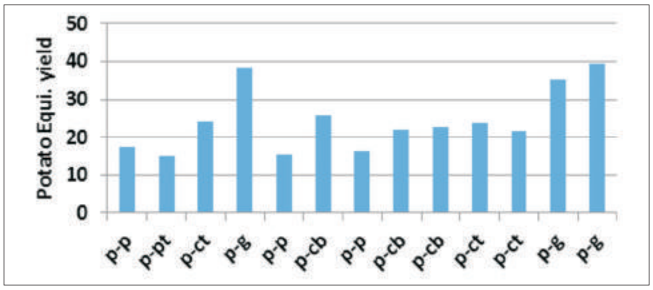


Fig. 12: Potato equivalent yield (t/ha) in different cropping systems

Long term plant nutrition studies in potato based cropping systems

Productivity: Three cropping systems, rice-potato-wheat, maize-potato-onion and groundnut-potato-green gram were studied in eleventh crop cycle. The inorganic treatment recorded total tuber yield (27.0- 31.2 t/ha) comparable to 100% inorganic nutrition + secondary nutrients or crop residue (28.6- 31.7 t/ha) in all three cropping systems where absolute control (7.2- 9.3 t/ha) had significantly lower yields (Fig. 13). Potato (35.5-50.7%), maize (30.6%) and onion (10.7%) yield was lower in 100% organic nutrition when compared with inorganic treatment. Whereas, productivity of rice, wheat, groundnut and green gram was at par in organic and inorganic nutrition. Mean system productivity was highest in maize-potato-onion (62.3 t/ha) followed by groundnut- potato- green gram (49.7 t/ha) and lowest system productivity was recorded in rice-potato-wheat (45.8 t/ha).

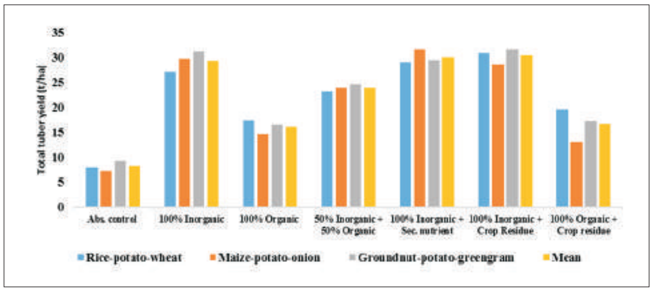


Fig. 13: Plant nutrition effect on total tuber yield

Soil Health: Per cent organic carbon content (OC) in soil had significant variations among different treatments of plant nutrition after tenth crop cycle (Fig. 14). Crop residue and organic manures application with or without inorganic fertilizers improved OC in soil. In rice- potato- wheat system, 100% organic+ crop residue treatment recorded highest organic carbon content (0.96%) whereas 100% inorganic nutrition and control had 0.49 and 0.42% OC only. In maize- potato- onion, highest OC was also observed in 100% organic+

crop residue treatment (0.63%) and similar findings were also there in groundnut- potato- onion (0.42%). These results may be utilized in system based optimization of nutrient application from organic and inorganic sources for lowering the cost of cultivation at farms.

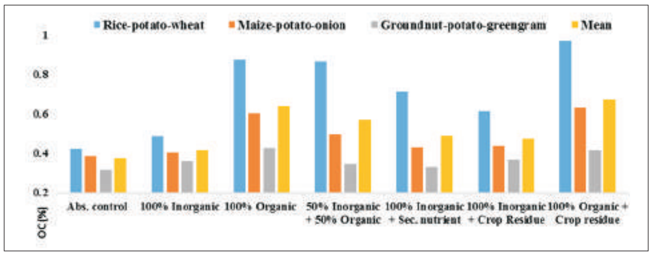


Fig. 14: Status of organic carbon in long term experiment after tenth crop cycle.

Disease incidence: Pathogens are affected by different sources of nutrients applied during crop cultivation and sequences of crops followed. Observations were recorded on foliar diseases of potato (phoma and leaf spot complexes) in three cropping systems viz., potato- wheat- paddy (C1), potato- onion- maize (C2) and potato- green gram- groundnut (C3). Results revealed that absolute control, 100 % NPK through organics and 100% organic+ crop residue had high disease incidence (DI) in all three systems over inorganic sources of nutrients (Fig. 15). Observations on black scurf of potato in all crop sequences showed that highest DI was in treatment of 100% organic+ crop residue (18.33%) followed by 100 % NPK through organics (15.44%) in C1 system. Highest DI of black scurf of potato was recorded in treatment of 100% NPK through inorganic fertilizer (42.00%) followed by 100% NPK through inorganic+ secondary nutrient (40.67) in C2 system, while in C3 sequence, highest DI (6.04%) was in 100% organic+ crop residue treatment (Fig. 16). In paddy crop (C1), disease incidence for sheath blight and bakane disease was recorded and highest DI of sheath blight was in 100% NPK through inorganic+ secondary nutrients (43.33%) followed by DI of 38.33% in 100% NPK through inorganic+ crop residue. Maximum DI of bakane disease in rice was in 100% NPK through inorganic+ crop residue (19.33%) followed by 100% NPK through inorganic fertilizer (18.00%). In C2 system, highest DI of banded sheath blight of maize was observed in 100 % NPK organics+ crop residue (40.0%) followed by 100% NPK organic manure. In this cropping system, incidence of alteraria leaf spot of onion was recorded and results revealed that less incidence was there in treatments consisting of organic nutrient sources over the inorganic one. Besides, these observations powdery mildew of wheat, dry root rot of green gram, sclerotium rot of ground nut and leaf spot of groundnut were also observed in C1 and C3 system.

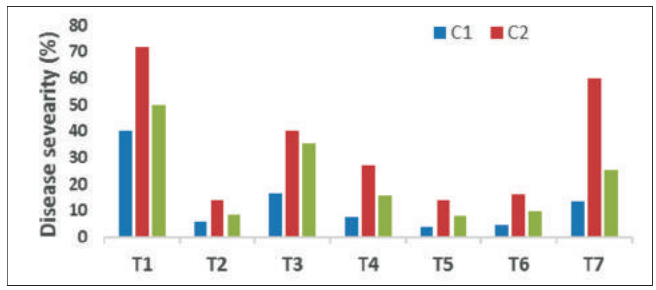


Fig. 15: Incidence of phoma and leaf spot complexes in potato- wheat- paddy (C1), potato- onion- maize (C2) and potato- green gram- groundnut (C3) cropping system

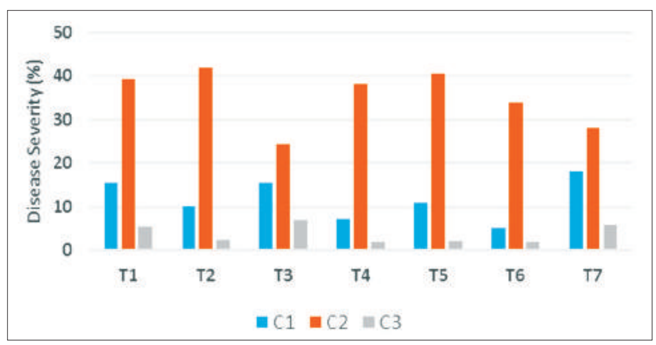


Fig. 16: Incidence of black scurf of potato in potato- wheat- paddy (C1), potato- onion- maize (C2) and potato- green gram- groundnut (C3) cropping system

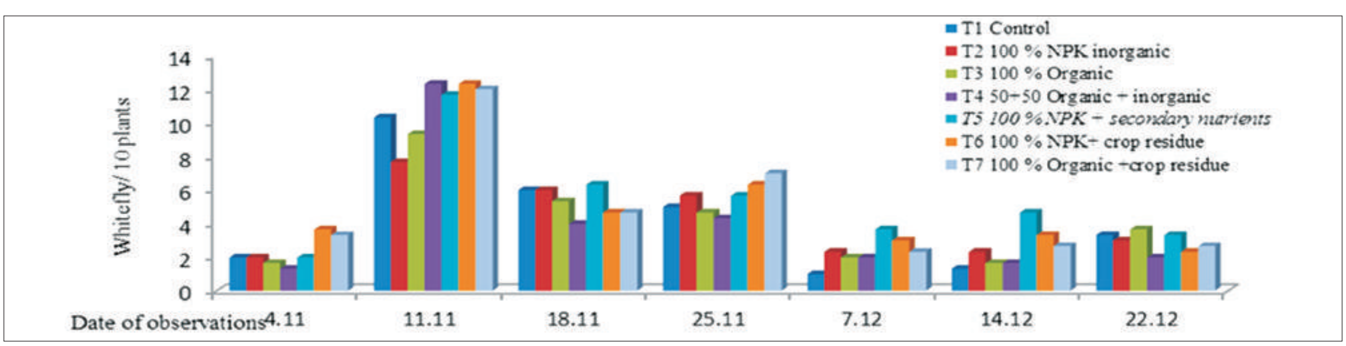


Fig. 17: White fly population in potato crop (C1)

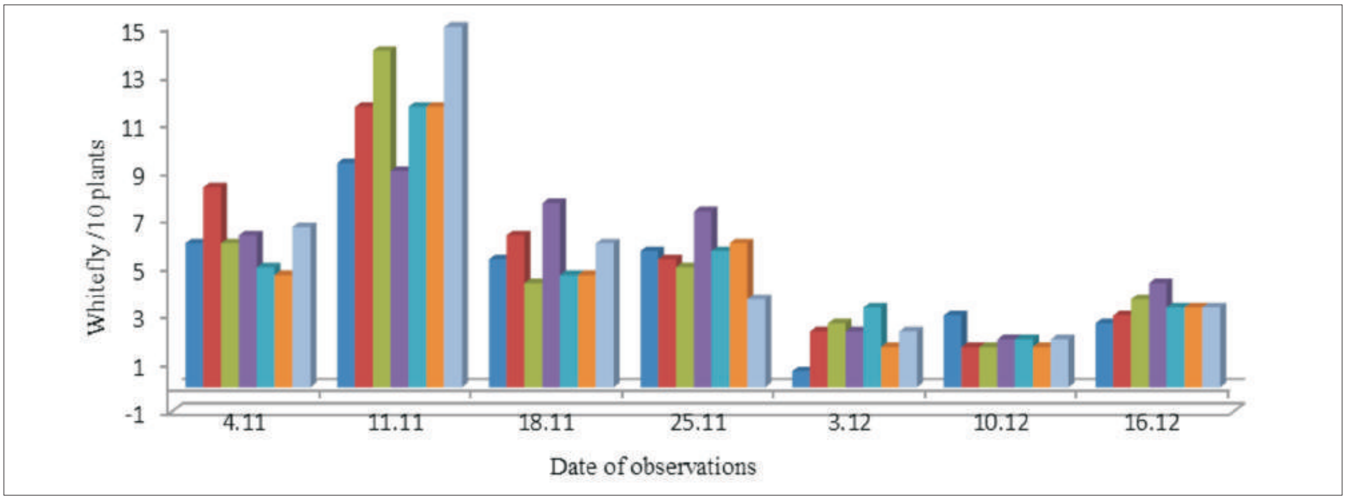


Fig. 18: White fly population in potato crop (C2)

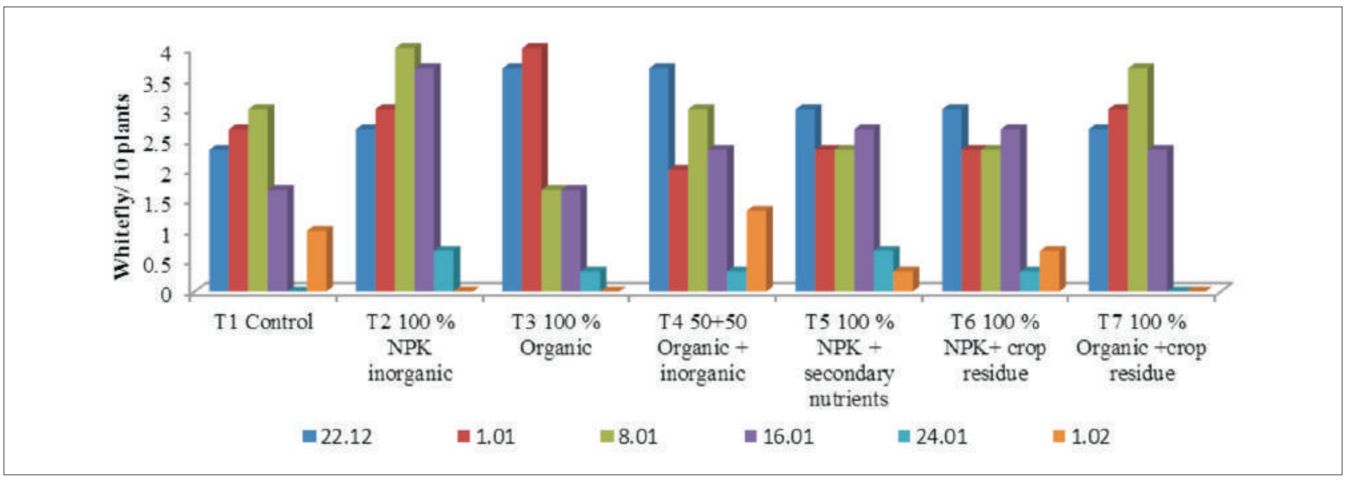


Fig. 19: White fly population in potato crop (C3)

Pest incidence: Population of thrips on groundnut, stem borer damage in maize and leaf folder and stem borer damage in rice did not show any significant differences among various treatments. Maximum incidence of blister beetle was recorded in groundnut in 100% NPK+ secondary nutrients followed by 100% NPK+ crop residue.

Similarly, maximum incidence of semilooper in groundnut was recorded in 100% NPK+ secondary nutrients in C3 system. Low incidence of whitefly and thrips was observed in green gram and onion crops, respectively. Sporadic incidence of pod borer was also found in green gram. Maximum bird damage in maize cobs was recorded in 100% organic+ crop residue. Population of leafhopper and mite did not buildup in potato crop during past season in any sequence. Whitefly incidence in potatoes showed marked differences among different treatments of C1, C2 and C3 cropping systems. In C1 (100% NPK+ secondary nutrients), C2 systems (50% organic+ 50% inorganic) and in C3 (100% organic) recorded maximum incidence of whitefly (Figs. 17-19). Cutworm damage in tubers was maximum in C3 (100% NPK+ secondary nutrients) followed by C2 (100% NPK+ secondary nutrients) and C1 (100% NPK+ secondary nutrients).

Mechanical technologies for potato cultivation

Assessment of potato damage during mechanical operations and its remedial measures: All rods of rod chain conveyor of elevator digger were covered with rubber lining (4 mm thick) for reducing damages caused to tubers during harvesting with a tractor operated potato elevator digger. Depth of digger blade, speed of forward travel and of moving parts of digger influence greatly harvest damages to the tubers.

Two tractor operated row potato elevator diggers (T1: with rubber lining on all rods & T2: without rubber lining) were tested at three different forward speeds at same harvest depth for assessing the damage index (DI). Samples were collected, washed and divided into categories of undamaged, scuffed, slight and severe damage. Severe type of DI was maximum (60.2) at forward speed of 2.0 km/hr and it was minimum (3.5) at forward speed of 2.6 km/hr (Fig. 20-22) in T2. Scuffed (6.27) and slight (3.45) DI for T1 was minimum at forward speed of 2.0 & 3.2 km/hr (Fig. 21). Bruising assessment of potato tubers after digging with elevator diggers with (T1) and without rubber lining (T2) was also carried out. This assessment was categorized as nil, slight and severe. Bruising (%) in T1 was 4 and 8% for slight and severe type, respectively (Fig. 22). Slight and severe types of bruising with T2 was 10.68 and 9.32% respectively (Fig. 23). A test was also performed for simulating mechanical damage caused by all tumbling and dropping during harvesting and handling operations. Tubers of cv. Kufri Pukhraj were dropped from various heights (30, 60, 90 and 120 cm) onto a hard surface for causing damage to tubers. External damages (30%) were maximum with drop height of 120 cm. Severe bruising was also maximum (40%) with drop of 120 cm.

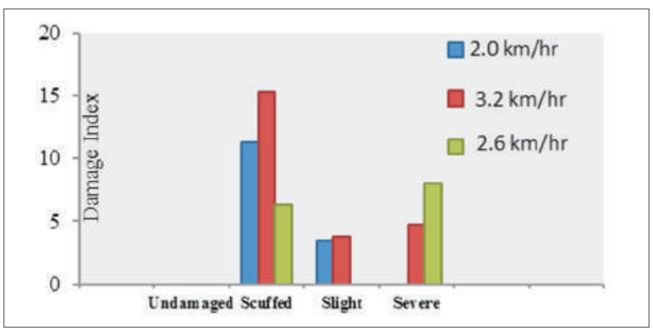


Fig. 20: Damage Index at three different speeds of operation with rubber lined rods of potato elevator digger (Kufri Pukhraj)

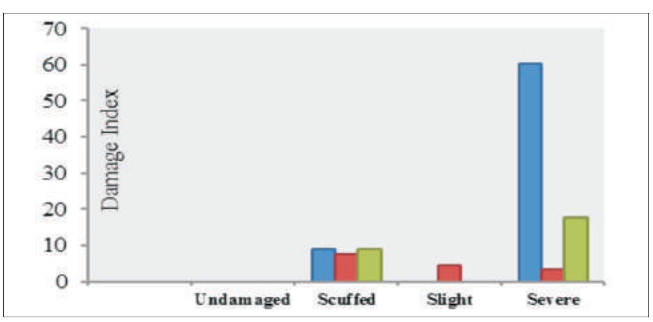


Fig. 21: Damage Index at three different speeds of operation without rubber lining on rods of potato elevator digger (Kufri Pukhraj)

Fig. 22: Bruising with potato elevator digger with rubber lined elevator conveyor rods (Kufri Pukhraj)

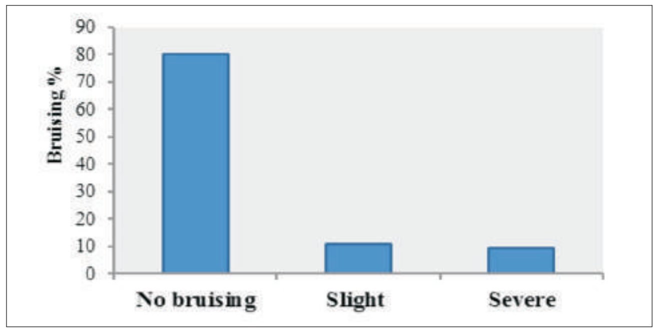


Fig. 23: Bruising with potato elevator digger without rubber lined rubber lined elevator conveyor rods (Kufri Pukhraj)

Conveyor for potato loading and unloading to reduce tuber damage and human drudgery: A variable height belt type conveyor was designed and developed for safe handling of loose potato and in bags (Fig. 24). It consists of a grooved rubber belt, electric motor, motorized hydraulic power pack, transporting wheels, programmable logic circuit and a control panel. Rubber belt (75 cm wide & of 3 ply rating) with rubber retainers of height 2.5cm constitutes the tuber conveying system. Conveyor belt has also been provided with four numbers of wheels for its easy transportation to work site. Height of conveyor belt can be easily hydraulically adjusted as per the requirement (Table 2). It can be transported either manually or with a tractor. A pair of telescopic arms has also been provided on the lower side of hydraulically controlled system for changing inclination of belt for efficient conveying of the potatoes.

Fig. 24: Conveyor for potato loading and unloading

Table 2: Salient features of conveyor for potato loading and unloading

S. No.	Item	Specifications
1	Type	Electric motor operated, hydraulically adjustable
2	Overall length (cm)	501
3	Overall width (cm)	137
4	Length of conveyor belt (cm)	500
5	Height adjustability range (cm)	70 to 207
6	Peripheral speed range of belt	0.11- 0.38 m/s
7	Power requirement	Two numbers of electric motors (1.5 kw and 1 kw)
8	Method of feeding	Manual feeding
9	Transportability	Four transport wheels
Performance evaluation of conveyor		
10	Average output capacity (t/h)	30-35
11	No. of labourers required	6-8

Potato minituber size grading system: A portable minituber grading system has been developed consisting of a feed hopper, conveying tray, grading unit, two electromagnetic vibrators and a controller. System is provisioned to grade the minitubers in four different sizes. The size of grading categories can be adjusted as per the requirements in the range of 6-30 mm) using a variable area of collection unit. An average throughput capacity of the machine is 40 kg/h.

CPRI Net-house: A low cost net house was developed at CPRS Jalandhar for multiplying early generation seed potato. It consists of a modular steel structure with steel wire web roof covered with a 40 mesh net. The covering net can be removed and structure can be dismantled in off-season. The structure is provisioned to shift to different location as per requirement. Tractor can easily be maneuvered inside the net house to perform various mechanical operations. On an average 60% cost of fabrication can be reduced as compared to existing net houses with this technology.

Hand tools for potato cultivation: A number of hand tools were developed at Jalandhar for use in potato as well as other horticultural crops. These hand tools were classified as per their shape and operational postures. 'L' and 'T' shaped tools are designed for weeding/ intercultural operations in squatting posture. Whereas, other triangular and 'T' type hand tools perform weeding/ intercultural operation in standing posture. Depth of operation of these tools is approximately 10-30 mm. A new design of spade was developed for intercultural operations such as ridging, earthing up, water channel making, digging, etc. especially in potato crop. This can be operated by male or female workers easily and less soil needs to be moved for shaping same length of ridge than traditional spades.

Potato cleaning, treatment and grading line: Several post-harvest operations such as cleaning, sorting, treatment, drying, grading, packaging etc. need to be performed before storage/supply of seed/ table potato. These operations consume more time, labour and cost. Therefore, a design of potato treatment and grading line was developed to perform all these operations in one go. The system consists of a brush type potato cleaning unit, seed treatment unit (with liquid solution of boric acid), hot air drying unit, sorting platform, size grading and packaging unit. Three-phase modulated electric gear motors were employed for conveying, cleaning, grading and packaging operation. Throughput capacity of the system is 10 t/h.

Development of potato starch extraction machine: Preliminary starch extraction experiments were conducted on two potato varieties (Kufri Chipsona-1 and Kufri Jyoti) and were tested on cassava starch extraction unit. Results of the experiments indicated that potato starch extraction efficiency of existing cassava starch extraction unit was more than 90% for both the varieties.

These findings indicate that cassava starch extraction unit can be used for potato tubers with some mechanical modifications.

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

Potato is no exception to climate change vulnerability. The global atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and certain manufactured greenhouse gases have all risen significantly over the last few hundred years. The impacts of extreme events, such as droughts, floods and typhoons, along with the temperature rise are crucial for food security. Climate change has far-reaching effects on crop, the prevalence of crop pests, food production systems and food security. Hence, miscellaneous efforts should be considered for impact assessment studies of climate change in a sustainable manner. The investigation under the present programme are intended to study the impact of climate change on potato productivity, farmer's perception about climate change, disease-pest dynamics and to develop improved management strategies for sustainable potato production in India.

Impact assessment and development of adaption strategy for potato using modelling and GIS tools: The negative impact of climate change can be offset to some extent by adopting agronomic management practices. In order to develop management strategies, simulation studies were carried out. InfoCrop, a generic crop model, which simulates the effects of weather, soils, agronomic management (planting, nitrogen, residues and irrigation), major pests, yield, soil carbon and greenhouse gas emissions was used for adoption studies.

Agronomic management practices for potato in Uttar Pradesh using InfoCrop Model: InfoCrop was run for Kufri Bahar for both RCP's (4.5 and 6.0) out for different time slices (2030, 2050 and 2080) for Agra, Allahabad, Azamgarh, Farrukhabad, Kanpur, Sitapur and Firozabad districts of U.P. (Fig. 1). The modeling results showed that, increasing fertilizers rate as well as the frequency of irrigation is likely to increase the yield over farmers' practice (180 Kg N/ha and irrigation at 7 days' interval) under both the RCPs scenarios and all the three time slices.

However, the effect of nitrogen was more pronounced than the effect of irrigation. Although, the application of increased levels of nitrogen may increase the yield in the range of 0.1 to 1.9 % (mean 1.5%) under RCP 4.5 and 1.4 to 3.5% (mean 2.5%) under RCP 6.0 in different time slices where the irrigation was applied at 7 days' interval, increasing frequency of irrigation from 7 days to 6 days' interval coupled with increased level of nitrogen further increased the tuber yield ranging from 1.3 to 1.45% (mean 2.9%) under RCP 4.5 and 1.2 to 5.3 % (mean 3.3%) under RCP 6.0. It shows that the combined influence of increased level of nitrogen and frequency of irrigation can reduce the impact of climate change on potato productivity in Uttar Pradesh greatly. Overall, the effect of higher doses of nitrogen along with the higher frequencies of irrigation was more in changing the potato yield positively under RCP 6.0 in 2050 and 2080 time slices as compared to under RCP 4.5.

Improved agronomic practices for counteracting the climate change impact on potato productivity

Effect of water levels and mulching on potato under drip irrigation: A field experiment at Modipuram showed that the effect of water levels and mulching was significant on total tuber yield under drip irrigation. Irrigations applied at 125 % CPE (cumulative pan evaporation) produced significantly higher total tuber yield (41.3 t/ha) in comparison to irrigation scheduled at 75 % CPE water level which gave 33.5 t/ha. The 125 % CPE water level was also found statistically superior over 75 % CPE. Similar trend was also noticed in case of large size tuber yield. However, the effect of water levels on total tubers and graded tuber numbers was non-significant.

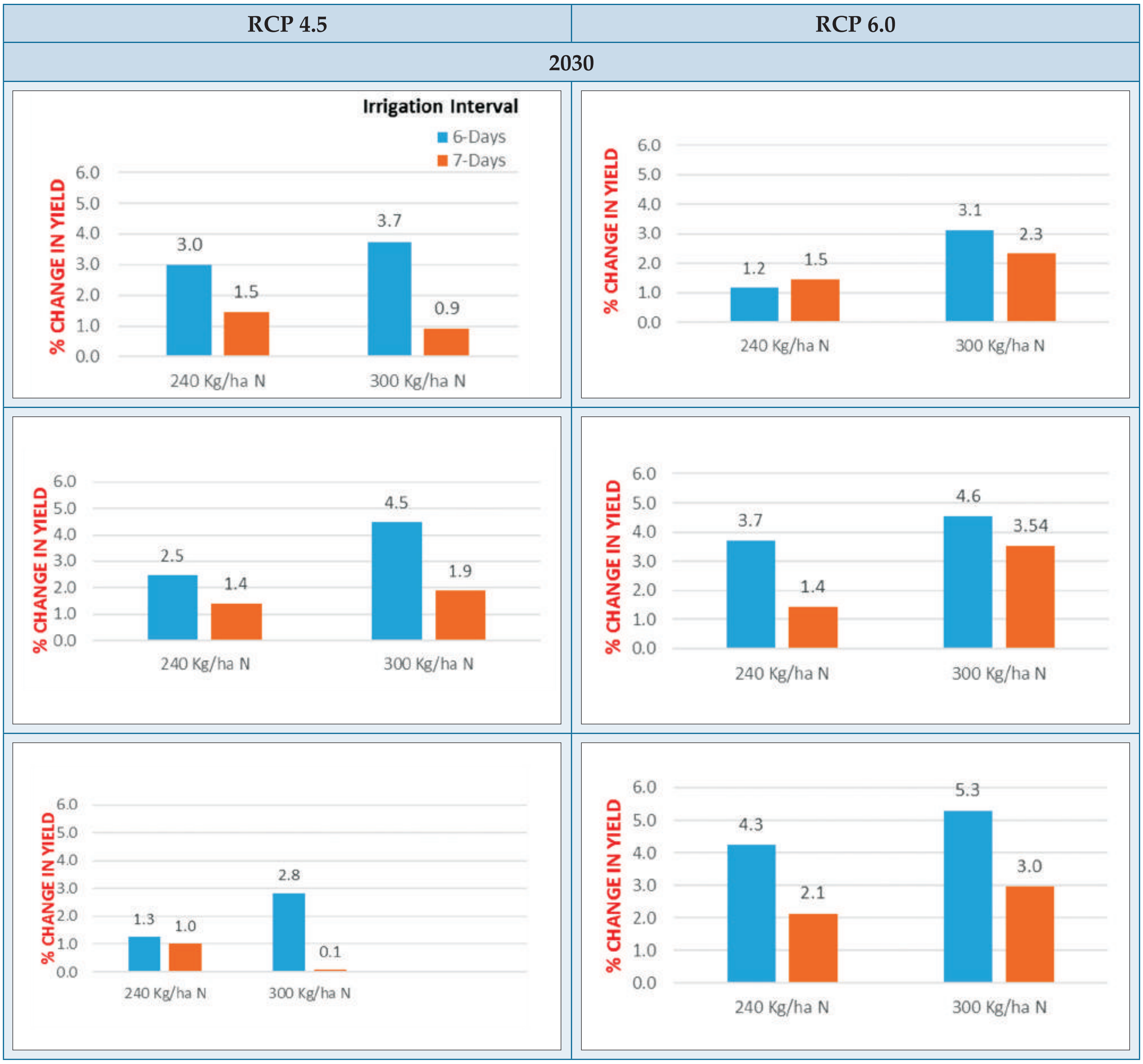


Fig. 1: Percent change in yield of Kufri Bahar in different time slices under RCP 4.5 and 6.0 with different levels of N and irrigation intervals over farmers' practice (180 kg N/ha and irrigation at 7 days interval)

The application of mulch with paddy straw @ 5 t/ha gave significantly higher yield (40.6 t/ha) followed by polythene mulching which produced 37.4 t/ha in comparison to other treatments. However, the effect of chemical formulation (CFs) spray was non-significant on total yield and tuber numbers. Interaction effect of water levels and mulching was non-significant on total tuber yield & numbers as well as graded tuber yields and numbers.

Effect of water levels and mulching on potato under sprinkler irrigation: In another experiment with sprinkler irrigation, the effect of water levels was found significant on total tuber yield. Irrigations scheduled at 150 % CPE (cumulative pan evaporation) produced significantly higher total tuber yield (40.2 t/ha) in comparison to irrigations given at 100 % CPE water level which produced 29.9 t/ha. The 150 % CPE water level was also found statistically superior over 100 % CPE water level. However, the effect of water levels was non-significant on total tuber numbers produced as well as graded tuber yields and numbers. In case of mulching, the effect of treatments was non-significant on total tuber yield and numbers as well as on grade wise tuber yields and numbers.

Table 1. Effect of different treatments on tuber yield (g/plant) of varieties/hybrids

	Kufri Badshah			Kufri Surya			HT/7-1329			HT/7-1105		
	I1	I2	% change	I1	I2	% change	I1	I2	% change	I1	I2	% change
T + CO2	590	520	-11.9	580	480	-17.2	610	510	-16.4	760	540	-28.9
Ambient	610	570	-6.6	490	460	-6.1	580	530	-8.6	630	510	-19.0
% change	-3.3	-8.8		18.4	4.3		5.2	-3.8		20.6	5.9	
CO2	730	680	-6.9	640	500	-21.8	650	540	-16.9	860	620	-27.9
Ambient	610	570	-6.6	490	460	-6.1	580	530	-8.6	630	510	-19.0
% change	19.7	19.3		30.6	8.7		12.1	1.9		36.5	21.6	

I1 = 100 % Irrigation; I2 = 75 % Irrigation; T = Temperature 30C higher; CO_2 = Carbon dioxide

However, the total yield was higher when paddy straw mulch was applied @ 5 t/ha which produced 36.2 t/ha tubers followed by yield with application of polythene mulch (35.5 t/ha), but the differences were non-significant. The crop sprayed with chemical formulation (CFs) did not show any significant effect on yield and tuber numbers. The interaction effect of water levels and mulching treatments on tuber yield and numbers was non-significant.

Identification of climate resilient potato cultivars in relation to rising CO_2 level and temperature: Increased level of CO_2, water scarcity and high temperature are the major concern for potato production in India. Therefore, an experiment was conducted in six open top chambers (OTCs) at Jalandhar to identify the climate resilient potato cultivars/hybrids in relation to rising CO_2 level, water stress and temperature. Two hybrids viz HT/7-1105 and HT/7-1329 with commercial check varieties Kufri Surya (heat tolerant) and Kufri Badshah were chosen. The enrichment of CO_2 started after 15 days of tuber emergence and maintained at 600 ppm from 8.00 AM to 5.00 PM, whereas, temperature rise was maintained 3°C higher compared to ambient throughout day and night (Table 1).

The perusal of data in Table 1 shows that tuber yield per plant decreased in all varieties/ hybrids by reduced irrigation (75 % of recommended). Tuber yield of Kufri Badshah, Kufri Surya, HT/7-1329 and HT/7-1105 increased by 19.7, 30.6, 37.0 and 10.5 %, respectively under elevated CO_2 and recommended irrigation level, while under elevated CO_2 and reduced irrigation level increase was about 19.3, 8.7, 1.9 and 21.6 % compared to control. Further, tuber yield under elevated CO_2 combined with raised temperature and recommended irrigation level increased in Kufri Surya, HT/7-1329 and HT/7-1105 only by 18.4, 5.2 and 20.6 %, whereas, it declined by 3.3 % in Kufri Badshah as compared to control. On the other hand, reduced irrigation level coupled with elevated CO2 and raised temperature, increased tuber yield by 4.3 and 5.9 in Kufri Surya and HT/7-1105, whereas, it reduced by 8.8 and 3.8 in Kufri Badshah and HT/7-1329.

Transcriptome analysis under elevated carbon dioxide and high temperature stress conditions in potato: Photosynthesis, major yield contributing process, is the most affected by the elevated CO_2 and the concomitant abiotic stresses. So far, we have studied the expression pattern of the genes involved in the photosynthesis process using the real time PCR but this was very narrow approach. It has been found that apart from the photosynthesis there are several other processes which are highly affected by abiotic stresses. Hence, we have studied the global gene expression pattern using transcriptomics approach. Potato cultivar, Kufri Badshah was selected for transcriptome studies under elevated CO2 and high temperature stress conditions. Samples were collected at four stages, namely vegetative, pre tuberization, tuberization and tuber bulking stages. Leaf samples were taken for RNA isolation from all growth stages whereas stolons and tubers were taken from post-tuberization stages. The library was prepared using Ion Total RNA-Seq Kit v2 and sequenced using Ion Proton™ Sequencer. The chip was loaded with two prepared library samples i.e. J7 and J15 and each sample consisted of different barcodes. The J7 consisted of Ion xpress™ RNA-Seq barcode BC12 primer and J15 consisted of Ion xpress™ RNA-Seq barcode BC11 primer. The representative results of the run are shown in Fig. 2. The library loading on chip was 78 Per cent. Two libraries each consisting of different barcodes were sequenced and obtained 2,370,601 and 5,805,801 reads respectively with mean read length of 70 bp . The bioinformatic analysis for the generated data is in progress and initial analysis reveals the upregulation transcription factor family genes under both abiotic stress conditions.

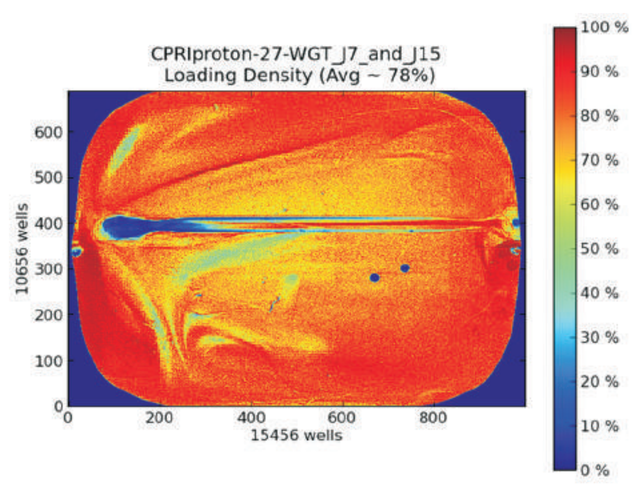


Fig. 2: Library loading on Ion Proton chip, showing average loading density of 78 per cent

Modelling potato pest dynamics for their effective management

Potential impact of climate change on potato late blight outbreak in Uttar Pradesh using Indo-Blightcast model: Uttar Pradesh is the second largest producer of potato in the country. The occurrence of late blight in this state is frequent and significantly affects the potato productivity once every three-four years. As climate is warming globally, it is going to affect the incidence of late blight, hence potential impact of climate change on late blight appearance in Uttar Pradesh was analysed using Indo-Blightcast. The model was run using districts level data on minimum and maximum temperature (0^oC) of Indian Meteorological Department's normal for baseline (year 2000) and future climate scenarios (years 2030 and 2050) for 61 districts. The model predicted that, in general, late blight favourable period is likely to be reduced in western, central and eastern UP. However, it is likely to be increased in Aligarh (western UP), Sahajanpur (central UP), Shrawasti, Basti, Gorakhpur, Deoria, Santkabirnagar, Azamgarh and Pratapgarh (eastern UP) districts in the future climate (2030 & 2050).

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 25-28 Jan, 2019 while its analogous Etah (27.739°N, 78.729°E) it appeared on 5th Feb, 2019. Similarly, at Jalandhar late blight appeared on 22 Nov, 2018 while its analogous Baghpat (29.274°N, 77.191°E) it appeared during first week of February (5-7 Feb., 2019). However, at Patna (25.617°N, 85.167°E) and its analogous Agra (26.753°N, 78.773°E), late blight appeared at same times i.e. last week of January, 2019 (Table 2).

Table 2: 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	*Last week of Jan (25-28 Jan, 2019)	Etah:27.739°N,78.729°E	First week of Feb (5 Feb, 2019)
2	Kannauj: 27.055°N,79.918°E	*Second week of Jan (21 Jan, 2019)	Bijnor: 29.313°N,78.377°E	Last week of Feb (24-28 Feb, 2019)
3	Jalandhar: 31.326°N,75.579°E	Third week of Nov (22 Nov, 2018)	Baghpat: 29.274°N,77.191°E	First week of Feb (5-7 Feb,2019)
4	Patna: 25.617°N,85.167°E	Last week of Jan (30 Jan, 2019)	Agra: 26.753°N, 78.773°E	Last week of Jan (25-28 Jan, 2019)

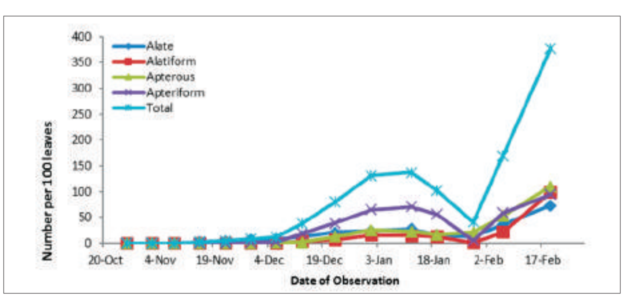
*observation recorded by telephonic communication

Table 3: AUDPC in seven cultivars at different dates of planting

Date of planting	AUDPC						
	K.Bahar	K. Sindhuri	K. Garima	K. Mohan	K. Chipsona-I	K. Himalini	K Girdhari
17 Oct,18	864.17	590.83	695.00	435.00	430.42	183.83	17.92
2 Nov,18	852.08	576.67	505.17	504.58	333.25	273.17	19.04
17 Nov,18	726.25	532.00	560.83	392.58	245.00	402.42	15.54

Effect of different dates of planting on late blight development in varieties having varying degree of resistance: Studies were conducted on seven different varieties viz. highly resistant (Kufri Girdhari, Kufri Himalini), medium resistant (Kufri Chipsona-1, Kufri Garima and Kufri Mohan) and highly susceptible (Kufri Bahar and Kufri Sindhuri) to know how these behave under different climate change scenarios. Planting was done at 15 days' interval (17 Oct, 2 Nov and 17 Nov, 2018). Under laboratory conditions by detached leaf test, lesion area was measured after challenge inoculation of *Phytophthora infestans* and difference was observed among the varieties with different dates of planting. Higher lesion area was observed in first two dates of planting than late planted crop. Area Under the Disease Progress Curve (AUDPC) was calculated for each variety for all dates of planting. The late blight appeared at maturity stage of the crop. The result revealed that under highly susceptible group (Kufri Bahar & Kufri Sindhuri) highest AUDPC was recorded for 17 Oct, 2018 date of planting followed by 2 Nov and 17 Nov date of planting (Table 3). Similar trend was observed for medium resistant (Kufri Chipsona-1, Kufri Garima & Kufri Mohan) cultivars except for Kufri Garima, where highest AUDPC was recorded for first date of planting followed by third and second date of planting; while in Kufri Mohan highest AUDPC was recorded for second date of planting followed by first and third dates of planting. Similar trend was observed in highly resistant (Kufri Girdhari, Kufri Himalini) cultivars, except for Kufri Himalini, where highest AUDPC was observed for third date of planting followed by second and first date of planting. These variations in AUDPC may be due to genetic make-up of the varieties and prevailing environmental conditions.

Periodic generation of data on arrival and build-up of aphid population on potato: The arrival and build-up of *Myzus persicae* (Sulzer) on potato crop was monitored by leaf count method and yellow sticky traps at weekly interval in unsprayed potato fields from the 3rd week of October 2018 till the third week of February, 2019. *Myzus persicae* first appeared on the potato plants in the 2nd week of November which is delayed by 1 week as compared to last year. The population remained below economic threshold till 3rd week of December when it crossed the critical limit of 20 aphids per 100 compound leaves on 22nd December (Fig. 3). The population kept increasing and reached more than 130 aphids per 100 leaves by the 3rd week of January, 2019. After this, the population growth of *M. persicae* reduced due to frequent rainfall. The population growth resumed by the end of February however, the population could not be monitored further due to loss of crop stand due to the development of fungal diseases. The production of alate and alatiform morphs started to increase after the 1st week of January.



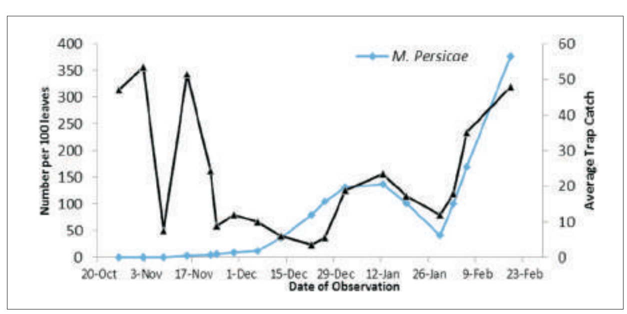


Fig. 3: Arrival and build-up of *Myzus persicae* determined by leaf count and trap catch methods. (a) Population build-up by leaf count method, (b) Comparison over time of leaf count and trap catch.

Development of vulnerability index in potato

Farm level climate change perception, impact and adaptation in potato growing areas of Uttar Pradesh: Different studies shown that without adaptation climate change is detrimental to agricultural sector but with adaptation, vulnerability can largely be reduced. Potato growers of western Uttar Pradesh are experiencing fog, poor quality irrigation water etc. Survey in Agra district found diverse trends of farmer's perception towards different climatic parameters observed during last ten years. Most of the farmers noticed delay (87.2%) in onset as well early (79.7%) end of rainy season. Also, dry spell occurrence (85.1%) and intensity of heat wave (88.3%) were more and pre-monsoon rain (70.2%), unusual heavy rain (48.9%), off-season rain (51%), winter rainfall (60.6%), rainfall in rainy season (91.4%) were less during last 10 years. It is found that, water table depletion and cost of cultivation have higher impact with weighted mean score (WMS) =3.09 as perceived by the farmers. Also, crop insurance (22.3%), changes in planting time (25.5%) and crop sequence (10.6%), crop diversification (23.4%), integrated farming system (19.1%) are the major adaptation strategies (Fig. 4).

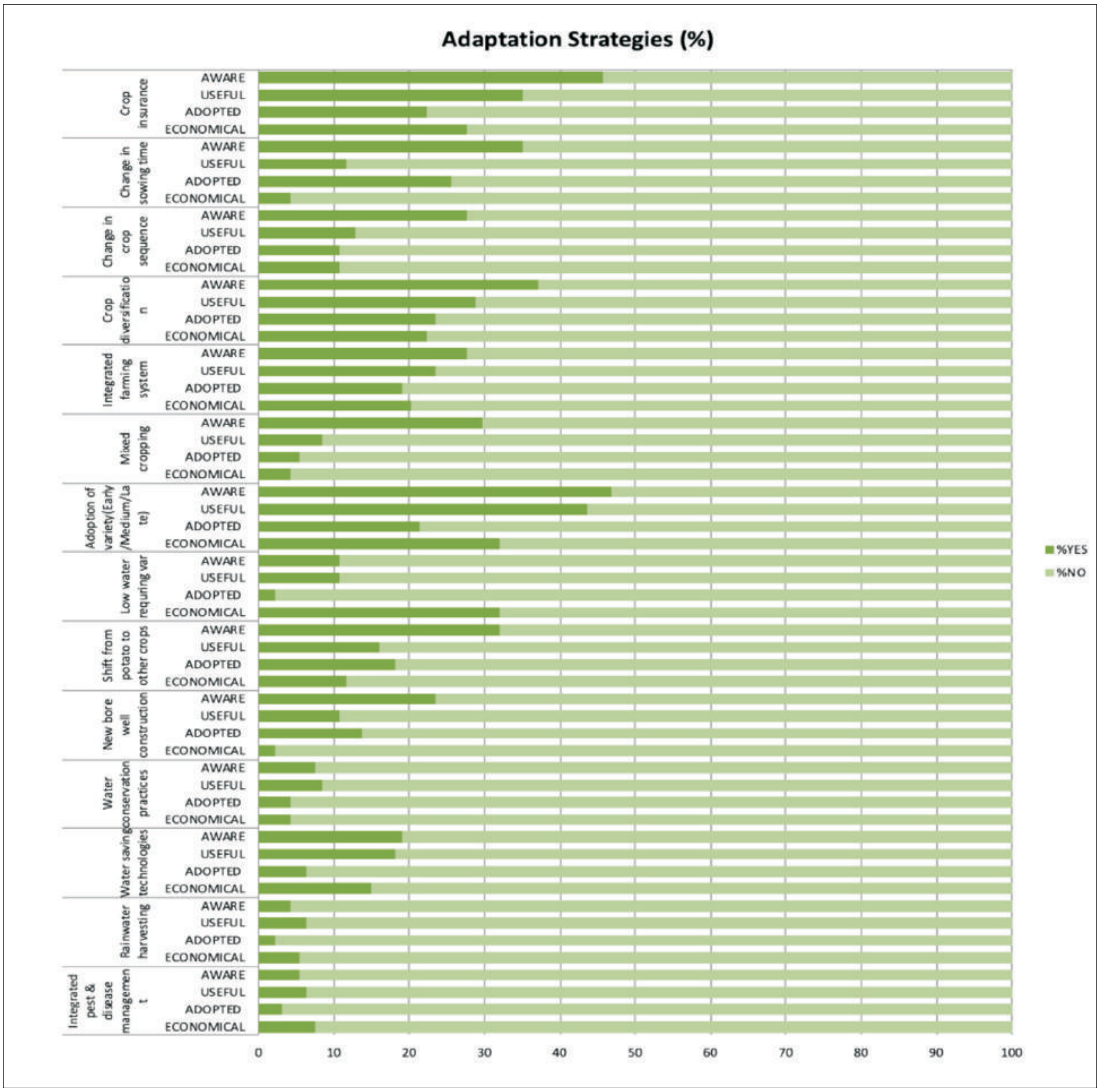


Fig. 4: Adaptation Strategies response among potato growing farmers of Agra district, Uttar Pradesh

DIVISION OF PLANT PROTECTION

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

Disease Monitoring and Pathogens Profile

This year blight appeared early in the month of November (22.11.2018) in Hoshiarpur region of Punjab where its severity was up to 30%. Stem blight was very common in this region. Blight again appeared at the end of the season in whole Punjab. In Himachal Pradesh, appearance of late blight was delayed by 13 days as compared to last year. This year blight appeared on 11th July, 2018 on cv. Kufri Jyoti in Shimla hills and its overall severity ranged from 30-80% in Himachal Pradesh depending upon the cultivar raised and plant protection measures adopted. Survey for late blight was also conducted in Darjeeling hills of West Bengal during first week of June, 2018 where its severity was up to 100%. None of the field was free from late blight.

In western Uttar Pradesh the disease appeared at Naglatashi, Meerut on 13th Feb, 2019 on cv. Kufri Pukhraj and its severity reached to 30%. Late blight survey was carried out in different districts of western UP (Meerut, Hapur, Muzaffarnagar, Bulandshahar & Bijnor). Highest disease severity was recorded in late planting crops at Muzafarnagar (100%) followed by Bijnor (75%), Hapur (60%), Meerut (55%), and Bulandshahar district (50%). Although, disease appeared at very late stage of the crop but economic losses occurred at late planted crop (Fig. 1).

Fig. 1: Late blight infected fields. Main season planted crop (Left) and late planted crop (Right)

Dry rot (*Fusarium* spp.) incidence of 33.3% and severity of 6.7% was observed in potato variety Kufri Frysona at 15 days of harvest (harvested on 19.03.2018 at Himmatnagar, Gujarat) i.e. just before storage at 10-12°C at Himmatnagar (Gujarat), Jalandhar (Punjab), Khanna (Punjab) and Shimla (Himachal). After six months of storage at this temperature, the average incidence and severity of dry rot increased to 52 and 18%, respectively. Isolations from diseased tissues yielded 12% *Fusarium sambucinum* and 88% other *Fusarium* spp. (Fig. 2).

Fig. 2: Dry rot of potato due to *Fusarium sambucinum* and other *Fusarium* spp. in Gujarat (Left), *F. sambucinum* culture on PDA (Right)

A joint survey was conducted during *kharif* 2018 in Darjeeling and Kalimpong districts of West Bengal by the Directorate of Plant Protection, Quarantine and Storage (DPPQS), Govt. of India; Department of Agriculture, West Bengal; ICAR and State Agriculture Universities of West Bengal in response to the Memo No. 12080/24/2018 PP-I dated 15.05.18 by The Department of Agriculture Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, GOI to know the present status of wart disease in the hilly districts of West Bengal. Wart was present in 11 villages out of 15 in Bijanbari block where its incidence ranged from 4 to 100 % (Fig. 3). In Sukhiapokhri block, wart was found in two out of twelve fields and in one field out of eleven in Kurseong block. In Kalimpong I & II, Gorubathan, Mirik and Takdah blocks, there was no standing crop in the field as farmers' had either harvested their crop or they plant during *Rabi* season.

Fig. 3: Wart symptoms on red skinned variety

However, few infected tubers were found in the harvested lots inspected in storage and during market survey. Most of the farmers were using red skinned varieties and the incidence of the disease was more on red skinned varieties than white skinned.

Comparative Genomics of Potato Pathogens

Characterization of *Phytophthora infestans* and *Ralstonia solanacearum*

It is essential to understand the pathogen variability to devise suitable management strategies. Since last three years, population of *P. infestans* is being monitored for sensitivity to cymoxanil, dimethomorph and fenamidone fungicides and this year also all the tested isolates were observed to be sensitive to these new fungicides. Bacterial wilt infected potato stems and tubers were collected from AICRP-Potato experimental fields at Raipur (Chhattisgarh), Bhubaneswar (Odisha) and farmer's field at Gope (Bhubaneswar, Odisha) during 16-18th January 2019. A total of 21 isolates were recovered and confirmed as *Ralstonia solanacearum* as expected single 280bp fragment resulted in all the isolates following PCR amplification using *R. solanacearum* specific primers pair 759/760. Phylotype specific multiplex PCR revealed that at Raipur centre, only race 3 is present as all 10 isolates belonged to phylotype II whereas at Bhubaneswar centre, both race 3 and race 1 are present as 7 isolates belonged to phylotype II and 2 to phylotype I. The two isolates from farmer's field belonged to phylotype I (race 1).

Molecular Diagnostics and Detection of Potato Pathogens

Development of isothermal based RT-LAMP assay for detection of *Potato virus A* and *Potato virus Y*

Reverse transcription loop-mediated isothermal amplification (RT-LAMP) assays were developed for detection of *Potato virus A* (Fig. 4A) and *Potato virus Y*. The assay was optimized with respect to its primer, isothermal temperature (Fig. 4B), incubation period (Fig. 4C) and total volume of the reaction mixture.

Visual detection of the LAMP reaction was also developed by adding SYBR gold nucleic acid staining dye where, change in color from dark orange to fluorescent yellowish green indicates positive reaction.

The assay was examined for its cross-reactivity (Fig. 4D) with other potato viruses and found specific to PVA. Its sensitivity (Fig. 4E) was assessed and found as sensitive as that of RT-PCR assay, as both the assays were able to detect the virus at 10^{-2} dilution. The optimized assay was validated by running across the potato leaf samples collected randomly from fields (Fig. 4F & 4G). The assay was also successful in detection of PVA from potato tubers (Fig. 4H & 4I). Similarly, RT-LAMP assay was also developed for specific detection of PVY in potato plants by targeting its coat protein gene (Fig. 5A).

The assay was optimized for its isothermal temperature (Fig. 5B) and incubation period (Fig. 5C). The assay was also successfully examined for its cross-reactivity with other important viruses and its non-specificity with host genome. Its sensitivity was assessed and found 10 fold more sensitive than RT-PCR assay. It was validated (Fig. 5D&E) by running across the randomly collected potato samples from fields and the same was confirmed by RT-PCR based assay as well.

Determination of viruliferous nature of aphids by isothermal based squash print RT-LAMP (SP-RT-LAMP) for detection of PVA and PVY

To determine the viruliferous nature of aphids, a squash print reverse transcription loop-mediated isothermal amplification assay was developed. The assay was successful in detection of PVA in single aphid (Fig. 6 A&B). The assay was validated for detection of PVA in 70 single aphids collected randomly from potato canopy. Out of 70 aphid samples, the assay successfully detected PVA in 33 samples thereby indicating viruliferous nature of aphids (Fig. 6C).

Similarly, SP-RT-LAMP assay was also developed for detection of PVY in insect system (Fig. 7 A & B).

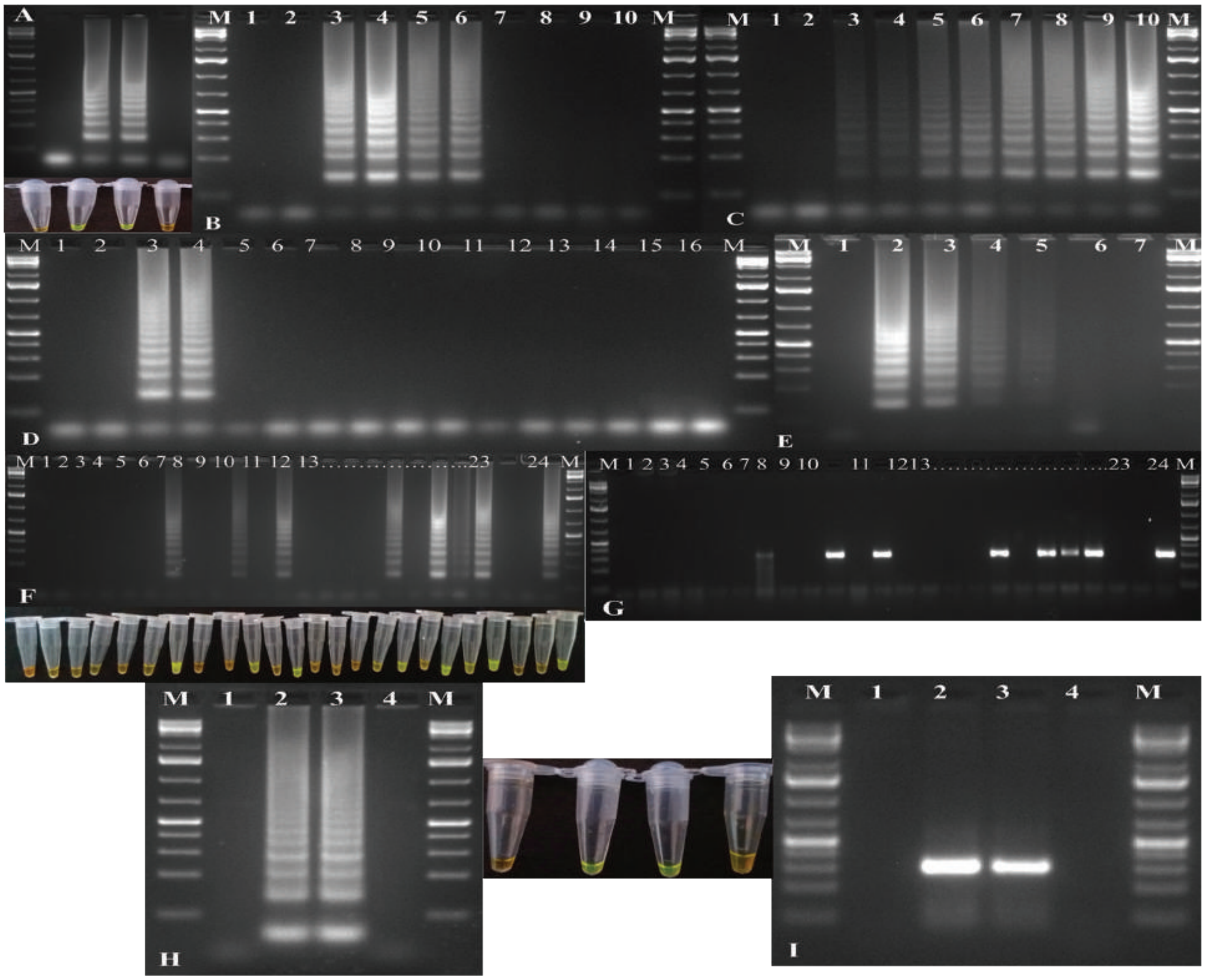


Fig. 4: Development of RT-LAMP assay for detection of PVA from potato plants (A). Optimization with respect to isothermal temperature (B), incubation period (C), its cross-reactivity (D) sensitivity (E) validation (F) & (G) and detection in tubers (H & I)

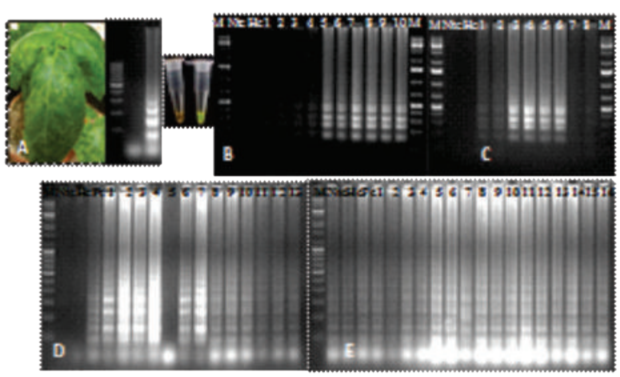


Fig. 5: RT-LAMP assay for detection of PVY from potato plants (A). Optimization with respect to isothermal temperature (B), incubation period (C) and its validation (D & E)

Healthy aphids were given an acquisition feeding on pure culture of PVY and used for isolation of RNA by squash print method.

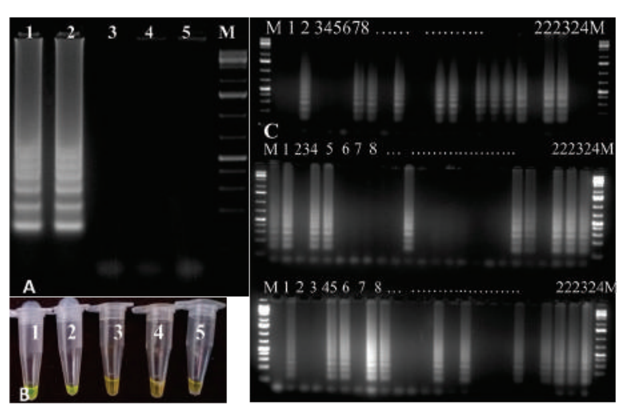


Fig. 6: Development of SP-RT-LAMP assay for detection of PVA in single aphids (A & B) and its validation (C)

Initially, the optimized RT-LAMP assay was used to detect PVY in group of acquired (PVY) aphids where it successfully amplified the target virus, which was evident in agarose gel electrophoresis.

Further, to determine the viruleferous nature of aphids, single virus acquired aphids were processed for SP-RT-LAMP assay. The assay successfully detected PVY from single aphids which were confirmed by RT-PCR based assay. It was also found to be reproducible as it was able to detect PVY repeatedly from single known positive or acquired (PVY) aphids.

The optimized SP-RT-LAMP assay was validated (Fig. 7 C&D) successfully by running across single aphids collected randomly from potato canopy of north-western hills (Shimla) of India.

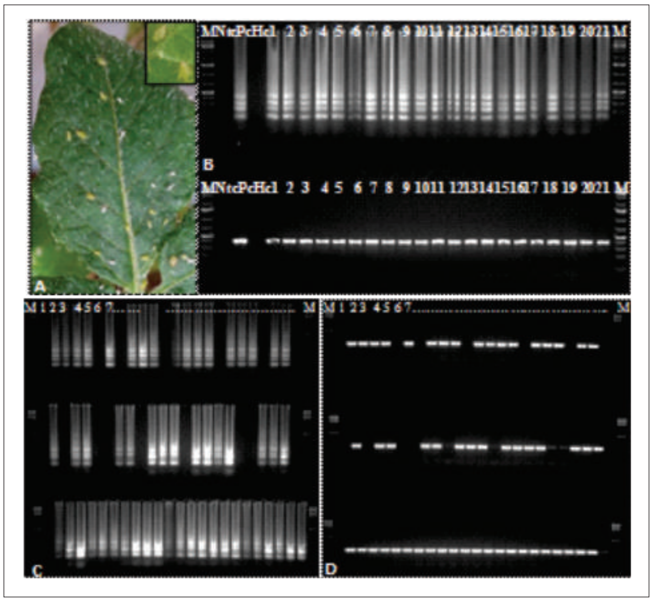


Fig. 7: SP-RT-LAMP assay for detection of PVY in aphids (A & B) and its validation (C & D)

Development of RT-Loop mediated isothermal amplification assay for detection of *Potato spindle tuber viroid*

Viroids are non-coding RNA (ncRNA) differ from viruses by the absence of protein coat and by their small size. We developed reverse transcriptase loop mediated isothermal amplification (RT-LAMP) assay targeting genomic region of PSTVd for its visual detection. LAMP is based on loop-amplification of a specific site of the genome by *Bst* DNA polymerase with DNA-strand displacement activity. *Warm-start Bst* DNA polymerase has been reported as a better alternative to *Bst* DNA polymerase due to its precise activation at particular temperature to avoid random amplification. The method used two sets of primers: two outer primers (F3 and B3), two inner primers (FIP and BIP) to accelerate the reaction (Fig. 8B).

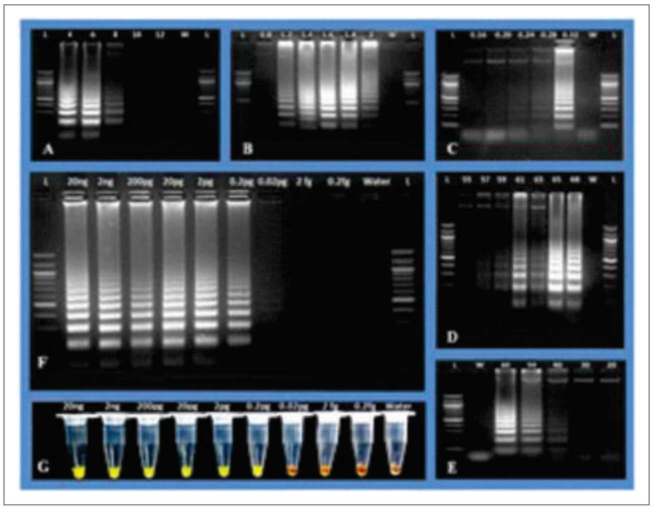


Fig. 8: RT-Loop Mediated Isothermal Amplification assay for detection of PSTVd

The targeted region was PCR amplified and the product was sequenced to make assay more specific and reliable. The F3 and B3 primers spanning 245 base pair (bp) region was cloned in pCR 4 TOPO vector and worked well as positive control (Fig. 8C). The PSTVd RT-LAMP assay efficiently amplified the target region in 60 min at 65°C (Fig.8D).The RT-LAMP reagents viz. MgSO4 (2–8 mM) (Fig. 8A), dNTPs (0.2–2 mM) and Warmstart Bst DNA polymerase (0.16–0.64 U µL−1) were optimized to obtain a defined set of condition for amplification. The assay was also subjected to various temperature sets (55-70°C) and runtime (20-60 min). Sharp amplification was observed at 65°C (Fig. 8D) for 60 min (Fig. 8E). The limit of detection (LOD) of PSTVd- LAMP assay was 0.2pg/µl DNA (Fig. 8F).

The described method employs SYBR Green dye, a nucleic acid stain found to be suitable for LAMP detection by fluorescence (Fig. 8G). The obtained results have shown PSTVd-LAMP assay as a sensitive, less time consuming and specific alternative for PCR-based detection methods of Potato spindle tuber viroid.

Validation of LAMP assay for detection of *P. infestans* infecting potato

Last year we developed LAMP assay for detection of *P. infestans* and this year the assay was extended for its validation using different species of Phytophthora artificially inoculated leaves, tubers and field samples. Accuracy and robustness of ITS1-LAMP assay was tested by running LAMP reactions using the optimized reagents with ITS1 specific F3, B3, FIP and BIP primers for an incubation time of 60 min at 650C. Each experiment was also performed with conventional PCR to compare the results. Twenty isolates of *Phytophthora* spp. *viz. P. infestans* (16) and each of *P. capsici, P. cactorum, P. colocasiae* and *P. palmivora* were included in this study. Of 20 isolates tested, except *P. capsici*, all were found positive in LAMP assay (Fig. 9E).

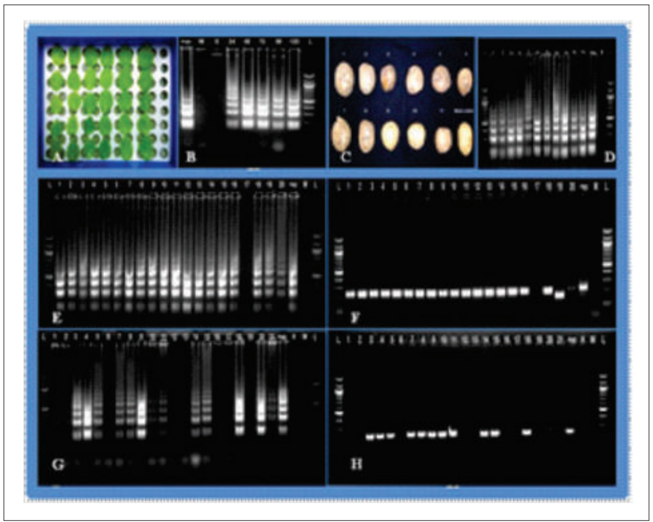


Fig. 9: Validation of ITS1-LAMP Assay for detection of *Phytophthora infestan*

These results are consistent with conventional PCR assay (Fig. 9F). The assay successfully detected the pathogen in artificially inoculated leaves (Fig. 9 A&B) and tubers (Fig. 9C), except mock treated leaves and tubers (Fig. 9D). Validation of assay was extended to freshly harvested potato tubers (n=98) {G (representative data shown)}. In total, 54 samples (55.1%) were found positive in ITS1-LAMP assay while remaining samples were negative. As comparison with PCR {H(representative data shown)} out of 98 samples tested 39 samples (39.79%) were confirmed as positive for *P. infestans* while remaining were negative. These results suggest that ITS1-LAMP assay is sensitive than conventional PCR and can be employed for detection of *P. infestans* in tubers.

Production of polyclonal antibodies against *Potato virus Y*

The purified *Potato virus Y* (PVY) particles were quantified w.r.t. its concentration using nanodrop (spectrophotometer) and outsourced for antibody production. The antiserum supplied by the firm was subjected to direct ELISA and determined its titer value as 1:5000 and can be used for serological based detection (ELISA).

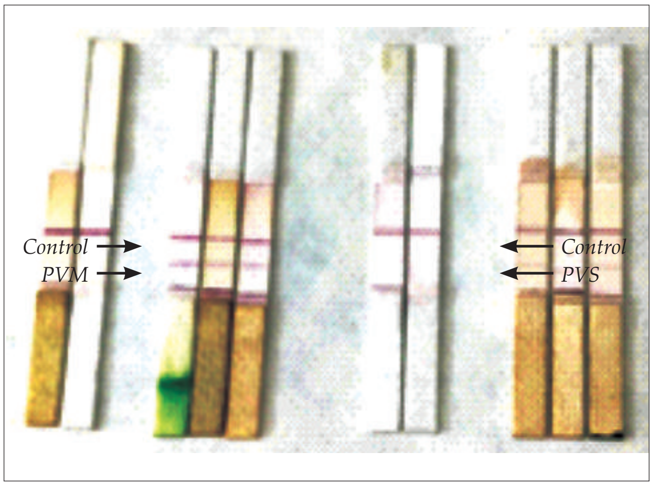


Fig.10: Lateral flow immune assay detection of PVS & PVM using commercial antibodies

Optimization of Lateral Flow Immuno Assay kit for PVX, PVM, PVA and PVS with commercial antibodies

Lateral flow immune assay (LFIA) for detection of PVX, PVA, PVS and PVM was optimized using commercial antibodies and validated with randomly collected field samples (Fig. 10).

The commercial antibodies of PVX, PVS, PVA and PVM were concentrated through 10K protein concentrated column and made up to required concentration. DAS-ELISA was performed for the same samples and the results were comparable to LIFA strip results.

Fig. 11: Purple top symptoms on Kufri Jyoti (a), hairy sprouts on tubers (b) and blind tubers with thin hairy sprouts of Kufri Himalini potato varieties

Validation of PCR protocol for detection of Phytoplasma in potato

The nested PCR protocol developed for detection of Phytoplasma amplified expected 1.2kb fragment of 16S rRNA gene of Phytoplasma from symptomatic potato leaves of Kufri Pukhraj (severe inward curling) from Modipuram, Kufri Jyoti (purple top) from Kufri and hairy sprouts and blind tubers of Kufri Himalini from Kufri (Fig. 11a, b & c). Sequence analysis of nested PCR product identified *Candidatus Phytoplasma ziziphi* associated with severe inward curling of Kufri Pukhraj leaves at Modipuram and *Candidatus Phytoplasma fragaria* with purple top symptoms of Kufri Jyoti, hairy sprouts and blind tubers of Kufri Himalini at Kufri.

Epidemiology and Forecasting of Potato Pathogens

Role of weeds and other host crops in the epidemiology of potato viruses

Field surveys were conducted in Jalandhar, Punjab for the collection of common weeds and crops for their sampling and testing for common potato viruses over three successive growing seasons. Overall, 123 samples of 30 plant species (3 to 10 samples per species) during *Rabi* 2016-17; 210 samples of 45 plant species (3 to 7 samples per species) during summer 2017, and 135 samples of 29 plant species (3 to 6 samples per species) during 2018 were tested by DAS-ELISA for common potato viruses. Some of the perennial/ biennial plants were repeatedly tested and overall 73 species from 32 plant families were covered in the study. Among the known alternate hosts, the presence of PVY was confirmed in *Parthernium hysterophorus, Sonchus oleraceus, Chenopodium murale, Pisum sativum, Capsicum annuum, Ca. annuum var. annuum, Solanum lycopersicum, S. melongena* and *S. nigrum*. For PLRV, *Ch. album, S. lycopersicum and S. nigrum* were found infected among the known alternate hosts whereas, *Ch. album, S. lycopersicum* and *S. nigrum* for PVM; *P. sativum* and *S. nigrum* for PVX, and for PVS, *Rumex obtusifolius* and *S. nigrum* were found positive among the known alternate hosts.

The study indicated a large number of potential new reports of alternate hosts for the potato viruses. Overall, 19 species of plants, whose status is not known as alternate host of PVY, tested positive for the virus. For PLRV, 22 new potential alternate hosts were found. For PVA, 22 new potential alternate hosts, for PVM 16, for PVS 26, and for PVX 6 new potential new alternate hosts were found.

Many of the weeds and crops were repeatedly tested over the three seasons, twice or thrice. Only a few species tested positive on both or all the three occasions for a certain virus. However, weed and other host samples collected from Gwalior region were found free from potato viruses.

Temporal dynamics of ToLCNDV-[potato] disease

The disease progress curve for ToLCNDV-Potato in potato cv. Kufri Pukhraj, Kufri Jyoti and germplasm number J-092-159 resulted in a straight line with an initial rapid increase in the incidence of ToLCNDV-[potato], followed by a gradual increase (Fig. 12). The incidence of ToLCNDV-[potato] during 2018-19 reached 45 % in Kufri Pukhraj, 33 % in Kufri Jyoti and 15 % in accession number J-092-159 starting with a potato seed infection of 5-8%. Randomly selected plants were tested through RT-PCR for confirmation of results. Therefore, it is concluded that germplasm accession number J-092-159 has moderate level of resistance or tolerance to ToLCNDV-[potato]. Disease incidence data were transformed as the number of plants displaying ToLCNDV-[potato] symptoms divided by the total number of plants observed. The disease progress curves were fitted to four growth models using linear regression analysis: monomolecular $\{\ln[1/(1-y)] = \ln[1/(1-y0)] + rMx\}$; logistic $\{\ln[y/(1-y)] = \ln[1/(1-y0)] + rLx\}$; Gompertz $\{-\ln[-\ln(y)] = -\ln[-\ln(y0)] + rGx\}$; and the exponential model $\{\ln(y) = \ln(y0) + rEx\}$; the symbols with their usual meanings.

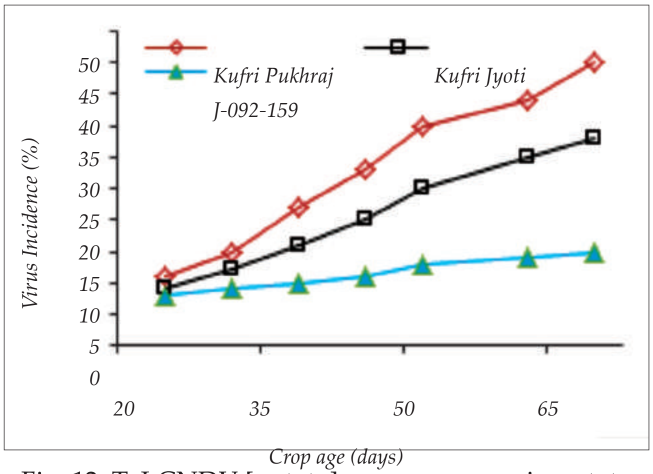


Fig. 12: ToLCNDV-[potato] progress curve in potato varieties at Jalandhar during 2018-19

Table 1. Summary of linear regression statistics for four growth-curve models to describe the disease progress of ToLCNDV-[potato] in potato varieties

Variety	Model	R^2	Adj. R^2	F-stat	P(>F)	Res. SE	AIC	BIC
Kufri Pukhraj	Exponential	0.93	0.92	71.08	0.00	0.145	-3.44	-3.60
	Monomolecular	0.98	0.98	452.1	<0.00	0.023	-28.88	-29.04
	Logistic	0.96	0.95	127.2	<0.00	0.153	-2.71	-2.87
	Gompertz	0.98	0.97	255.7	<0.00	0.061	-15.50	-15.67
Kufri Jyoti	Exponential	0.96	0.95	129.3	<0.00	0.101	-8.50	-8.67
	Monomolecular	0.99	0.98	550.2	<0.00	0.013	-36.36	-36.52
	Logistic	0.97	0.97	211.0	<0.00	0.101	-8.47	-8.63
	Gompertz	0.99	0.98	585.8	<0.00	0.031	-25.02	-25.18
J-092-169	Exponential	0.97	0.96	191.9	<0.00	0.041	-21.15	-21.31
	Monomolecular	0.97	0.96	149.6	<0.00	0.006	-46.77	-46.93
	Logistic	0.97	0.97	225.6	<0.00	0.043	-20.54	-20.38
	Gompertz	0.98	0.97	286.1	<0.00	0.016	-34.27	-34.43

These models were used as predicted equations to compare the fitment of linearly transformed data. Statistical analysis was performed with R-software using the "lm" function.

The parameters of the adjusted models indicated that the monomolecular growth model best described the disease progress of ToLCNDV-[potato] (Table 1). The data confirms the last year's observation and therefore, it is concluded that the ToLCNDV-[potato] is a monocyclic or simple interest disease.

Determination of viruliferous nature of whiteflies for ToLCNDV-[potato]

The weekly variation in proportion of viruliferous whiteflies collected during the last season (2017-18) indicated that the infection pressure was highest during the last week of October with 83.33 % of the tested whitefly samples being found positive for the virus. The proportion of viruliferous whiteflies fell to 23.52 % by the first week of November and was negligible afterwards. The activity will be repeated to confirm the results.

Whitefly mediated ToLCNDV-[potato] transmission

Whitefly, *B. tabaci* is a species complex, consist of 29 putative genetic groups across the world. These genetically varied groups exhibit remarkable phenotypic variability in terms of virus transmission. Thus, characterizing the whitefly population on potato crop and establishing relationships with *Tomato Leaf Curl New Delhi Virus-Potato* (*Geminiviridae*) is crucial for virus epidemiology and management. The whitefly samples were collected from Jalandhar (Punjab) from potato host and cultured on potato in glasshouse at ICAR- Central Potato Research Institute, Shimla. The genetic group was identified by sequencing mtCOXI gene of five individual whiteflies from culture using forward primer C1-J-2195 (5'-TGATTTTTTGGTCATCCAGAAGT-3' and reverse primer L2-N-3014 (5'-TCCAATGCACTAATCTGCCATATTA-3'). BLAST analysis of the mtCOXI sequences revealed potato whitefly population from Jalandhar (Punjab) as Asia II 5 genetic group (Fig. 13).

Fig. 13: Whitefly mediated PALCV transmissions (a) and ToLCNDV-potato symptoms (b). Testing of whitefly mediated ToLCNDV-potato transmitted plants (one to eight) using PCR with CP specific primers (c)

Further, whiteflies of same genetic group were used for ToLCNDV-potato transmission studies. The whiteflies were allowed to acquire ToLCNDV-potato from infected potato plant for 24 hours as Acquisition Access Period.

Thereafter, 10 whiteflies were released on seven to eight days old virus free mini tuber raised potato plants for a period of 24 hours (Inoculation Access Period) and then virus transmission was terminated by spraying Imidacloprid 17.5 SL @ 0.3 ml/ litre. Test plants were transferred to insect proof cages in glasshouse maintained at 25±3^{0}C for symptom development. The plants were tested for ToLCNDV-potato presence using CP specific primers (forward (5′-AAAGTCATGTGTGTTAGTGATGTTACC-3′) and reverse (5′-TAGAAATAGATCCGGATTT TCAAAGTA-3′) primers. PCR results revealed presence of ToLCNDV-potato in all the eight plants; thus, indicating that Asia II 5 species was able to transmit ToLCNDV-potato with hundred per cent efficiency (Fig.13).

Studies on systemic nature/ infection of GBNV in potato

A study was carried out to know the systemic nature of *Groundnut bud necrosis virus* (*GBNV*) which is responsible for causing stem necrosis disease in potato. Mechanical inoculation was carried out using 0.05 M potassium phosphate with 7.0 pH containing. 0.1 per cent 2- Mercaptoethanol for transmission of the virus under study.

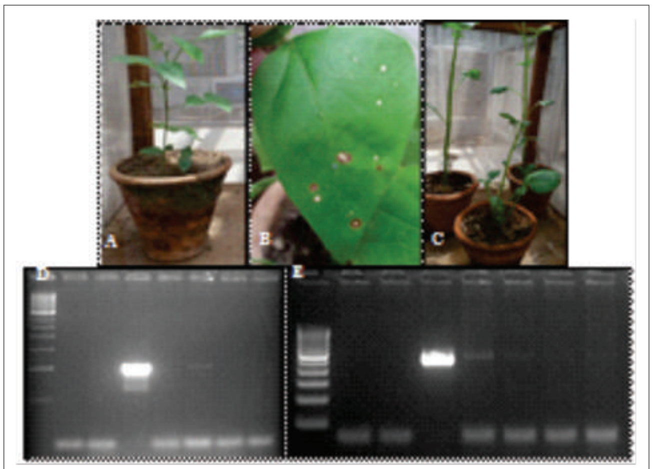


Fig. 14: Studies on systemic nature/ infection of GBNV. Cowpea plants inoculated with GBNV (A), Necrotic spots on cowpea (B), potato plants maintained for examining the movement of the virus (C) and gel images showing the presence/ movement of GBNV in different portions of plant (D & E)

The inoculum was mechanically inoculated to indicator/ diagnostic hosts like cowpea (Fig. 14A) and *Chenopodium amaranticolor* plants and also to main host i.e. on potato. After two weeks of mechanical inoculation, we observed visual chlorotic rings/ spots (initially) which later turned to necrotic spots on cowpea (Fig. 14B) but not on potato. Whereas, RT-PCR based confirmation revealed successful mechanical transmission of GBNV on to cowpea and potato plants. In addition, dodder (*Cuscuta* spp.) and thrips as vectors were also used for transmission of the virus under study, but it was not successful. The potato plants showing the successful transmission of GBNV were maintained and allowed to grow further to know the systemic movement of the virus under study. The leaf samples were drawn from potato plants at regular intervals from lower, middle and upper portions of the plant. The movement of the virus was tested by processing the collected samples by RT-PCR. We found an expected amplicon i.e., the presence of virus even in the upper portion of leaf sample which gave a sign for upward movement of the virus (Fig. 14 C,D&E). All the above studies were carried out in an insect proof cages maintained in glasshouse facility.

Spread of potato viruses in re-circulating hydroponic/aeroponic system

The importance of soilless minituber production using open or closed hydroponic/aeroponic system has increased worldwide. In these production systems, plants are usually supplied with a nutrient solution circulating in gullies to allow more accurate control of the root environment. This can result in optimal use of water and nutrients, and thus in higher yields and better quality. However, re-circulating the nutrient solution facilitates the rapid and efficient spread of pathogens throughout the whole crop. There are reports which indicate that viruses are transmitted through the recirculating nutrient solution. Keeping this in mind, studies were undertaken to see the efficiency of ToLCNDV-potato, PLRV, PVM, PVY^N and PVY^C transmission via the nutrient solution in closed re-circulating growing boxes by monitoring viral spread into the roots and shoots of potato plants during a growing period. Three boxes were used in the study. In first and second boxes healthy tissue cultured plants were raised while in third box, virus infected plants were planted.

Table 2: Spread of potato viruses in re-circulating aeroponic system

Treatment	Virus reaction after days of planting									
	30					60				
T + CO_2	PLRV	ToLCNDV-potato	PVM	PVY^n	PVY^c	PLRV	ToLCNDV-potato	PVM	PVY^n	PVY^c
Box 1	-	-	-	-	-	-	-	-	-	-
Box 2	-	-	+	+	-	-	+	+	+	+
Box 3	+	+	+	+	+	+	+	+	+	+

Table 3: Performance of Indo-Blightcast model during 2018-19

Location	Prediction date of late blight	Actual date of late blight appearance
Shimla (HP)	07.07.2018	11.07.2018
Jalandhar (Punjab)	16.11.2018	22.11.2018
Modipuram (UP)	12.02.2019	13.02.2019
Pantnagar (Uttarakhand)	Blight appearance not likely	Did not appear
Jalpaiguri(WB)	Blight appearance not likely	Did not appear
West Midnapur (WB)	Blight appearance not likely	Did not appear
Bankura (WB)	Blight appearance not likely	Did not appear
Burdwan (WB)	Blight appearance not likely	Did not appear
Kanpur	03.01.2018	18.01.2019

Nutrient solution of second and third box was common. After 30 days of planting, first sampling was done and test results indicated that plants raised in box two had PVM and PVY^N infection. After 60 days of planting, plants grown in box two were found infected with ToLCNDV-potato, PVM, PVY^N and PVY^C (Table 2). This indicates that ToLCNDV-potato, PVM, PVY^C and PVY^N can be released from injured plant roots into a nutrient solution and can infect other healthy plants through the roots and ultimately spread into the green parts of these plants.

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 2018-19 and it predicted late blight accurately at each location (Table 3). Accordingly the advisories were issued to respective regions to protect the crop from late blight attack.

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 series of experiments were conducted.

At Modipuram, out of eight treatments tested, application of dimethomorph (0.1%) and fluopicolide 62.5 + propamocarb hydrochlorid 625 SC @ 0.3% resulted in 18.00 and 18.17% disease severity respectively as against of 97.67 % in control (Table 4). Similarly, fungicides were tested for developing spray schedules for managing late blight of potato. Among the treatments, prophylactic spray with mancozeb (0.2%) followed by fluopicolide 62.5 + propamocarb hydrochlorid 625 SC @ 0.3% at onset of the disease and one more spray with fluopicolide 62.5 + propamocarb hydrochlorid 625 SC @ 0.3% after 7 days recorded lowest disease severity (30.00%) against control (98.00%). The next best treatment was prophylactic spray with mancozeb (0.2%) followed by dimethomorph 50%WP @ 0.1% + mancozeb 75% @ 0.2% at onset of disease and one more spray with dimethomorph 50%WP @ 0.1% + mancozeb 75% @ 0.2% after 7 days.

Table 4: Effect of new fungicides against *Phytophthora infestans*

Treatments	Terminal disease severity (%)	Disease control (%)
T1: Fluopicolide 62.5+propamocarb hydrochlorid 625 SC @ 0.25%	21.33	78.16
T2: Fluopicolide 62.5+propamocarb hydrochlorid 625 SC @ 0.3%	18.17	81.40
T3:Azoxystobin 11.5% + Mancozeb 30% WP @ 0.25%	41.67	57.34
T4: Dimethomorph 50% WP @ 0.1%	18.00	81.57
T5:Cymoxanil8+ mancozeb 64% WP @ 0.3%	30.67	68.60
T6:Fenamidon10+ mancozeb50% WG @ 0.3%	27.50	71.84
T7: Benalaxyl M 4%+ mancozeb 65% WP @ 0.3%	33.33	65.87
T8:Control	97.67	0.00
CD (0.05)	3.87	

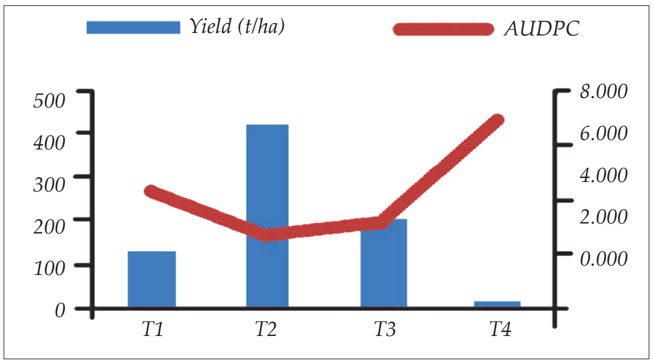


Fig. 15: Effect of different fungicides spray schedule for management of late blight

Experiment conducted at Ooty in *kharif* season revealed that prophylactic spray with chlorothalonil @0.25% followed by famoxadone 16.6% + cymoxanil 22.1% SC @ 0.3% at onset of the disease and alternate sprays at 6-12 days intervals recorded lower AUDPC (105) as compared to control (430). The next best treatment was prophylactic spray of chlorothalonil @ 0.25% followed by ametoctradin + dimethomorph @ 0.3% and alternate sprays at 6-12 days (Fig. 15). In another experiment, efficacy of phosphorous acid against late blight was tested on susceptible (Kufri Jyoti) and moderately resistant (Kufri Himalini) cultivars. Results of two years pooled data revealed that application of phosphorous acid reduced blight severity considerably compared to untreated (Fig. 16). Reduction was more in susceptible (53.75%) than moderately resistant (41.18%) cultivar.

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

An experiment, with three sub-sets of treatments, was laid out at ICAR-CPRI, Shimla for scheduling fungicides application for management of late blight using Indo-Blightcast model. In first set of treatments, spraying of fungicides was initiated after 40 days of planting i.e. at the time of canopy closure and thereafter at weekly interval (calendar based).

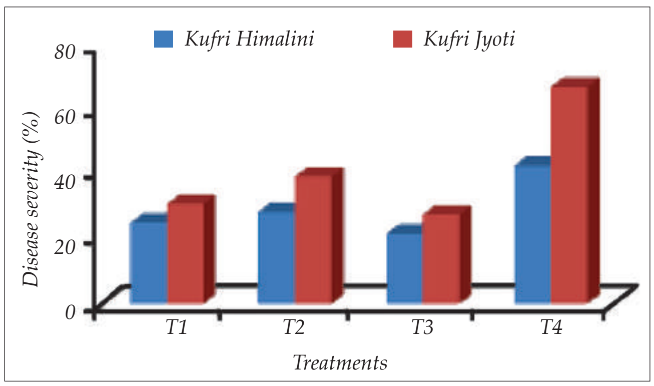


Fig. 16: Efficacy of phosphorous acid against late blight on susceptible and moderately resistant cultivars

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. Late blight was predicted on 7th July, 2018 and it appeared on 11th July, 2018. Mancozeb was sprayed prophylactically and at onset of disease, translaminar/systemic fungicides were applied. In total eight sprays were given in first set of treatments while five were given in second set of treatments. Terminal disease severity was 65 and 62.8% in first and second set of treatments respectively as against of 95% in control. Late blight favourable period continued for 62 days after appearance of late blight. Though there were no significant differences in terminal late blight severity and yield in first and second set of treatments, but three sprays were saved when scheduling fungicides application was done as per Indo-Blightcast.

Application of ZnO, ZnO-nano and $ZnSO_4$ in potato (*Solanum tuberosum*) to counter the DNA replication of ToLCNDV-potato

Earlier we reported that application of Zn inhibited ToLCNDV-potato in tissue culture raised plants and demonstrated the role of zinc finger proteins in replication of ToLCNDV-potato DNA.

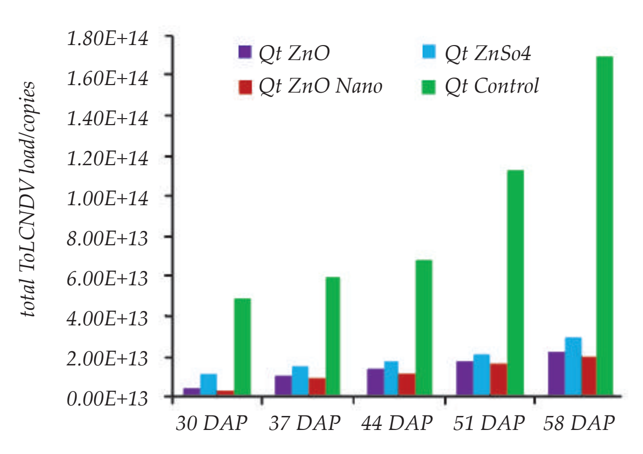


Fig.17: Real time analysis of total ToLCNDV load/ copies after soil application of Zn

This year, pot experiment was conducted under glass house to see the effect of different doses and formulations of zinc on potato against ToLCNDV-potato as foliar and soil application. The tubers of Kufri Pukhraj were first agroinoculated with ToLCNDV infectious clone culture and then planted in pots followed by soil and foliar application in the different form of zinc. Leaf samples were collected at weekly interval after 30 days of planting (DAP) and analyzed by real time PCR for quantitative load/copies of ToLCNDV in treated and untreated plants (Figs. 17 & 18).

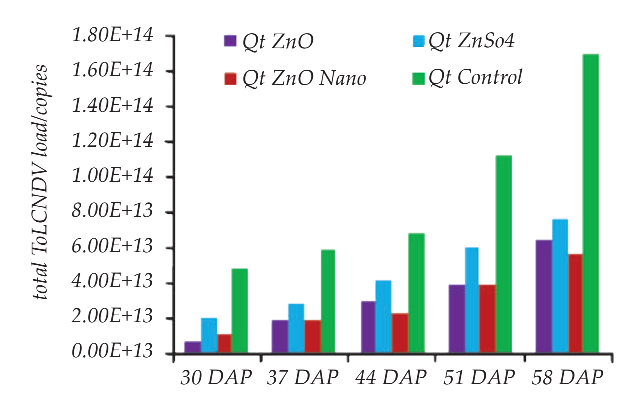


Fig. 18: Real time analysis of total ToLCNDV load/ copies after foliar application of Zn

Results revealed that foliar as well as soil application of Zn in all forms inhibited virus DNA replication compared to untreated plants.

Evaluation of disinfectant Huwa San TR 25 for management of soil and tuber borne diseases

A disinfectant Huwa San TR 25 was evaluated for its efficacy as dip / spray treatment of tubers (@ 0.75, 1.0 and 1.25% along with boric acid @ 3.0%) before cold storage on tuber rotting during storage and common scab and black scurf diseases in subsequent field experiments. At Jalandhar, no significant difference on tuber rottage during cold storage was observed among the Huwa San, boric acid treated tubers and control. Also, Huwa San treatment did not have any adverse effect on germination. In subsequent field experiments, no significant effect on common scab and black scurf reduction was observed. At Modipuram, lower dry rot (2.75-6.04%) and soft rot (1.59-3.95%) incidence compared to control (8.49% dry rot and 4.25% soft rot) was observed. In field, Huwa San@ 0.75, 1.0 & 1.25% as tuber dip was more effective in managing black scurf than tuber spray when used before storage.

Chemical management of black scurf

Among the six fungicides evaluated as foliar sprays, only Thifluazmide 24% SC @ 0.2% (two sprays) proved effective in reducing black scurf incidence to 72% as against 100% in control.

Biotechnological Approaches

Nanoclay dsRNA formulation (fungicides): As an alternative and novel protection strategy for potato late blight

In earlier studies, demonstrated that spraying of potato plants with dsRNA encoding *Phytophthora infestans* genes (sporulation, metabolism, effector and protein machinery of the cell) imparts protection against late blight (Fig. 19).

Fig. 19: Efficacy of dsRNA nanoclay formulation against late blight

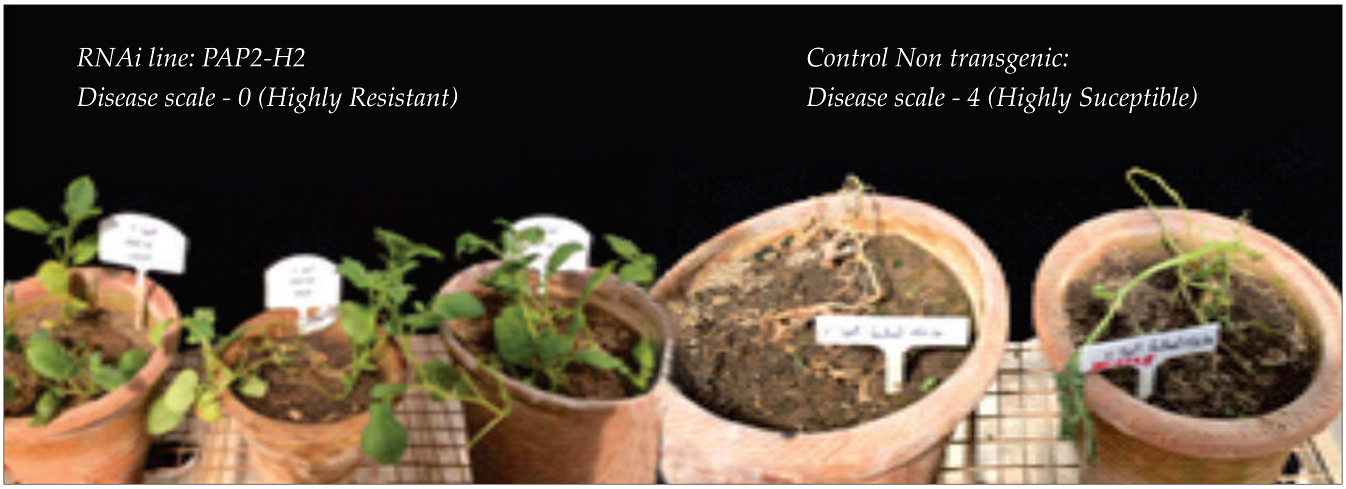


Fig. 20: Response of RNAi Kufri Jyoti lines against *R. solanacearum*

Therefore, efforts were made to synthesis dsRNA molecule with nanoparticles to enhance the stability of the dsRNA under *in vitro* conditions. When dsRNA molecules assessed through detached leaf assay for its bio-efficacy, it resulted in least lesion area (0.4 cm^2) compared to control (7.5 cm^2). Under whole plant assay, highest late blight severity (24%) was recorded when dsRNA molecules were sprayed individually while only 10% severity was recorded when applied as combination as against of 95% in untreated control. The efficacy of dsRNA was further improved when mixed with nano clay (1%). Late blight severity was reduced to 5% and spore production to $1x10^3$ sporangia/ml as against of 1.2 $x10^4$ sporangia/ml in untreated plants. This indicates that nanoclay prevented the degradation of dsRNA and improved the cellular uptake of dsRNA. This finally demonstrated RNAi efficacy in *P. infestans* and a new plant protection strategy for late blight management in an environmental friendly and sustainable manner.

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 wilt disease via degradation of accumulation of reactive oxygen species/ hypersensitive response, this was demonstrated using VIGS technology and observed that bacterial wilt resistance is correlated with down regulation of PAP2 gene. Using this approach, RNAi transgenic lines (120 lines) were developed and subjected to bacterial wilt assay. Results revealed that few lines (4) exhibited complete immunity to bacterial wilt while 6 lines showed delayed infection as compared to control (Fig. 20). Resistance was authenticated by quantifying expression of FLS2 and PR-4 (JA pathway) genes by qPCR, which confirmed the activation of defense pathway for wilt resistance. This is the first report demonstrating the development of alternative approach for bacterial wilt resistance.

Genome editing for development of late blight resistant potato

The *Phytophthora infestans* is considered as top most important oomycete pathogen because of flexibility in its genome. The present work aim at finding a solution to this problem by deploying the genome editing tools to disrupt the expression of major genes involved in pathogenicity. CRISPR/Cas9 is a breakthrough genome editing technology that permits site-specific cleavage of DNA targets in the genome. Each sgRNA is designed using sgRNAdesign tool to contain a short sequence homologous to a target gene sequence of choice, with which it directs the Cas9 nuclease to introduce a double-stranded break at that sequence. Based on our earlier Potato-Phytophthora microarray data, we selected three susceptible genes from Kufri Bahar.

As a proof, we performed *in vitro* sgRNA transcription and screening assay. sgRNA sequence was synthesized for the target region of the gene of interest and tested in potato. The 1416-bp of StCMPG1 target gene fragment was amplified, and sgRNA designed at 141 nucleotide position of target gene was *in vitro* transcribed using the Guide-it Complete sgRNA Screening System. The target fragment, the sgRNA and recombinant Cas9 enzyme were combined in an *in vitro* cleavage reaction according to the protocol.

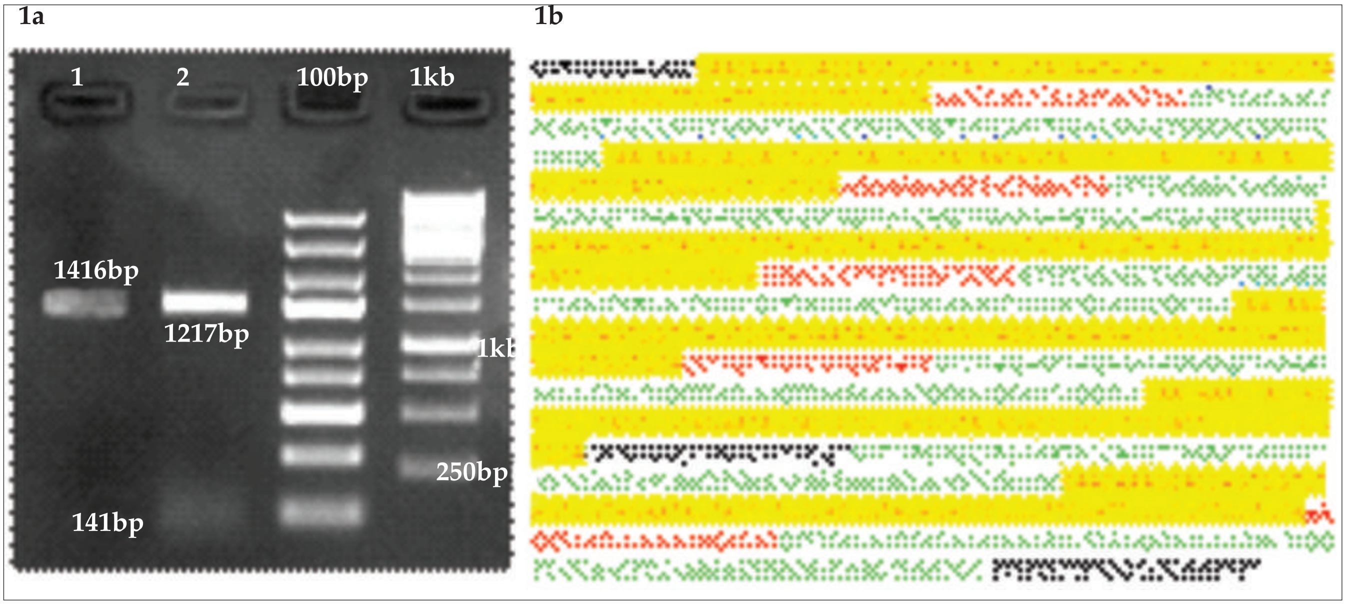


Fig. 21: The potato target StCMPGsgRNA *in vitro* transcription and Cas9 cleavage assay and multiplex gRNA guided CRISPR module for development of CRISPR/Cas9 construct. Lane 1 shows the untreated StCMPG fragment (1416 bp St CMPG), Lane 2 shows the cleaved StCMPG fragment (1275 bp and 141 bp).

Agarose gel electrophoresis indicated that this sgRNA directed Cas9-mediated cleavage of the target StCMPG gene (Fig. 21a). To construct genome editing module for late blight susceptibility genes, we designed a specific gRNA from the selected StCMPG, StPIP1C and StCNGC gene. A 20-bp gRNA sequence (two gRNA) was selected for each of the three genes by using the SSFinder tool (CCTop) and confirmed by manual analysis. The 20-bp sequence had tri-nucleotide PAM sequence i.e. 5′-AGG-3′ on its 3′ end. We designed multiplex editing of all the 3 genes using potato glyinestRNA for the simultaneous expression of all 6 gRNA under the control of AtU6 promoter (Fig. 21b). This construct will be used for genetic transformation of potato for editing all the three susceptible genes simultaneously for enhancing late blight resistance.

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

Ten tubers, each of two promising transgenic lines GTLC2-127 and KPLC2-53, were planted in containment facility for phenotypic observation. 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.

Fig. 22: Screening of GTLC2-127 transgenic line through agro inoculation technique. A- Transgenic line, B- Non transgenic line (Control)

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 (Fig. 22) as against non transgenic (control plants).

Biological Approaches

Identification and characterization of endophytes against *Phytophthora infestans, Ralstonia solanacearum* and *Streptomyces scabies*

Thirty one cultures of endophytic bacteria isolated from potato plants were tested for their antagonistic activity against *R. solanacearum* and *S. scabies in vitro* through agar diffusion method (Fig. 23). Twenty two cultures were found inhibitory to *R. solanacearum* whereas 09 were ineffective.

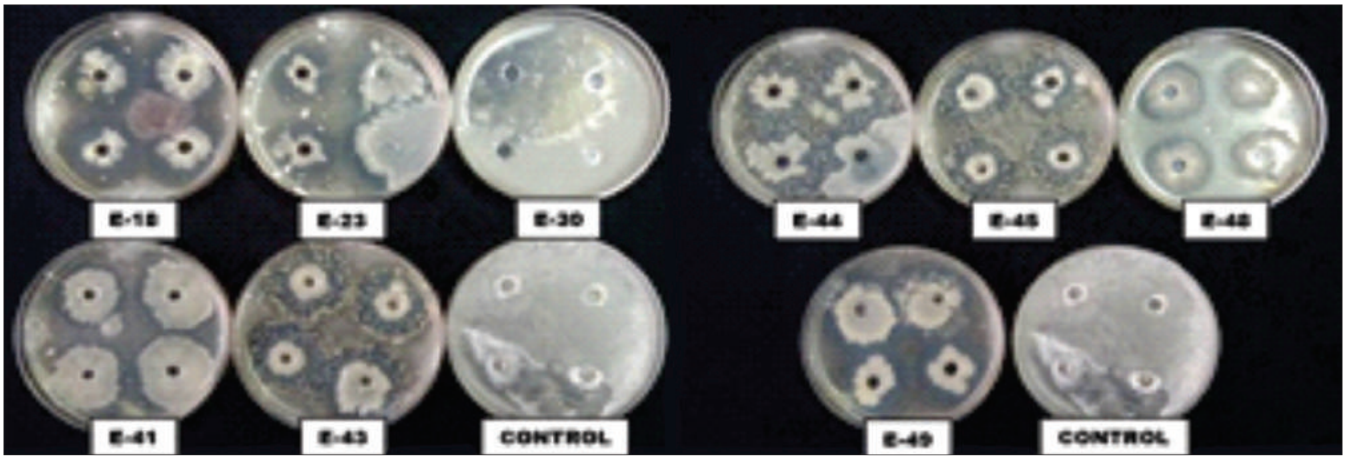


Fig. 23: Antagonistic effect of endophytic bacteria against *Streptomyces scabies*

Eleven cultures completely dried the Ralstonia growth within 48 hrs, 01 formed >3.0 cm inhibition zone, 05 formed >2.5-3.0 cm inhibition zone, and 05 formed >1.0-2.5 cm inhibition zone. Against *S. scabies*, one culture formed >4.0 cm inhibition zone, 06 formed >3.0-4.0 cm inhibition zone, 02 formed >1.5-3.0 cm inhibition zone and 10 over grew Streptomyces culture while 11 were not effective. Forty eight endophytic bacterial isolates were partially identified by the analysis of 16S rDNA sequence. Specific primers used for PCR were: fD1 and rp2 and 16S rDNA gene sequences of bacterial isolates were matched with those from NCBI BLAST search and they belonged to genera *Stenotrophomonas, Pseudomonas, Bacillus, Acinetobacter, Klebsiella, Pantoea, Chryseobacterium, Janibacter* and *Enterobacter*.

Characterization of endophytes for plant growth promotion activities

Bacterial endophytes which showed potential against late blight, bacterial wilt and common scab pathogens were characterized for their plant growth promoting activities viz., siderophore production, nitrogen fixation and phosphorous solubilisation. Out of 60 endophytes, 26 endophytes were confirmed to produce siderophore by CAS-blue agar assay, 32 were found nitrogen fixers and 26 endophytes exhibited phosphate solubilizing activity by forming clear zones on NBRIP agar plates.

Bio-fumigation of soil with brassicas for the management of soil and tuber borne diseases

Field trails were conducted at Jalandhar, Modipuram and Shimla (Lower Lab) to see the effect of bio-fumigation of soil with brassicas namely, Indian mustard, taramira, rape seed, radish and Indian rape on soil and tuber borne diseases. In the fourth consecutive year of experimentation, significantly low common scab intensity (20.6 to 22.7%) was observed for bio-fumigation with Indian mustard, taramira, rape seed and Indian rape compared to control (30.6%). The effect was however, non-significant on the incidence and intensity of black scurf of potato. At Modipuram, comparatively low black scurf incidence was observed in brassica bio-fumigated plots (74.9 to 80.0%) than in control (90.0%). At Shimla, in the third year of experimentation also, the bio-fumigation with five brassicas did not prove effective against bacterial wilt of potato.

Management of *Potato virus Y* by eco-friendly approaches

Different botanicals *viz*., Ricinus leaf, Ricinus seed, Bougainvillia and Mirabilis were tested against management of PVY. These botanicals are potential source of defense related proteins which have shown broad-spectrum antiviral activity against plant viruses. Healthy potato tubers of Kufri Jyoti were planted in pots under glass house conditions (Fig. 24).

After 3-4 leaf stage, the plants were treated with defense related proteins followed by (after 24 hr) challenge inoculation (mechanical inoculation) with *Potato virus Y*. To know the defense response, biochemical assays were carried out where, Ricinus leaf and Ricinus seed showed maximum defense related responses *i.e.*, peroxidase (8.14 μmole/min/g FW), MDA (1.19 nmol/ml), phenols (355μg/g FW), chlorophyll (1.530 mg/g FW), total soluble sugars (4.89 mg/g FW), proline (150.79 mg/100g FW) and anthocyanin (27 mg/100g FW).

Fig. 24: Eco-friendly management studies to manage PVY

The role of these biochemical compounds in disease suppression/defence will be ascertained.

Post entry quarantine testing of imported germplasm

A total of 41 *in vitro* cultures of potato imported by Crop Improvement Division, ICAR-CPRI, Shimla (22 cultures), M/s Bhatti Tissue Tech., Jalandhar (5 cultures), M/s TechnicoAgri Sciences Ltd (10 cultures) and M/s McCain Foods India Pvt Ltd (4 cultures) were tested for post entry quarantine pathogens.

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

Five thousand three hundred and four 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 11,80,966. In addition, one thousand nine hundred ninety three mother cultures of potato were also tested for the above mentioned viruses. 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.

Apart from this, nearly 831 samples from M/s PepsiCo India Holdings Pvt. Ltd. Hoshiarpur (Punjab), M/s Technico Agri Science Pvt Ltd. Baddi, Solan (HP), M/s Mahindra HZPC Pvt. Ltd., Mohali, M/s Sashanka Agri Tech Pvt. Ltd., Ranchi, M/s Govt of Karnataka, M/s Potato Technology Center, Haryana and M/s Merino Industries Ltd., Hapur, were also tested for different viruses through DAS-ELISA/PCR under contract research/contract services (Fig. 25).

Fig. 25: Certification process of potato and apple crops from different accredited TCPUs

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

Monitoring of various potato pests/ vectors

Aphids

The population of peach-potato aphid (*Myzus persicae*) and other aphid species was monitored at Modipuram, Jalandhar and Gwalior in unsprayed potato fields from October 2018 to the February, 2019. At Jalandhar, *M. persicae* arrival was delayed almost one week as compared to the previous year. It first appeared on the potato plants in the 2nd week of November and crossed the critical limit of 20 aphids per 100 compound leaves on 22nd December (Fig. 1).

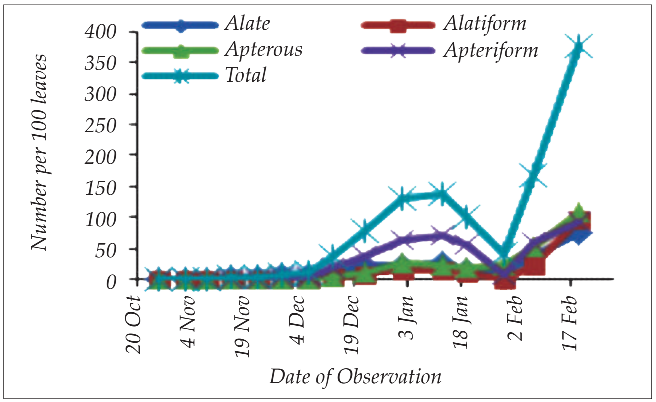


Fig. 1: Population dynamics of *M. persicae* on potato at Jalandhar (2018-19)

The population of winged morphs of *Aphis* spp. started out at 15 aphids per 100 compound leaves and increased briefly till 2nd week of November.

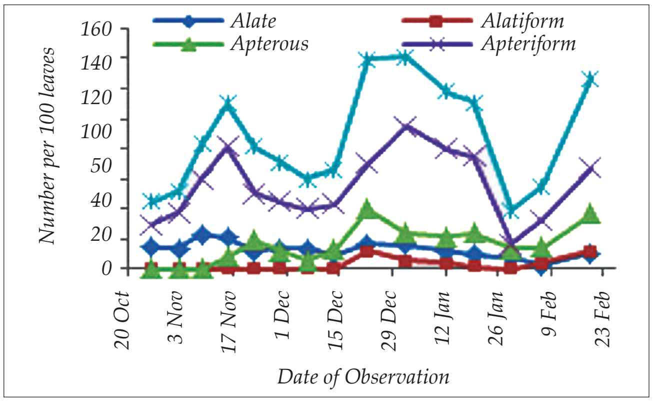


Fig. 2: Population dynamics of *Aphis* spp. on potato at Jalandhar (2018-19)

In general, the population of *Aphis* spp. remained above the critical threshold throughout the cropping season (Fig. 2).

The yellow sticky traps (YSTs) catches also indicated similar trends (Fig. 3). *M. persicae* crossed the critical level in first week of January at Modipuram. High population (351/100 compound leaves) of both the aphids *M. persicae* and *A. gossypii* was recorded on potato during last week of February in western Uttar Pradesh. The YSTs data at Modipuram revealed that maximum number of aphids (1063/trap/week) was recorded in 48th standard week of 2018.

Whitefly

The population of whitefly (*Bemisia tabaci*) at Jalandhar was monitored from the last week of October to 3rd week of February by leaf count method and with the help of YSTs. In general, the population of whitefly adults showed a general decline in population over time which begun very high initially (Fig. 4a).The population remained above economic threshold till the 2nd week of November. Up to 41 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).

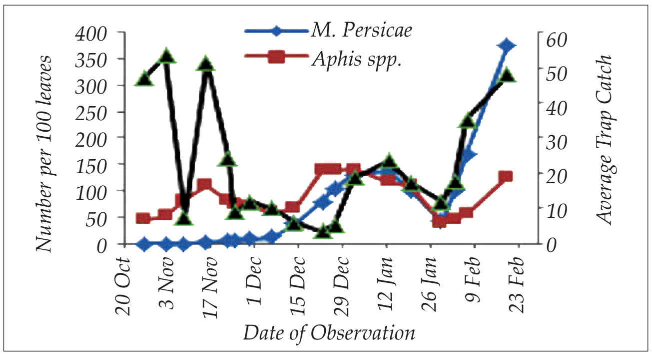


Fig. 3: Comparison of the population dynamics of *M. persicae, Aphis* spp. and average YSTs aphid catch on potato at Jalandhar (2018-19).

At Modipuram, the population of whitefly remained high (32/05 plants) on early potato crop (Kufri Pukhraj) while it was 3.67/05 plants on main potato crop (Kufri Pukhraj). The YSTs data revealed that maximum number of whitefly (163/ trap/week) was recorded in 51st standard week of the year 2018.

At Gwalior, the incidence of whitefly started on potato crop in 4th week of November and reached its peak population in second week of December.

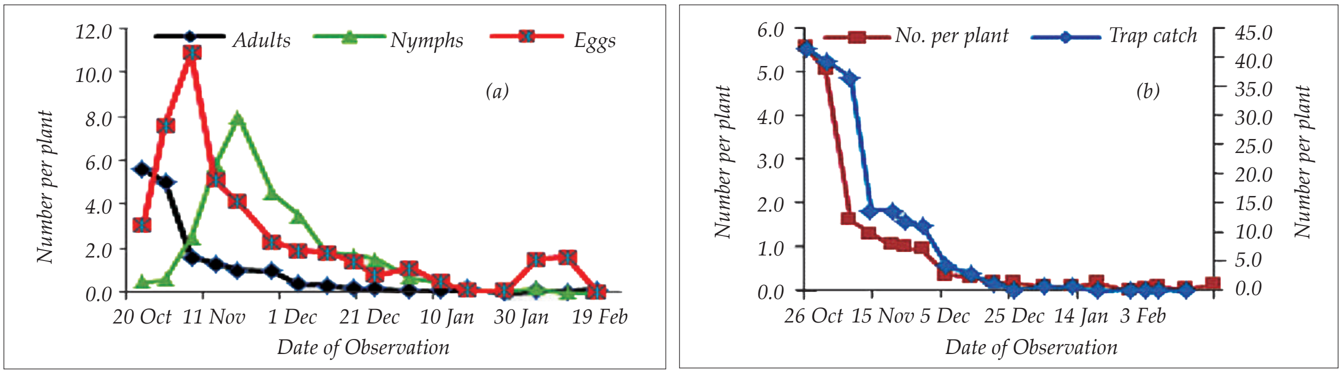


Fig. 4: Population dynamics of *B. tabaci* sampled by (a) leaf count method and (b) YSTs catch in potato at Jalandhar (2018-19)

A maximum of 15 whiteflies/plant and 48 thrips/plant were recorded in ware crop while 10 and 13 on seed crop respectively (Figs. 5&6).

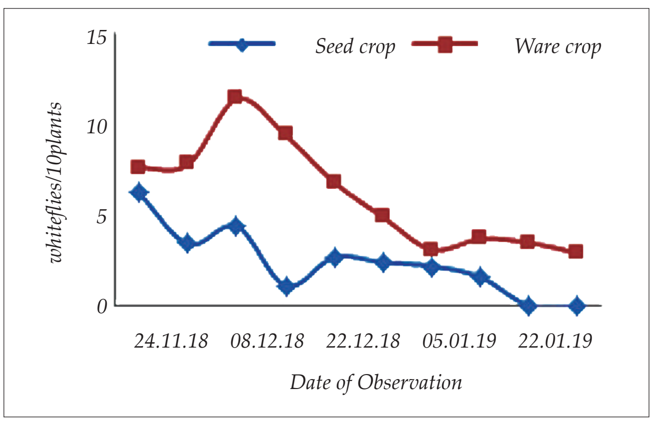


Fig. 5: Population dynamics whitefly on seed and ware crop at Gwalior (2018-19)

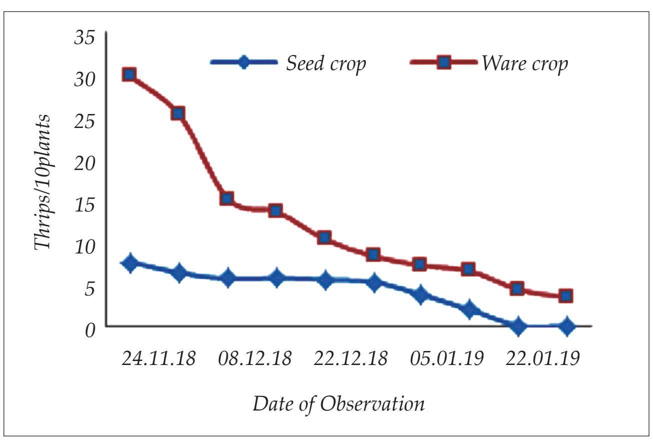


Fig. 6: Population dynamics of thrips on seed and ware potato at Gwalior (2018-19)

Population buildup of whitefly on potato cultivars grown under organic and inorganic conditions

The population build-up of whitefly was studied on ten potato cultivars grown under organic and inorganic set of conditions during main crop season at Modipuram.

In general, potato cultivars Kufri Mohan, Kufri Garima, Kufri Ganga, Kufri Khyati, Kufri Bahar and Kufri Chipsona- 1 showed slightly high incidence of whitefly grown under organic condition throughout crop growth as compared to inorganic condition (Figs. 7 & 8).

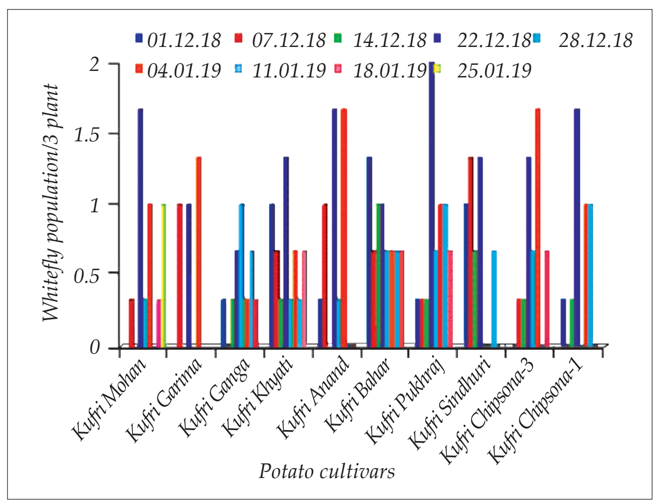


Fig. 7: Whitefly population on potato cultivars under inorganic condition

Incidence of aphids and leafhoppers on potato cultivars were almost insignificant under both organic and inorganic conditions.

Whitefly preference to potato cultivars under net house

Ten varieties including (Kufri Neelkanth, Kufri Mohan, Kufri Ganga and Kufri Lima) and three genotypes (MS/7-645, MS/8-1148 and MS/0042) were exposed to whiteflies under net house conditions with open/free choice of settlement/multiplication on potato varieties and genotypes. The data revealed that least preferred genotype was MS/0042 and the most preferred potato varieties were Kufri Mohan (1.49/plant) and Kufri Neelkanth (1.73/plant).

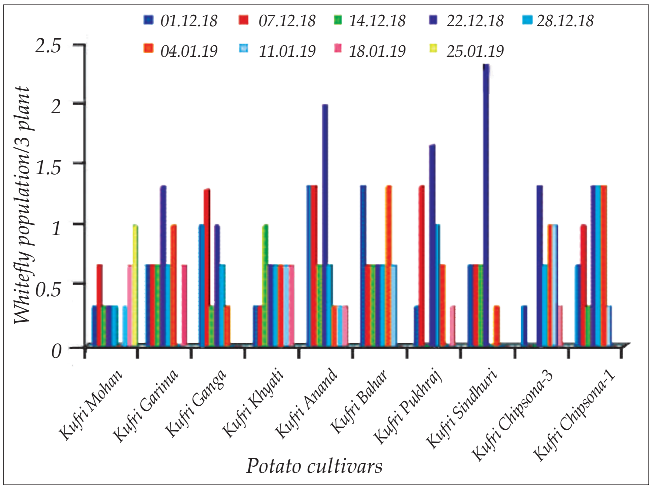


Fig. 8: Whitefly population on potato cultivars under organic condition

Management of vectors/pests

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 was evaluated. The potato crop rows were covered with PP row covers either for the whole duration of the crop *i.e.* from crop emergence till haulm cutting or from emergence to last week of November which corresponds to the period of whitefly infestation in potato crops (Fig. 9). The PP row covers completely excluded the whitefly and aphids from covered rows and infestation started only after the row covers were removed from specific plots.

Data recorded indicated that both PP row covers are effective for insect vector exclusion and thereby in reduction of virus disease incidence. The incidence of late blight of potato remained lower in covered crop rows however; they became more susceptible to the disease once the covers were removed. The tuber yield reduced by 25 to 32 % in covered plots.

Evaluation of Potassium silicate and Flonicamid 50 WDG for the management of whitefly, *B. tabaci* and peach-potato aphid (*M. persicae*) in potato

Potassium silicate is not able to suppress the adult whitefly population by more than 62 % at Modipuram and Jalandhar. However, suppression in disease incidence is at par with other insecticides. Only Imidacloprid 17.8 SL @ 0.04 % and Flonicamid 50 WDG @ 0.04 % have significant residual toxicity up to 14 DAT at Jalandhar. Incidence of viruses was considerably lower for all treatments as compared to control with no significant variation among the treatments. At Jalandhar, potassium silicate causes only 40-60% reduction in aphid population up to 14 DAT however; the virus incidence suppression is at par with other insecticides. Highest reduction in aphid population is caused by Flonicamid 50 WDG @ 0.04 %, followed by Flonicamid 50 WDG @ 0.03 %, Dimethoate 30EC @ 0.1% and Imidacloprid 17.8 SL @ 0.04 %, both as knockdown and as residual toxicity.

Fig. 9: Potato crop rows covered with floating and hoop supported PP covers

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

At Jalandhar, the bio-efficacy of Aavya @ 0.4%, Nanma @ 0.50%, 0.75%, 1.0%, Neem oil @ 0.5% in comparison to Imidacloprid 17.8 SL@ 0.04 % to adult whiteflies and peach-potato aphid was evaluated in separate trials. No significant adult knockdown was noted for the tested insecticides against whitefly. While as Nanma @ 1.0%, mineral oil @ 0.5%, and Imidacloprid 17.8 SL @ 0.04 % provided some degree of control over the first 3 days, Nanma @ 1.0% and Imidacloprid 17.8 SL @ 0.04 % could provide sustained reduction up to 9 days after treatment.

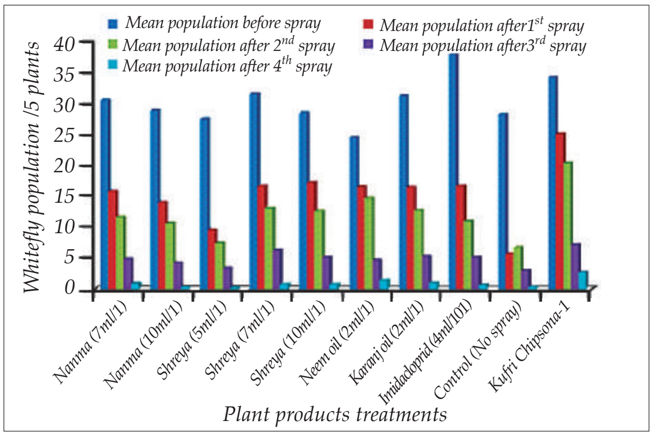


Fig. 10: Effectiveness of plant products against whitefly on early potato crop at Modipuram (2018-19)

Aavya @ 0.4% had no appreciable knockdown or residual toxicity against whitefly. On the other hand, Nanma @ 1.0% and Imidacloprid 17.8 SL @ 0.04 % could provide sustained reduction of aphid population up to 9 days after treatment. Aavya @ 0.4% had no appreciable knockdown or residual toxicity against the peach-potato aphid.

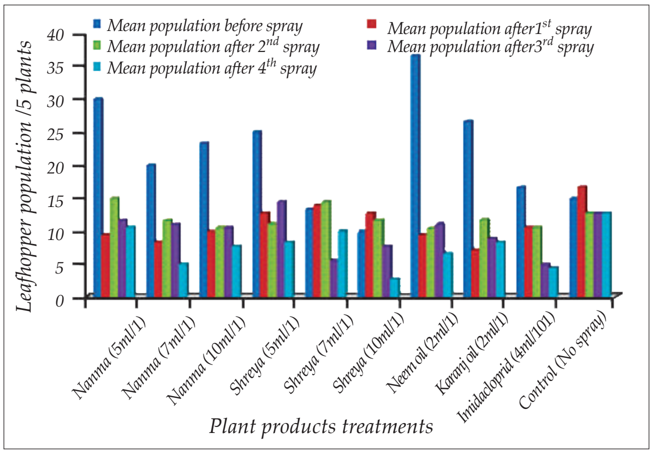


Fig. 11: Effectiveness of plant products against leafhoppers on early potato crop at Modipuram (2018-19)

Data recorded at Modipuram revealed that Nanma and neem oil treatments recorded 12.39 and 5.45 % increase in tuber yield as compared to Imidacloprid treatment with 17.63% increase in tuber yield. Similarly, highest tuber yields 20.4, 19.14 and 21.35 t was recorded in the respective treatments with a C: B ratio of 1:4.29, 1:2.52 and 1:5.58, respectively (Figs. 10 & 11). At Gwalior, bio-pesticides results indicated that Nanma @10ml/L was found effective for managing whitefly and thrips on potato.

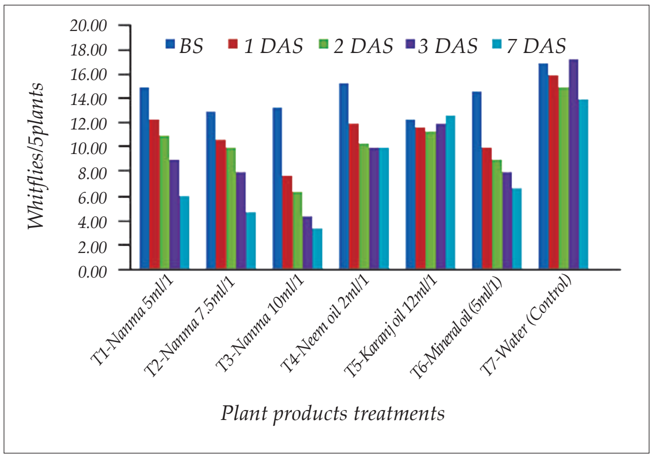


Fig. 12: Effectiveness of plant products against whitefly at Gwalior (2018-19)

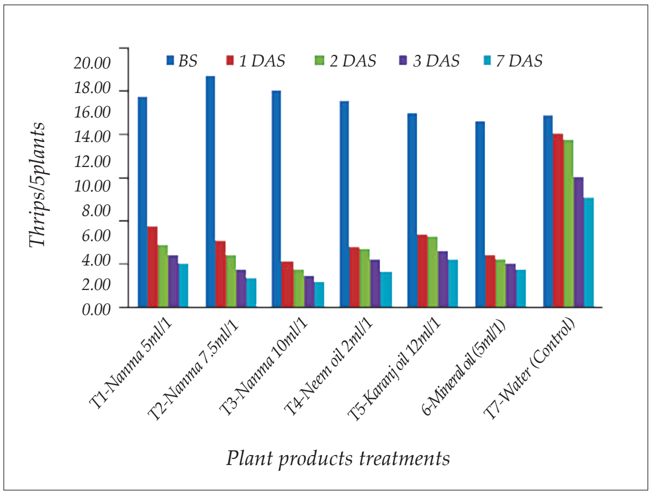


Fig. 13: Effectiveness of plant products against thrips at Gwalior (2018-19)

There was no aphid incidence during experimental period. Nanma did not result any phytotoxicity on potato crop (Figs. 12 & 13). At Modipuram, Nanma (10 ml/l) was effective against whitefly, plant hopper and aphid and lost their effectiveness within 2-3 days in the main season. Therefore, frequent spray will be required to bring down the population of sucking pests. Data revealed that Nanma (10ml/l) recorded 4.05 % increase in tuber yield as compared to control (Figs. 14 & 15).

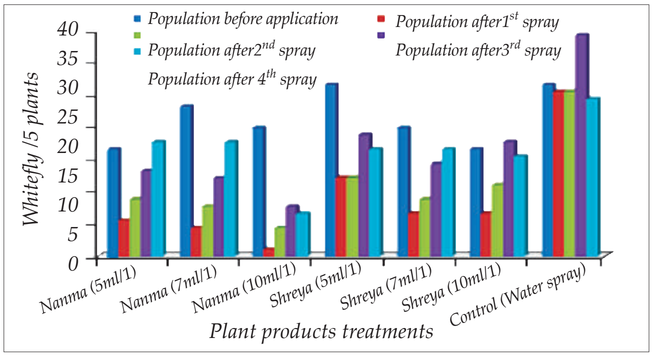


Fig. 14: Effectiveness of plant products against whitefly on main crop season potato crops at Modipuram

Bio-efficacy of IGR and TTA Insecticides against cotton whitefly (*B. tabaci*) and peach-potato aphid (*M. persicae*) in potato

At Modipuram, data revealed that Buprofezine 25SC (16 ml/10 l) effectively reduced the population build-up of whitefly and leafhopper, which is at par with Imidacloprid. The maximum increase in tuber yield 5.94% was recorded in Buprofezine 25% SC at (16 ml/10 l) followed by (12 ml/10 l) of the same insecticide and highest tuber yields of 34.40 and 34.30 t were recorded in the respective treatments with a C: B ratio of 1:7.55 and 1:7.46 (Figs. 16 & 17). At Jalandhar, the bio-efficacy of Spiromesifen 240SC @ 0.1%, Spirotetramat + Imidacloprid 240 SC @ 0.075%, 0.10% and 0.125%, Buprofezin 25 SC @ 0.08%, 0.12% and 0.16%, Pyriproxyfen 10 EC @ 0.1%, 0.15% and 0.2% in comparison to Imidacloprid 17.8 SL @0.04% against whiteflies and peach-potato aphid was evaluated.

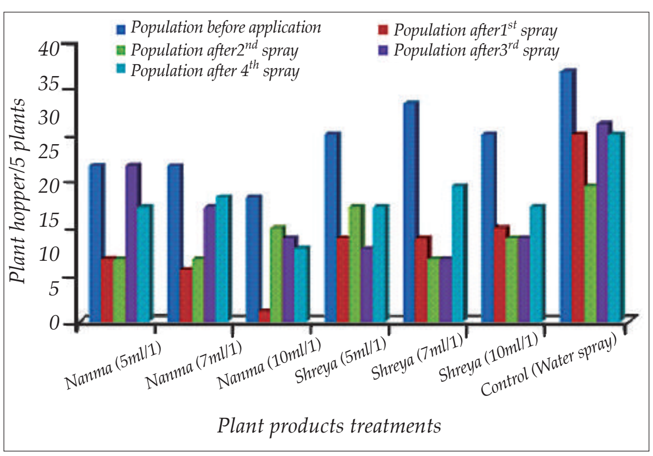


Fig. 15: Effectiveness of plant products against plant hoppers on main crop season potato crops at Modipuram

The IGR and TTA insecticides are effective against nymphs and eggs only, therefore the populations were monitored up to 24 days after treatment to allow the nymphs and eggs to moult into adults. No significant knockdown or residual toxicity was found associated with IGR and TTA insecticides on whitefly in potato. Further, only Spirotetramat+Imidacloprid 240 SC @0.125% and Imidacloprid 17.8 SL @ 0.04 % had significant knockdown effect on aphid population, while as residual toxicity is associated with IGR and TTA insecticides on peach-potato aphid. Spirotetramat + Imidacloprid 240 SC @ 0.125%, Buprofezin 25 SC @ 0.16% and Pyriproxyfen 10 EC @ 0.2% provided excellent residual control of PPA populations.

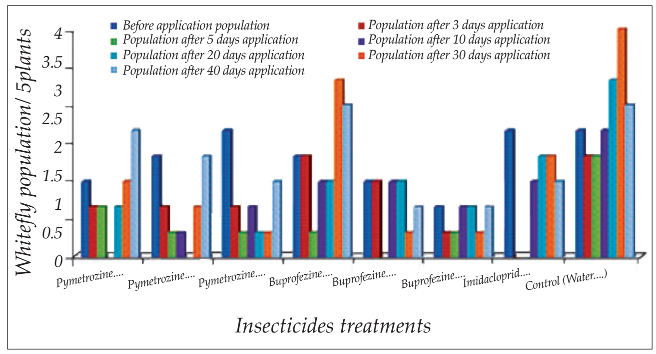


Fig 16: Bio-efficacy of knock down insecticides against whitefly on main potato crop at Modipuram

Bio-efficacy of knockdown insecticides against cotton whitefly (*B. tabaci*) and peach-potato aphid (*M. persicae*) in potato

The bio-efficacy of Dinotefuran 20 SG @ 0.03% and 0.04%, Flupyradifurone 200 SL @ 0.05%, 0.75% and 0.1%, Diafenthiuron 50 WP @ 0.06%, 0.08% and 0.1%, Pymetrozine 50 WG @ 0.04%, 0.06% and 0.06% in comparison to Imidacloprid 17.8 SL @ 0.04 % against adult whiteflies and peach-potato aphid was evaluated in separate trials at Jalandhar. No significant immediate knockdown was noted for the tested insecticides but Imidacloprid 17.8 SL @ 0.04 %, Pymetrozine 50 WG @ 0.06% and Diafenthiuron 50 WP @ 0.1% could provide significant control of adult whiteflies up to 2 weeks.

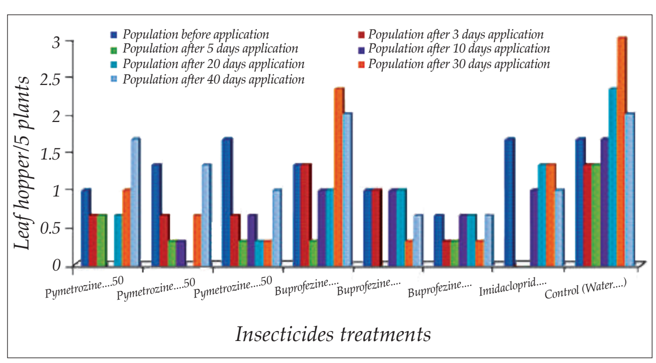


Fig 17: Bio-efficacy of knock down insecticides against leaf hoppers on main potato crop at Modipuram

Further, Flupyradifurone 200 SL @ 0.1%, Diafenthiuron 50 WP @ 0.08% and 0.1%, followed by Imidacloprid 17.8 SL @ 0.04 % could provide knockdown effect on PPA with consistent performance up to 2 weeks but Pymetrozine 50 WG @ 0.06% and 0.08% could provide control of PPA populations over longer periods of time. At Gwalior, Pymetrozine 50 WG and Buprofezine 25% SC were evaluated at different doses as foliar spray with standard insecticide and untreated check against whitefly and thrips on potato.

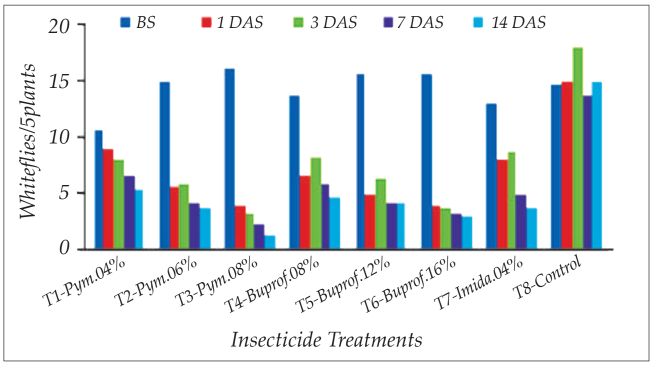


Fig. 18: Effect of insecticide treatments on whitefly population on potato at Gwalior

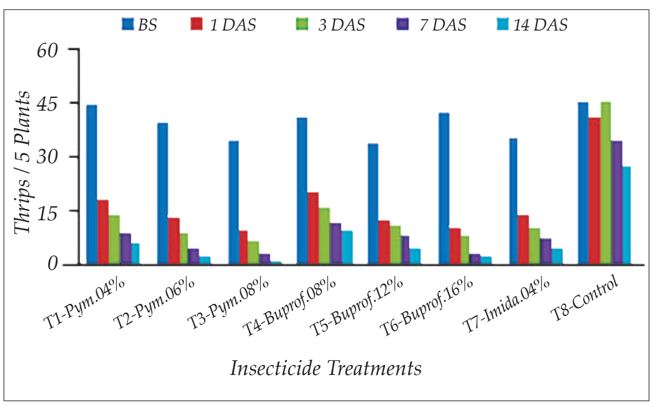


Fig. 19: Effect of insecticide treatments on thrips population on potato at Gwalior

The result indicates that Pymetrozine 50 WG@ 0.08% and Buprofezine 25% SC @ 0.16% found effective for the managing whitefly and thrips on potato (Figs. 18 & 19). There was no aphid incidence during experimental period. No phytotoxicity symptoms were observed in any treatment of Pymetrozine and Buprofezineat Gwalior.

Bio-efficacy of soil incorporated insecticides against cotton whitefly (*B. tabaci*) and *Aphis* spp. in potato

At Modipuram, Jalandhar and Gwalior, the bio-efficacy of soil insecticides-Cartap Hydrochloride 4 G at three doses (15, 20 and 25 kg/ha) and Fipronil 0.3 G at three doses (15, 20 and 25 kg/ha) was assessed against sucking insects and results were compared with Phorate 10 G (15 kg/ha) along with control. At Modipuram, data revealed that Cartap Hydrochloride 4 G at (20 kg/ha) was effective against whitefly and leafhopper, which is at par with Phorate 10 G (15 kg/ha). The maximum % increase in tuber yield 8.84 was recorded in Cartap Hydrochloride 4 G at (20 kg/ha) followed by (15 kg/ha) of the same insecticide. Similarly, highest tuber yields 37.13 and 36.83 t was recorded in the respective treatments with a C: B 8.00 and 1:7.86 (Figs. 20 & 21).

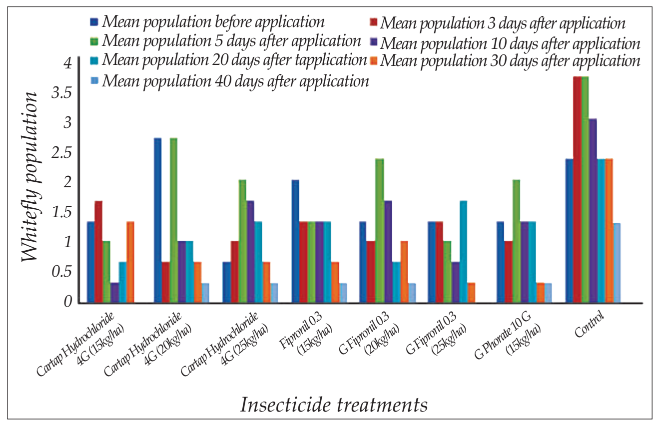


Fig. 20: Bio efficacy of soil incorporated insecticides against whitefly on main potato crop

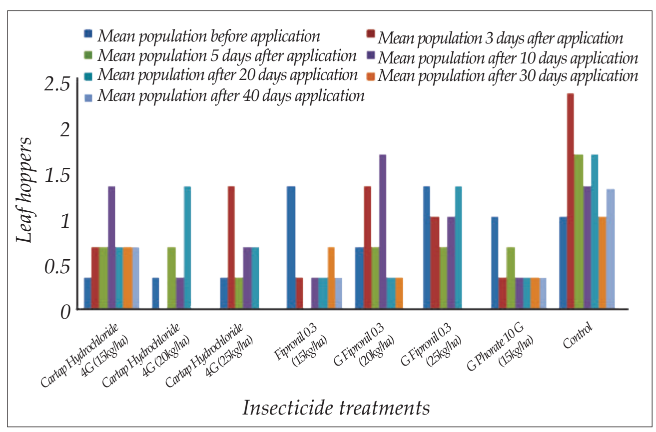


Fig. 21: Bio-efficacy of soil incorporated insecticdes againts leafhopper on main potato crop

At Jalandhar, Fipronil 0.3 G @ 25Kg/ha, and Cartap hydrochloride 4 G @ 25 Kg/ha in general, were more effective in suppressing whitefly population as compared to Phorate 10 G @15 Kg/ha as soil incorporated insecticides. Fipronil 0.3 G @ 25 Kg/ha and Fipronil 0.3 G @ 20 Kg/ha performed better or at par with Phorate 10 G @ 15 Kg/ha against Aphis spp. as soil incorporated insecticides. At Gwalior also result indicated that Fipronil 0.3 G

@25Kg/haand Cartap hydrochloride 4G @25 Kg/ha were effective against whiteflies (Fig. 22).

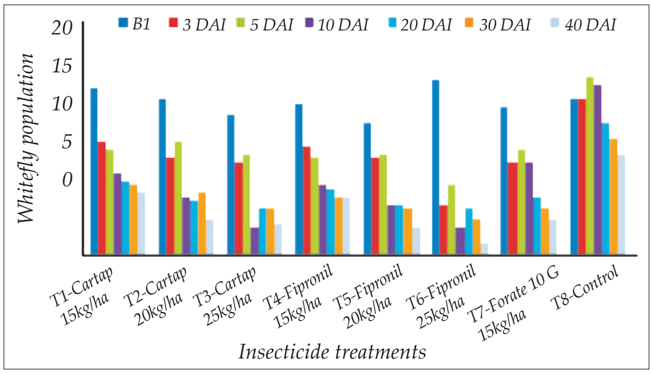


Fig. 22: Effect of soil incorporated insecticides on whitefly population at Gwalior

Glass-house aphid *Aulacorthum solani* genome analysis for gene annotation and gene ontology (GO)

Gene prediction was carried out with 89,260 scaffolds using the AUGUSTUS-3.2.1 gene prediction program using *Ac. pisum* as a model aphid. A total of 22,021 genes were predicted in *A. solani* genome in which average gene length was 1,104 bp ranging from 201 to 40,377 bp. Of these, 2,733 genes were ≥ 2000 bp. Predicted genes had 42.63% GC content. Functional annotation of the 22,021 predicted genes was performed using BlastX program against the NCBI BlastX 'Nr' protein database. Of which, 20,359 genes were annotated with putative functions based on the sequence homology and remaining 1,662 genes were with unknown function.

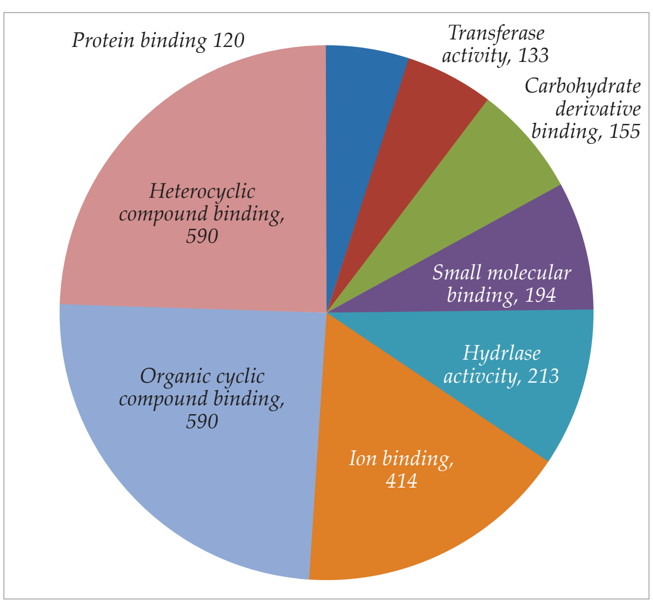


Fig. 23: Gene ontology analysis of *A. solani* genome-Molecular Process

Most genes were annotated with *M. persicae* genome. Several genes with putative functions were identified in *A. solani* genome such as 277 defensive and detoxifications genes (e.g. 54 cytochrome P450s), 55 salivary genes (e.g. 4 salivary gland proteins), 48 insecticide target genes (26 acetylcholine receptors/acetylcholinesterase) and 37 virus transmission genes (11 dynamins, 3 serine protease inhibitors and 23 vesicle transport/trafficking proteins) so on. Gene ontology analysis of 22,021 predicted genes was carried out using Blast2GO program in which maximum number of genes were associated with molecular functions (1,139) followed by biological processes (835) and cellular components (754) (Fig. 23).

Relative Transmission of *Potato Leafroll Virus* (PLRV) by two aphids Species, *M. persicae* and *A. solani*

The *Aulacorthum solani* have also been recorded in potato at potato at different potato growing regions apart from *M. persicae* and found viruliferous to PLRV. Hence, the present study was aimed to investigate the role of *A. solani* in PLRV transmission and relative transmission efficiency with an efficient vector *M. persicae*. This will helpto elucidate the infection process of phytoviruses. Virus transmission was undertaken by allowing five aviruliferous aphids of each species to acquire the PLRV (Potato as source plant) for 96 hrs as acquisition access period (AAP).

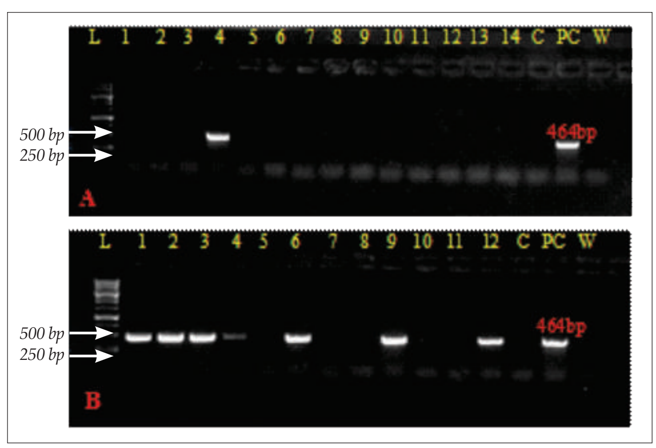


Fig. 24: L-1kb Ladder; lane one to fourteen in gel A and one to twelve in gel B are PLRV transmitted plants by *A. solani* and *M. persicae* respectively; C, negative control; PC, positive control and W, PCR reaction control.

After the prescribed AAP, the aphids were then transferred on the healthy tissue culture raised plants (Kufri Jyoti) with a constant 96 hrs inoculation access period (IAP). After the IAP of 96 hrs, the transmission was terminated by the application of insecticide. The plants were allowed for symptoms development at 24±20C at glasshouse conditions in insect proof cages and thereafter, two months old plants were tested for PLRV through PCR. The *A. solani* could transmit PLRV with low efficiencies (7.1%) only in one plant out of fourteen plants which is the first ever report of transmission whereas *M. persicae* could transmit the virus in eight plants out of twelve (66.6 %). This study indicates *A. solani* as potential vector of PLRV though the transmission efficiency is less as compare to *M. persicae* (Fig. 24).

Characterization of whitefly from different location on potato host

The whitefly (*Bemisia tabaci*) is now recognized as a cryptic species complex composed of at least 34 genetic groups across the world. These genetic groups exhibit considerable phenotypic variability with regards to the relative ability to transmit begomoviruses, the rate of development, ability to utilize different hosts and the ability to induce physiological changes in some hosts. Genetic identification of whiteflies collected from potato host at seven locations Modipuram (UP), Pantnagar (Uttrakhand), and Hisar (HR), Jalandhar (PJ), Pune (MH), Dessa (GJ) and Gwalior (MP) were completed by partial amplification of Mitochondrial DNA (Fig. 25).

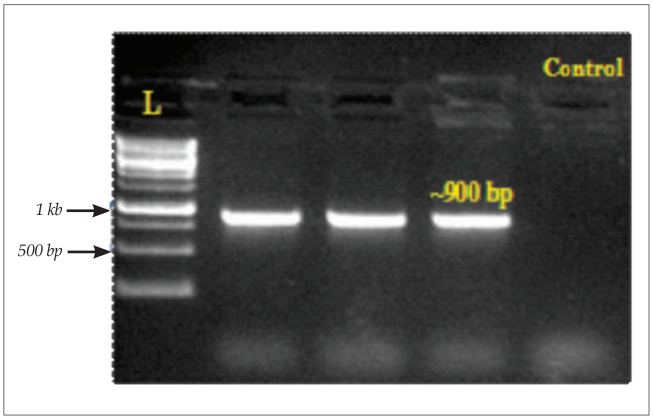


Fig. 25: PCR amplification of mtCOXI gene of whitefly

The mtCOXI gene sequence of three individuals from each location was analyzed for genetic identification. Approximately 900 bp of the mtCOXI gene fragment was amplifie d using forward primer L2 – N 3014 COI (5′-TCCAATGCACTAATCTGCCATAT) and reverse primer C1 J2195 COI (5′–TTGATTTTTTGGTCATCCAGAAGT). Amplified mtCOXI gene of each sample were visualized in 1.3 % agarose stained with Ethidium dibromide and PCR products were eluted and purified using QIAquick Gel Extraction Kit (Qiagen) an cloned into pTZ57R/T vector (Thermo Scientific). The positive clones were sequenced with vector specific primers (M13-F for T/A clone) by 3500 genetic analyzer (Applied Biosystems). Whitefly collected from Modipuram (UP), Pantnagar (Uttrakhand), and Hisar (HR) was identified as Asia II 1 whereas, whitefly from Jalandhar (PJ), Pune (MH) as Asia II 5 and whitefly from Dessa (GJ) and Gwalior (MP) were found to be Asia 1 genetic group. The present study will he help to understand whitefly population structure on potato, establishing relationship with begomovirus (PALCV) and understanding it's epidemiology.

Endosymbionts profile of Asia II 5 whitefly collected from Potato host

Whitefly harbor primary *Portiera* and many secondary endosymbionts like *Wolbachia, Cardinium, Rickettsia, Arsenophonus* and *Hamiltonella* are known for manipulating reproduction, circulative transmission of viruses in vectors, ability to tolerate synthetic pesticides and thermo tolerance. Hence, profiling the whitefly endosymbionts used for virus transmission will help to know the possible role of endosymbionts in virus transmission. Genomic DNA was isolated from 24 different individuals for detection of six endosymbionts by bacteria specific primers using PCR. Four endosymbionts were detected in Asia II 5 whitefly genetic group *viz*., *Arsenophonus, Cardinium, Portiera, Rickettsia,* whereas *Wolbachiaand Hamiltonella* could not be detected. The endosymbionts *Arsenophonus, Portiera* were widely present in the whitefly Asia II 5, could be detected in 23 individuals out of 24 whereas, *Cardinium* and *Rickettsia* could be detected in 18 and 17 whitefly individuals respectively.

Effect of Sodium hypochlorite (NaOCl) on potato cyst nematode (PCN) under *in vitro* condition

PCN cysts (*Globodera* spp.) were treated with different concentrations of NaOCl viz., 0.5, 1.0 and 2.0% under *in vitro* condition. With increase in concentration, time required for disintegration of cyst wall reduced drastically. Among the treatments, cent-percent cyst disintegration was recorded in NaOCl @ 2.0% after 10 min whereas it took 30 min. in NaOCl @ 1.0% and 120 min in NaOCl @ 0.5%. NaOCl was effective against eggs also.

Efficacy of NaOCl on seed tubers infected with PCN

PCN infested seed potato tubers were treated with different concentration of NaOCl viz., 0.5, 1.0 and 2.0% for different durations viz., 30, 60 and 120 min. to check its effect on PCN disintegration along with control (water).Among the treatments, 100% cyst disintegration was recorded in NaOCl @2.0% after 30 min., 60 min. in NaOCl @1.0% whereas it took 120 min. in NaOCl @0.5%. These treatments had no adverse effect on sprouting of seed tubers after two months of storage.

Genetic diversity of *Globodera rostochiensis* in Ooty and Shimla

Genomic DNA of single *G. rostochiensis* female, collected from Ooty (*GrO*) and Shimla (*GrS*) sick fields were checked with the primers developed by Mulloholand et al. (1996) which resulted 238 bp amplicon size. The eluted products were cloned into plasmids and five clones from each cyst of Ooty and Shimla were sequenced. The sequence received were compared with sequences in Gene Bank using BLAST, the *GrO* sequences had 100% identity with *G. rostochiensis* population from Australia (MH820361), India (MG575646), Belgrade (KR057953), Czech Republic, (KJ409624), Serbia (KC508108), Poland (JF907547), Russia (DQ847120) and Canada, Newfoundland (GQ294519). Whereas, *GrS* had 100% identity with Japan (LC030413), Italy (LT159840), China (MK534188), Russia (KJ409617), Poland (JF907541) and Newfound land (FJ212164). From these results, we concluded that *GrO* population is close to Australia and European populations while *GrS* is close to China, Japan, Italy, Canada and some European populations.

Validation of LAMP assay for the identification of *Globodera* spp. from soil samples

To validate the applicability of the Glo-LAMP method in field samples, 250 mg soil was artificially inoculated with 1, 3, 5 and 10 cysts of *Globodera* species and used for LAMP assay which resulted in amplification at 60°C isothermal conditions within 1hr (Fig. 26a).For analytical sensitivity tests, the Glo-LAMP reactionswere performed using serial dilutions of DNA fromsingle potato cyst i.e. 50ng/µl, 30ng/µl, 10ng/µl, 1ng/µl, 100pg/µl, 10pg/µland 1pg/µl (Fig. 26b).

The same results under visual fluorescence detection with SYBR Gold nucleic acid stain, positive or negative results were determined, the samples giving positive reactions appearing green, while the negative control remained orange (Figs. 26 c & d).

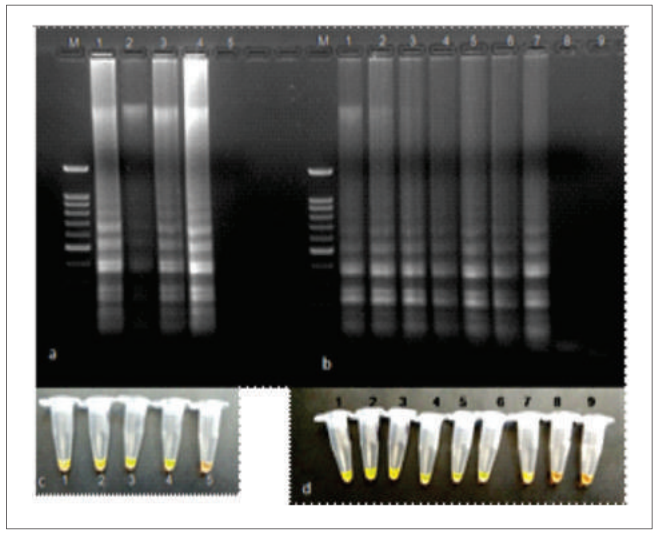


Fig. 26: LAMP assay for the identification of *Globodera* spp

Effect of different management strategies on root-knot nematode

Root-knot nematode (RKN) management studies on potato were carried out at Modipuram. Various RKN management strategies had significant effect only on tuber yield among different parameters studied. Dazomet @ 400 kg/ha recorded significant maximum yield along with minimum RKN female per g of root after 60 DAP.

Evaluation of different doses of Dazomet (new) on potato cyst nematodes

The results with Dazomet at Ooty revealed that all the treatments yielded significantly higher than treated and untreated control. The highest yield (44.57 t/ha) was observed with Dazomet @ 50 g/m2, followed by Dazomet @ 40 g/m2 (41.74 t/ha). The reproduction factor was found lowest in the treatment with Dazomet @ 40 g/m2 (1.22).

Effect of split application of Carbofuran against PCN

The study revealed that application of Carbofuran @ 65 kg/ha (half dose at 15 DAP & half at 30 DAP) recorded maximum yield of 15.58 t/ha and found at par with carbofuran application at the time of planting and lowest was observed in untreated control (11.48t/ha).

LC-MS analysis of secondary metabolites or phenolics in mustard root exudates and roots

Phenolic secondary metabolites viz. Sinapic Acid, Quercetin, Kaempferol, Isorhamnetin and Allyl isothiocyanates act as chemical defense systems against pests in *Brassica* species. Accordingly the presence of sinapic acid was checked in mustard root exudates and roots collected after 50 DAP through LC-MS. Sinapic acid was not detected in mustard root exudates but it was recorded in low amount in roots (Fig. 27).

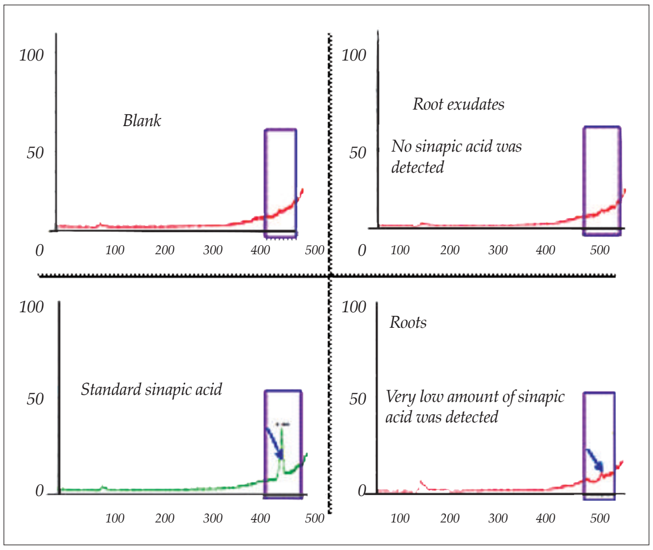


Fig. 27: LC-MS analysis of sinapic acid in mustard roots

Effect of cropping system on PCN population

Study on the effect of different cropping system on PCN population was initiated during 2018-19. Among different cropping system after one year of study minimum reproduction factor recorded in the treatment T6 followed by T3, T2 and T1 (Fig. 28). T1: *Solanum sismbrifolium* for 1 year followed by potato followed by french beans; T2: *S. sismbrifolium* for 3 years; T3: *S. sismbrifolium* for 1 year followed by french beans followed by potato; T4: Fellow land for 3 years; T5: Only potato for 3 years; T6:Dazomlt 40 g/m2 for 3 years before planting.

Evaluation of *S. sisymbriifolium* and other antagonistic crops against PCN

The results with root ball technique revealed that *S. sisymbriifolium* drastically reduced the PCN population during first season and helped in maintaining the lowest population in subsequent season. In first season of potato cv. Kufri Jyoti after *S. sisymbriifolium* PCN populations were found lowest in Marigold followed by mustard and garlic.

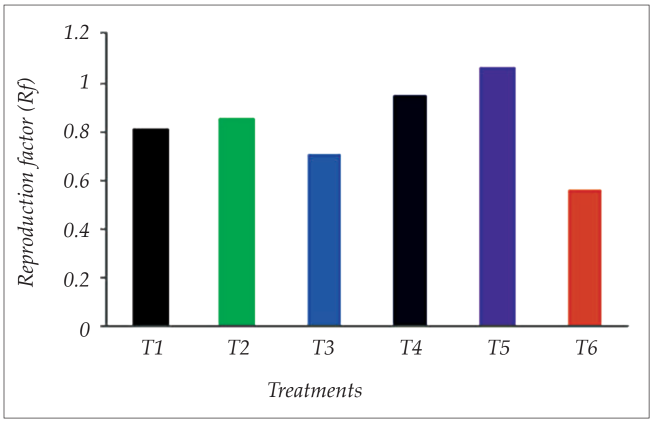


Fig. 28: Effect of cropping system on PCN reproduction factor (Rf)

Results showed that *S. sisymbriifolium* and marigold could be a very good strategy for management of PCN when planted one season prior to planting of main potato crop.

Identification of native strains of EPN from Nilgiris: Phylogenetic analysis of *Steinernema cholashanense*

The *S. cholashanense* was reported for the first time from India and phylogenetic analysis was done using Consensus neighbour-joining tree for ITS rDNA sequences from *S. cholashanense* derived from composite maximum likelihood scores (Fig. 29). Caenorhabditis elegans was used as out group. For identification of new native strains of EPN, soil samples were collected from the tea gardens of Udhagamandalam (Tamil Nadu) and based on morphological observations, Steinernema CPRSUS02 and CPRSU03 strains were identified.

Identification of Entomopathogenic fungus (EPF), *Metarhizium anisopliae* from Nilgiris, India

Based on colony morphology and spore development, Metarhizium CPRSUM01 strain showed the resemblance of the species to *M. anisopliae*. The ITS region of rDNA yielded a single fragment of approximately 552 base pairs and sequence was compared using BLAST search.

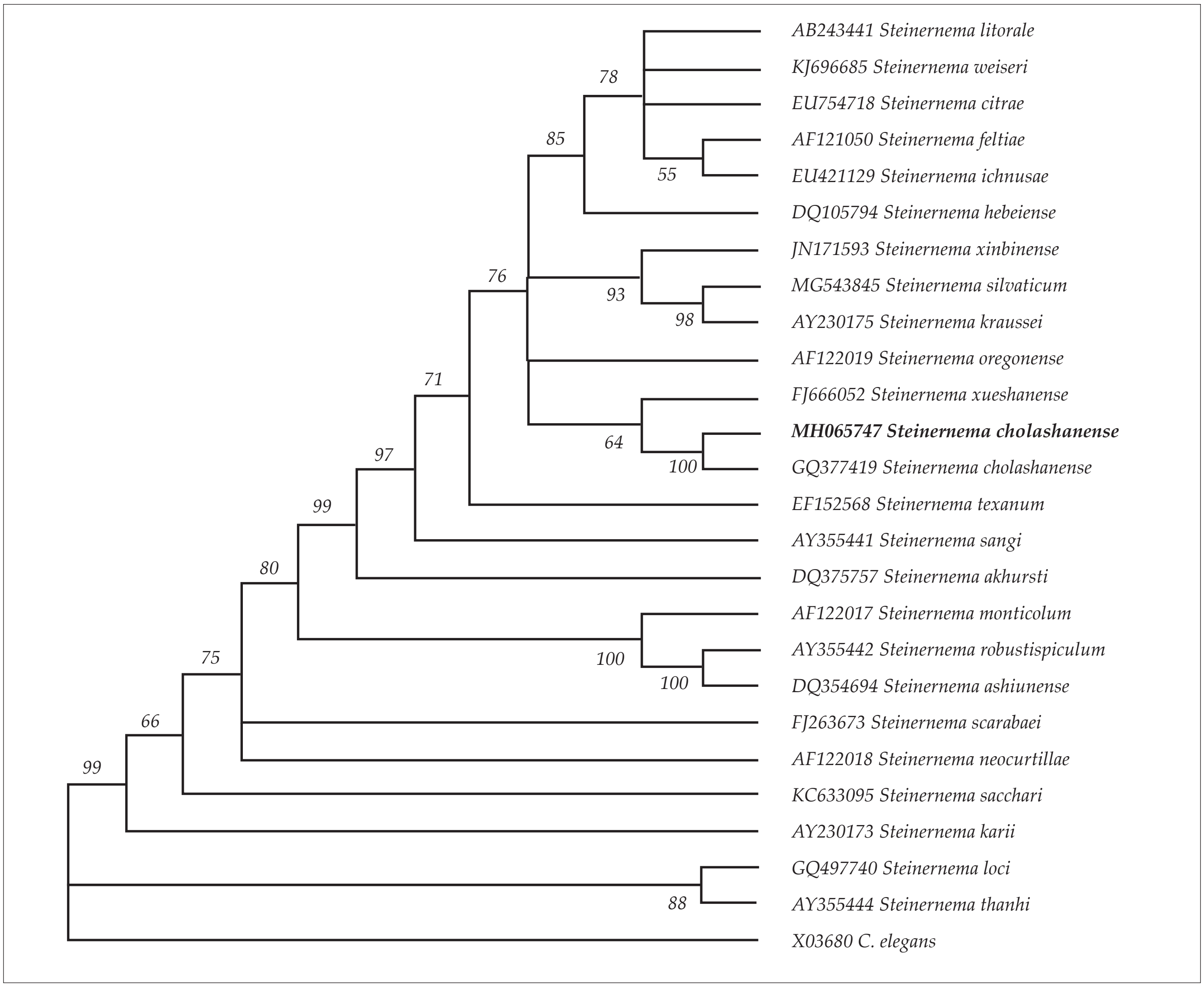


Fig. 29: Phylogenic analysis of *Steinernema cholashanense*

The sequence revealed 99% similarity with *M. anisopliae* isolates. *M. anisopliae* CPRSUM01 was found capable to cause significant mortality in early instars of *Galleria mellonella* and white grub under laboratory conditions (Fig. 30).

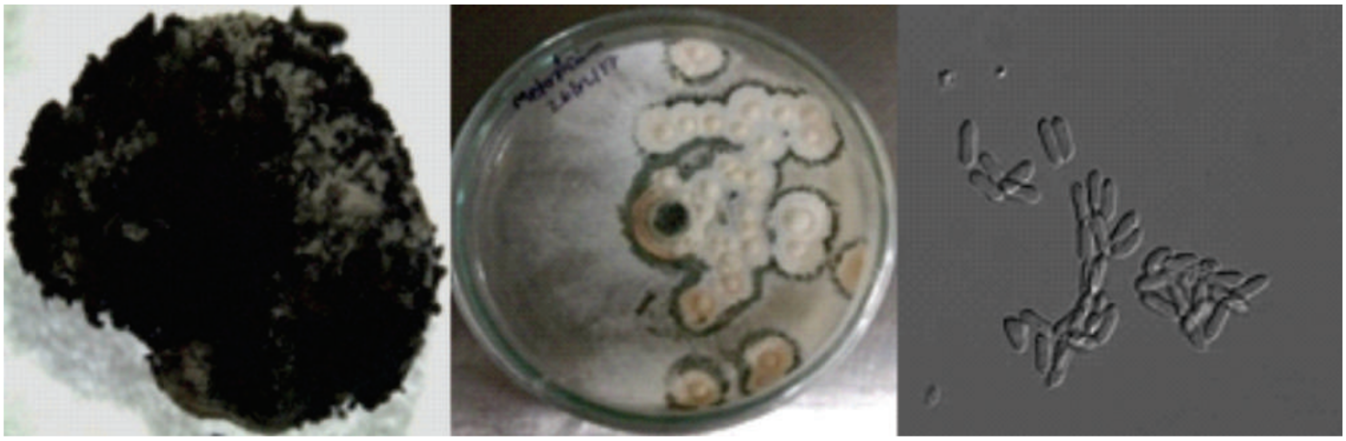


Fig. 30: Dead grub recovered from soil ((Left), Colony/spores development of *M. anisopliae* on PDA (Middle), Light microscope photograph of *M. anisopliae* (Right)

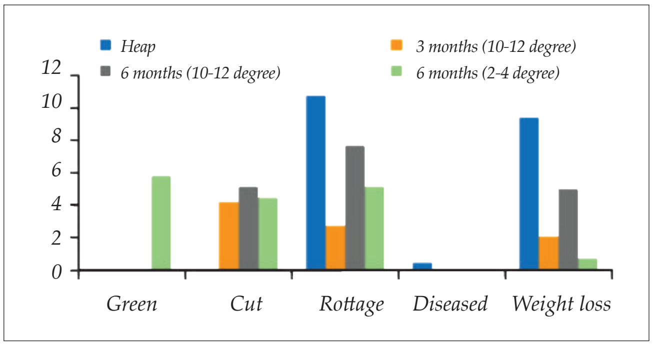
DIVISION OF CROP PHYSIOLOGY, BIOCHEMISTRY AND POST-HARVEST TECHNOLOGY

PROGRAMME: POST-HARVEST MANAGEMENT AND NUTRITIONAL ENHANCEMENT OF POTATOES

This programme aims to assess the post-harvest losses in potatoes during harvesting to retailing chain 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 through an experiment using two potato varieties, Kufri Chipsona-3 and Kufri Pukhraj under Modipuram conditions.



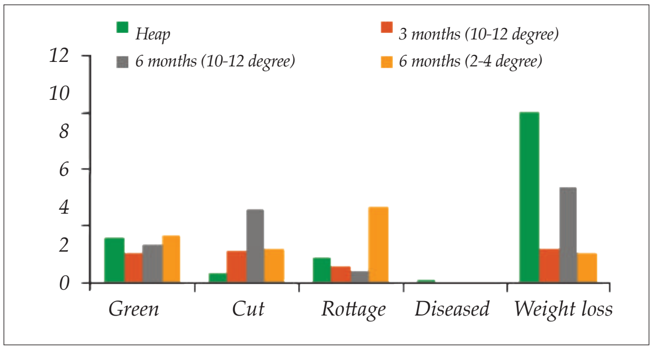


Fig. 1: Effect of different storage methods on post-harvest loses in Kufri Chipsona-3 (up) & Kufri Pukhraj (down)

Potatoes were harvested, graded and stored in heap for three months, and at 2-4°C and 10-12°C for up to six months and were observed for loss assessment. Kufri Chipsona-3 showed maximum rottage percent in heaps at 3 months storage (11.77) followed by storage after 6 months at 10-12°C and 2-4°C. Weight loss in heap was also high during 3 months in heaps (10.69), followed by 10-12C after six months (Fig. 1). In case of Kufri Pukhraj also the trend was similar, however, the overall losses were higher compared to Kufri Chipsona-3.

Sprout Suppression with Naturally Occurring Volatile Compounds

To evaluate the synergistic effect of naturally occurring volatile oils, 35 combinations of different oils were tried at laboratory scale in 6 kg containers. Three combination treatments T15, T17 and T21 containing combinations of 4, 6 and 9 oils, respectively were found effective for sprout suppression up to 300 days of storage at 12°C (Fig. 2).

Fig. 2: Tubers with T17 treatment (left) V/s control (right) after 6 months of storage at 12°C

Treated potatoes remained totally sprout free with an acceptable level of shriveling even after three months of removal from the controlled temperature chamber. The results were in accordance with the previous year's trials. Further refinement and optimization of percentage concentration of component oils is being targeted.

Coating Technology to Reduce Post-Harvest Losses of Potatoes

Tubers of Kufri Frysona (procured from Gujarat) and Kufri Jyoti (procured from Modipuram) sprayed with CIPC and coated with three concentrations of chitosan (0.1%, 0.25% and 0.5%) before storage were analyzed for sugars accumulation, chip colour, rate of respiration, weight loss and dry rot incidence periodically upto 170 days (stored at 10-12°C).

After 90 DOS, reducing sugars were significantly low at 0.25% chitosan coating (CC) in both the varieties compared to control and other treatments. Content of reducing sugars of coated tubers remained low compared to uncoated tubers in both the varieties after 170 DOS. The sucrose content was the least in tubers coated with 0.1% chitosan, however, with increasing concentration of chitosan the content of sucrose increased (Fig.3).

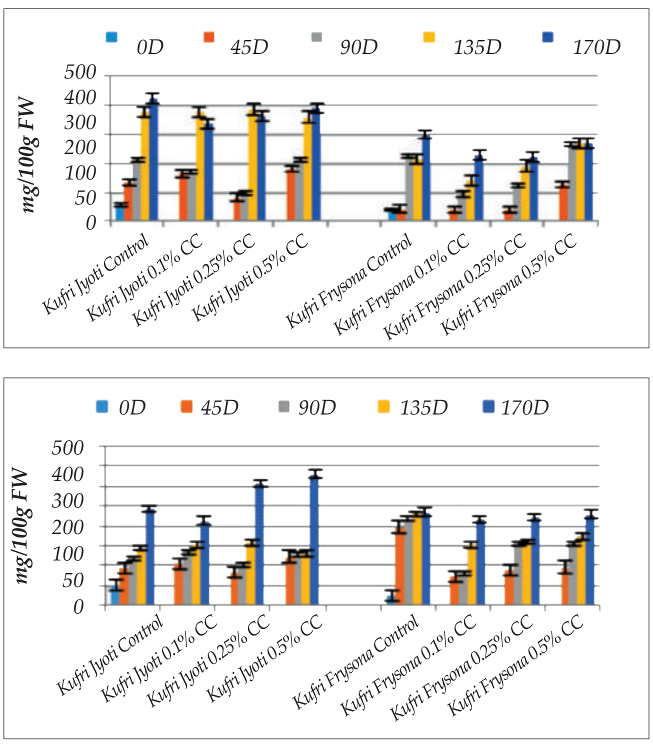


Fig. 3: Effect of chitosan coating on reducing sugars (up) and sucrose (down)content

At the end of storage, a small degradation in colour of chips prepared from control as well as CC at 0.1% and 0.5% concentration was observed, whereas CC at 0.25% was able to retain better processing quality compared to control and other two concentrations. In case of Kufri Jyoti, the rate of respiration was the maximum in uncoated tubers (83.17 CO_2 ppm/kg/h) and least in tubers coated with 0.1% chitosan (65.29 CO_2 ppm/kg/h).

Tubers of Kufri Frysona showed concentration dependent decrease in rate of respiration. After 170 DOS, weight loss was significantly low at 0.1% and 0.5% CC compared to control as well as 0.25% CC in Kufri Jyoti. In Kufri Frysona non-significantly low weight loss was observed at 0.25% CC. Rate of respiration showed good correlation with weight loss (r = 0.552) (Fig. 4).

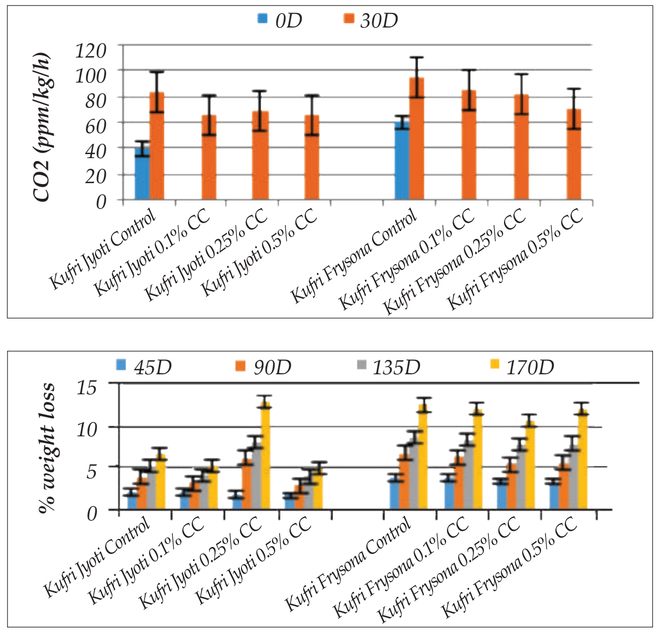


Fig. 4: Effect of chitosan coating on rate of respiration (up) and weight loss (down)

After 2 months of storage (MOS), chitosan showed dose dependent decrease in fusarium infection. Disease incidence was significantly high in Kufri Frysona compared to Kufri Jyoti. The population of Fusarium propagules was high after 2 MOS and decreased significantly after four months of storage in both the varieties (Fig.5). A good correlation was observed between colony forming unit/ml (cfu/ml) and weight loss in both the varieties and the correlation value for Kufri Jyoti and Kufri Frysona was 0.957 and 0.804, respectively.

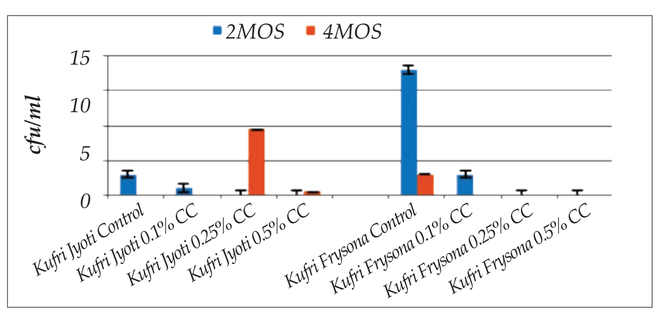


Fig. 5: Effect of chitosan coating on Fusarium population

Similarly, cfu/ml also exhibited positive correlation with rate of respiration and value was

0.233 and 0.722 for Kufri Jyoti and Kufri Frysona, respectively. This technology can help potato processors/stakeholders to extend the storage duration of potatoes without compromising the processing quality.

Development of Good Keeping Quality Potatoes

It is a well-known fact that weight loss in potatoes is caused due to evaporative and respiratory losses and sprouted potatoes loose more water than the dormant potatoes. Therefore, to develop good keeping quality potatoes, longer dormancy and thick periderm are the desired attributes. 14 varieties *viz.* Kufri Pukhraj, Kufri Chip-1, Kufri Chip-2, Kufri Bahar, Kufri Jyoti, Kufri Chandramukhi, Kufri Surya, Kufri Badshah, Kufri Pushkar, Kufri Dewa, Kufri Sutlej, Kufri Khyati, Kufri Arun and Lady Rosetta were selected for different parameters including keeping quality characteristics (sprouting, weight loss, rottage and firmness), periderm thickness using simple microscope, dry matter, respiration rates are under study.

Respiration Rates: All varieties were observed to show increased respiration rates after damage which peaked immediately after damage or upto one day after damage and there after they showed a declining trend upto 10 day due to wound healing. Variety Kufri Arun showed maximum respiration rates at day 0 followed closely with Lady Rosetta, Kufri Khyati and Kufri Badshah, immediately after damage (Fig. 6).

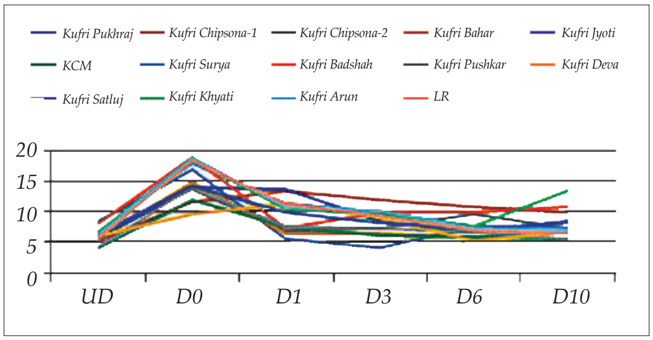


Fig. 6: Respiration rates in undamaged (UD) and damaged potato tubers of different varieties recorded at days 0 (D0), 1 (D1), 3 (D3),6 (D6) and 10 (D10) after afflicting damage

Microscopy studies: The periderm of the 14 potato varieties was excised and stained with Sudan III and observed under the simple microscope. The periderm distinguishable as Phellem, pellogen and phelloderm was observed and its approximate measurement at eight weeks after harvest in 3 tuber replicates was recorded. The variations in periderm thickness for the different varieties as observed, for the three layers have been depicted in Fig. 7.

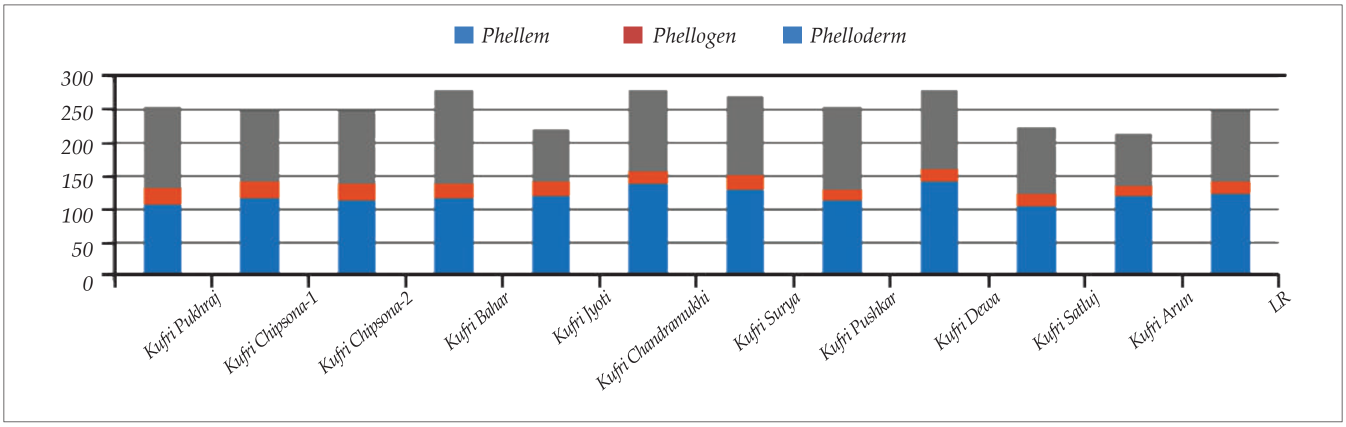


Fig. 7: Variation in potato periderm thickness (μm) observed for 12 varieties constituting of outer phellem, middle phellogen and inner phelloderm

Table 1: Correlations for periderm thickness and its constituting layers

	Phellem	Phellogen	Phelloderm	Total periderm
Sprouting at 60 days	-0.651	-	-0.435	-0.298
Respiration rates at wounding (D0)	0.304	-	-	-0.542
Respiration rates at day 1 after wounding (D1)	-	-	-0.680	-
Respiration rates at day 10 after wounding (D10)	-	-	-	-0.843

Correlations were worked out between thickness of phellem, phellogen, phelloderm and the total periderm and the observations on keeping quality parameters for different varieties as observed. The significant correlations observed have been depicted in table 1. These may be explored further considering larger sample size.

Ampliseq for Dormancy Related Genes in Potato

Key genes responsible for the delayed dormancy/ sprouting and storage in potato were identified from the publicly available transcriptome data (SRR1103933) and EST libraries (JK483901 to JK484204). Amplicons from five selected genes mainly GA20ox1 (AJ291453.1), StNCED1 (AY662342.1), StNCD2 (AY662343.1), ERF5 (PGSC0003DMT400027937, IAA-amino acid hydrolase (PGSC0003DMT400006691) were amplified from Kufri Dewa (best keeper) and Kufri Pukhraj (poor keeper). The selected amplicons will be sequenced from the panel consisting of 159 potato clones with different dormancy duration. The panel will have potato clones with 0, 45, 60, 90, 150, 180, 210 and 240 days of dormancy. The ampliSeq reveals the SNP level differences in the genes associated with the dormancy in potato (Fig. 8).

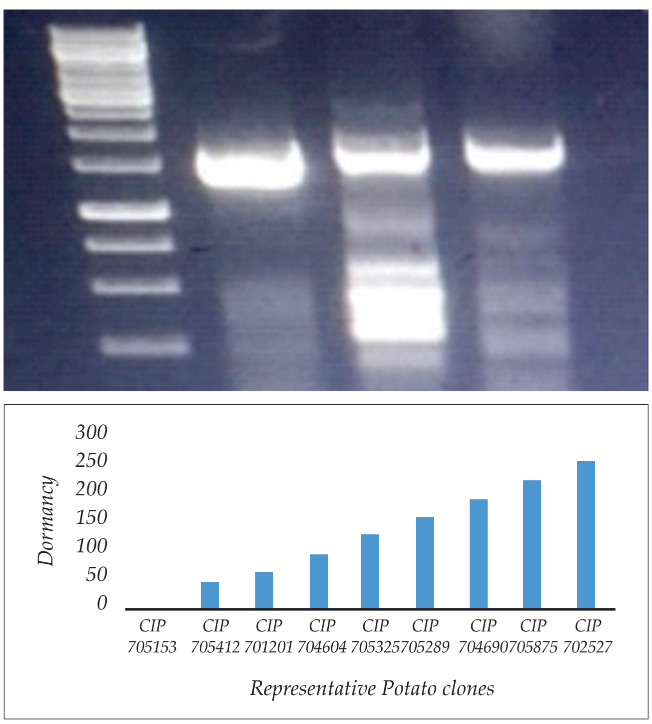


Fig. 8: Gel image showing the amplification of GA20ox1, NCED1 and NCED2 from the Kufri Dewa (M: 1Kb DNA ladder, 1: GA20ox1, 2: NCED1, 3: NCED2), (up) and Ampliseq panel showing the diversity for the tuber dormancy traits (down)

Development of Improved Protocol for *In vitro* Estimation of Glycemic Index (GI) In Potato

Potato starch is hydrolyzed in human in different stages in the digestive tract. Consuming high starchy food like potato that is having high Glycemic Index (GI) leads to the development of serious diseases like type 2 diabetes, obesity and colonic cancer. GI is the parameter that is used to measure the increase in blood sugar after a meal as compared to the reference food (glucose, white bread). An *in vitro* method for estimation of GI was developed, which has low cost and is precise and will help to screen a large number of food and food products. We took six varieties *viz.*, Kufri Chipsona 1, Kufri Chipsona 3, Kufri Frysona, Kufri Girdhari, Kufri Jyoti, Kufri Pukhraj for this study. The protocol for the potato with major modification in Goni's protocol for estimation of GI was used where dialysis membrane mimicking the inner wall of the small intestine was used. The final colour development was done by GOPOD reagent which gives precise and uniform result as compared to anthrone reagent which is used for estimation of glucose (Fig 9).

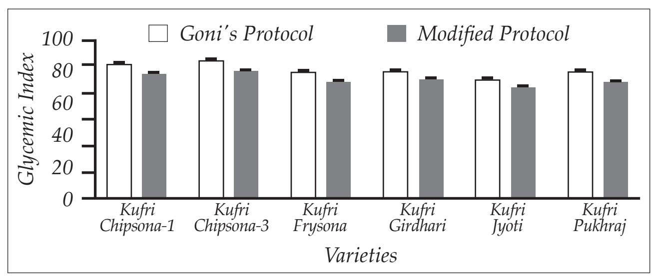


Fig. 9: GI estimation using Goni's Protocol and Modified Protocol

The developed protocol showed a strong significant positive correlation with the Goni's protocol (Linear equation, Y=0.9326x+0.525, R2=0.9641).

Relationship of Glycemic Index with Resistant Starch (RS) and Amylose Content (AC) in Potato

As potato is rich in starch which contributes to more hydrolysis, which leads to an increase in GI. The hydrolysis index (HI) was calculated as the percentage of total glucose released from the samples as compared to that released from standard glucose (0–180 min). The hydrolysis index was strongly positively correlated with GI of potato. Whereas, RS and GI are highly significant and negatively correlated with R = 0.383. The above results indicate that the varieties which have lower RS contribute to a higher rate of starch hydrolysis which ultimately increases GI. The variety containing higher RS was digested slowly under *in vitro* condition (Fig. 10). When amylose content was compared with GI, it was found to be negatively correlated with GI (R = -0.523).

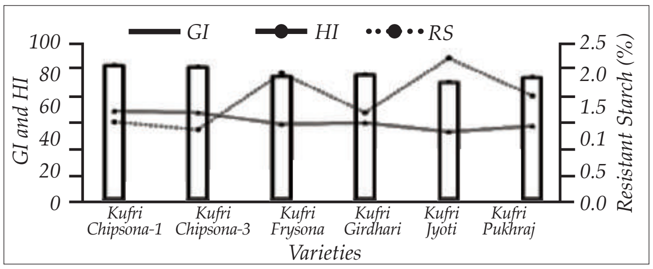


Fig. 10: HI, GI and RS of six potato varieties estimated by modified protocol

Correlation of Glutamate Content with Organoleptic Evaluation in Potatoes

Glutamate is a major umami amino acid that imparts taste to cooked potatoes. In raw tubers of all the tested varieties (viz. Kufri Chipsona-3, Kufri Frysona, Kufri Jyoti, Kufri Bahar, Lal Gulab, Kufri Himsona, Kufri Khyati, Kufri Gaurav, Kufri Girdhari, Kufri Pukhraj, Kufri Garima, Kufri Pushkar, Kufri Himalini and Kufri Sindhuri) glutamate content ranged from 4 to 24 mg/100g FW. The content was maximum in variety Kufri Garima, followed by Kufri Himalini and Lal Gulab. Cooking has shown significant increase in glutamate content. On an average, boiling increased the glutamate content to 79%, whereas increase reported after microwaving was quite high and was upto 250%.

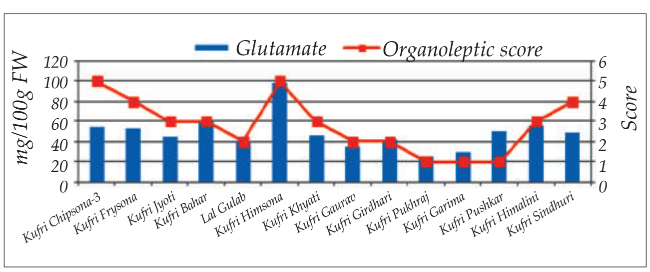


Fig. 11: Glutamate content and organoleptic score of microwaved tubers

Glutamate content ranged from 17-41mg/100g FW after boiling and Kufri Pukhraj exhibited the highest content amongst the boiled cultivars. Glutamate content after microwaving ranged from 25-98mg/100g FW (Fig.11). Variety Kufri Himsona possessed highest glutamate content after microwaving followed by Kufri Bahar and Kufri Himalini. Organoleptic test was carried out only in microwaved potatoes. A scale of 1 to 4 was developed, where score 1 denotes Bitter, 2 Neutral, 3 Very good and 4 outstanding. The results of organoleptic evaluation showed almost similar trend as that of glutamate. Microwaved tubers having high glutamate content were liked by most of the panelists. Free glutamate content showed strong positive correlation (0.73) with organoleptic score, which indicates that free glutamate can be selected as an indicator of potato taste.

Profiling of Individual Phenols in Potatoes

Ten individual phenols *viz.* chlorogenic acid, catechin, quercetin, caffeic acid, p-coumaric acid, sinapic acid, ferulic acid, gallic acid, p-catechuic acid and rutin were evaluated from flesh and peel of seven popular potato varieties *viz.* Kufri Sindhuri, Kufri Pukhraj, Kufri Chipsona II, Kufri Lalima, Kufri Himsona, Kufri Girdhari and Kufri Giriraj (Fig 12). Chlorogenic acid ranged from 90-1099 µg/10g FW in flesh and 1616-4239 µg/10g FW in peel. Catechin ranged from 7-1261 µg/g FW in flesh and 47-1464 µg/g FW in peel. Quercetin ranged from 31-159 µg/10g FW in flesh and 182-663 µg/10g FW in peel. Caffeic acid ranged from 2-14 µg/100g FW in flesh and 36-180 µg/100g FW in peel. P-coumaric acid, sinapic acid and ferulic acid in flesh ranged from 0.1 to 21 µg/10g FW, 1-24 ng/100g FW and 0-16 µg/10g FW, respectively and in peel from 6-288 µg/10g FW, 1-193 ng/100g FW and 11-108 µg/10g FW, respectively.

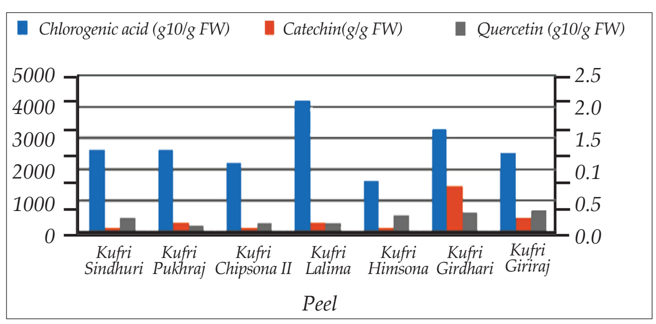


Fig. 12 (a): Individual phenols in potato peel of few Indian varieties

Gallic acid, p-catechuic acid and rutin in flesh ranged from 0.4-8 µg/10g FW, 0.39-11 µg/g FW and 0.23-2 µg/g FW, respectively, and range reported in peel was 3-201 µg/10g FW, 45-455 µg/g FW and 2-13 µg/g FW, respectively.

Table 2: Varieties exhibiting maximum content of individual phenols in flesh and peel of raw tubers

S.No.	Individual Phenols	Maximum content in flesh	Maximum content in peel
1	Chlorogenic acid	Kufri Lalima	Kufri Lalima
2	Catechin	Kufri Girdhari	Kufri Girdhari
3	Quercetin	Kufri Himsona	Kufri Giriraj
4	Caffeic Acid	Kufri Girdhari	Kufri Lalima
5	p-coumaric acid	Kufri Girdhari	Kufri Girdhari
6	Sinapic acid	Kufri Girdhari	Kufri Lalima
7	Ferulic acid	Kufri Lalima	Kufri Sindhuri
8	Gallic acid	Kufri Sindhuri	Kufri Pukhraj
9	Proto catechuic acid	Kufri Giriraj	Kufri Chipsona II
10	Rutin	Kufri Chipsona II	Kufri Chipsona II

The varieties exhibiting maximum content of these phenols in flesh and peel have been indicated in Table 2. The study indicates that there a large variation in concentration of each phenol in flesh and peel of same variety. There is significant variation in the concentration between varieties as well.

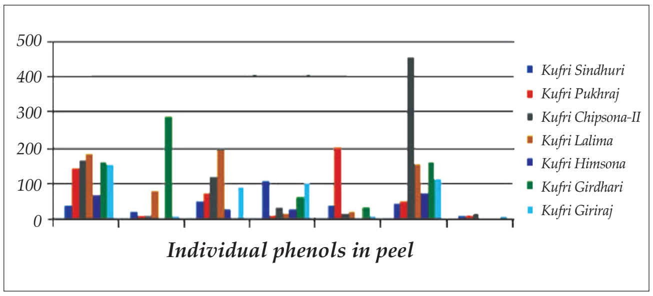


Fig. 12 (b): Individual phenols in potato peel of few Indian varieties

The results not only can be related to the nutraceutical potential of each variety, but can also be correlated to disease resistant and susceptible nature of varieties due to variation in these phenols.

Prebiotic Activities of Resistant Starch from Potatoes

Prebiotic activity of resistant starch was evaluated in collaboration with Jaypee University, Solan. Resistant starch (RS) was prepared through three methods *viz.* (1) autoclaving-cooling cycles, (2) using alpha amylase and (3) alpha amylase and amyloglucosidase combination, from starch of Kufri Bahar. Five different probiotic lactic cultures *viz. L. paracasei* CD4, *L. gastricus* BTM7, *L. fermentum* K75, *L. rhamnosus* GG and *Brevibacillus aydinogluensis* BTM9 were used in the study. The different RS preparations were tested at a level of 0.001 and 0.025% in reconstituted skimmed milk. The RS supplemented tubes were inoculated with the probiotic culture at 1% level. A control without RS was also inoculated for comparative studies. The inoculated tubes were incubated at 37°C for 24 h. The results showed that the viable count with *L. paracasei* CD4 increased by 24% and 11% at RS concentration of 0.025% and 0.001%, respectively. Low stimulatory increase with viable cell count was observed with other lactic cultures. Results showed that potato resistant starch is good for the growth of *L. paracasei* CD4 (Fig 13).

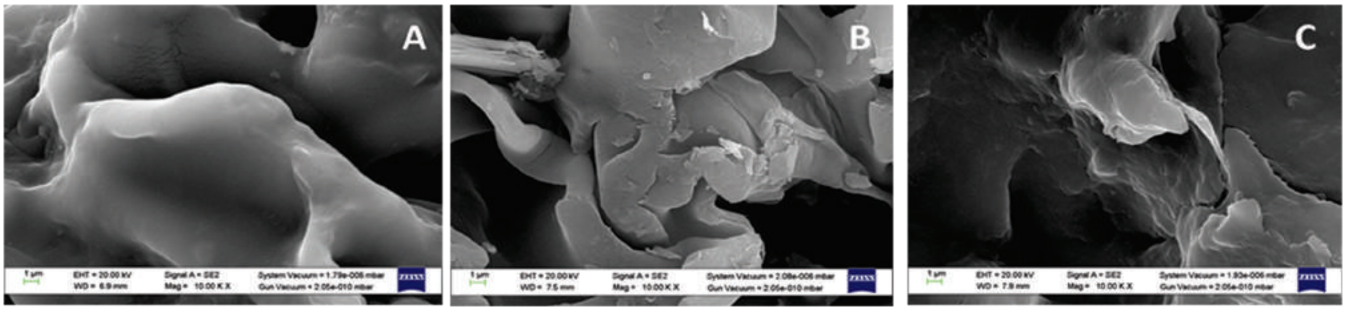


Fig. 13: SEM images of resistant starch prepared with autoclaving-cooling cycles (A), with one enzyme treatment (B) and with two enzyme treatment (C)

Presence of Metformin in Potato Sprout

Metformin was determined from potato flesh, peel and sprout using LC-MS. Three potato varieties *viz.* Kufri Jyoti, Kufri Sindhuri and Kufri Pukhraj were used for the estimation of metformin from peel and flesh. Approximately 3cm long sprout of Kufri Jyoti was used for estimation. The maximum concentration of metformin was reported in flesh (1.14 mg/g FW) and peel (0.92 mg/g FW) of Kufri Pukhraj (Fig. 14). Concentration of metformin in potato sprout was higher than the concentration reported in peel and flesh of Kufri Jyoti and Kufri Sindhuri and was 0.68 mg/g FW. The study showed that the whole tuber whether unsprouted or sprouted contains metformin. This hints that consumption of potatoes have positive effect on human health as far as diabetes is concerned. In case of sprouted potatoes, these whole tubers can be used for extraction of metformin to prepare some formulations for diabetics.

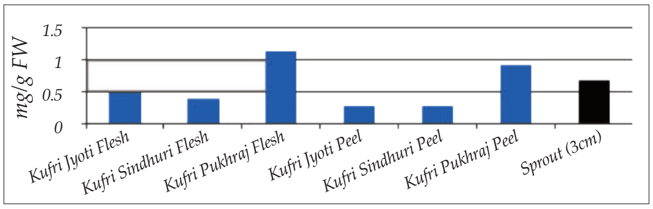


Fig. 14: Metformin concentration in potato peel, flesh and sprout

Cloning of Carotenoids Biosyn-thesis Pathway Genes from Potato

Carotenoids are the second most abundant naturally occurring pigments on earth, with more than 750 members. Carotenoids have numerous health-promoting properties. Some carotenoids are precursors of vitamin A, and prevent human age-related macular degeneration, and some are potent antioxidant and are considered to prevent prostate cancer and cardiovascular disease. Potatoes contain carotenoids in lesser amount. The most abundant potato carotenoids are composed mainly of the xanthophylls, lutein, antheraxanthin, violaxanthin. In order to understand the regulatory network and mechanisms the genes of the carotenoids pathways need to be characterized expensively. Carotenoid pigments are mainly C40 lipophilic isoprenoids and synthesized in plastids from isoprenoid pathway, and are accumulated in most plant organs. The carotenoids metabolism pathways are very complex and involve a cascade of reactions catalysed by multitude on enzymes and thus needs thorough understanding about each of these enzymes at molecular levels. Keeping this in view, the genes of carotenoids pathways were in silico analysed in potato. Few of these genes have been amplified, cloned and sequenced (Fig. 15).

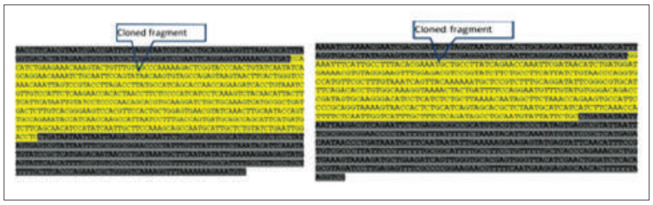


Fig. 15: Sequencing of carotenoids biosynthesis genes cloned from potato

Oil Coating to Enhance Palatability of Microwaved Chips

To enhance the palatability of microwaved chips, oil was applied on the surface of potato slices before microwaving. Four treatments *viz.* single oil coating, two oil coatings, three oil coatings and four oil coatings along with uncoated sample were tried. Fat content was estimated from these samples along with organoleptic evaluation. A scale from 1 to 9 was developed, where 1 indicates poor, gradually increasing palatability with increase in score and score 9 indicates excellent. The overall acceptability of oil coated chips has increased with single oil coating. Per cent oil content increased with increasing number of oil coatings.

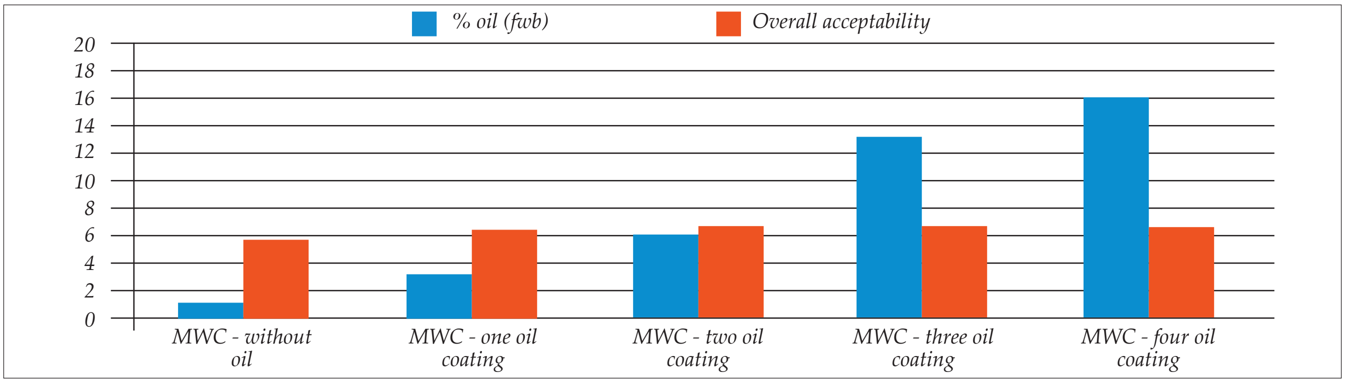


Fig. 16: Effect of oil coatings (no oil, 1, 2, 3 & 4 coatings) on oil content (%) and palatability of microwaved chips (MWC)

Oil content was reported to be 1.2% in uncoated microwaved chips, 3.6% in single oil coating, 6.4% in two oil coatings, 14.4% in three oil coatings and 17.2% in four oil coatings (Fig. 16). As far the colour, fat content and overall acceptability scores are considered, for development of low fat potato chips, two oil coatings is recommended.

Utilization of Waste Potatoes for Synthesis of Metal Nanoparticles

Reports are available on synthesis of metal nanoparticles using antioxidant rich fruits, vegetables and foliage. No report is available on synthesis of metal nanoparticles using potatoes. As huge quantities of potatoes are wasted either due to post harvest losses or during processing, there is scope to use this wastage for synthesis of metal nanoparticles. For this purpose, peel and juice was extracted from one year old potatoes (stored at 10-12°C) to check their efficiency in synthesizing nanoparticles. Aqueous peel extract and potato juice were mixed with silver nitrate (50 mM) and zinc oxide (50 mM) solution at 1:1 ratio and pH of the solutions was raised to 8 with sodium hydroxide. Samples were incubated overnight at room temperature and sonicated for 30 minutes before TEM studies. Images of transmission electron microscope (12 kV, FEI make, USA) revealed that potato peel (Fig. 17) as well as potato juice (Fig. 18) has potential to synthesize silver nanoparticles. The shape of silver nanoparticles was circular and the size was below 30 nm. Synthesis of zinc nanoparticles was much less than silver nanoparticles which showed that further optimization is required for zinc nanoparticles synthesis using potatoes. The size of zinc nanoparticles was also below 50 nm.

The study indicated that waste potatoes can be utilized for silver nanoparticles synthesis. However, further studies are required to evaluate the antimicrobial and other properties of synthesized nanoparticles.

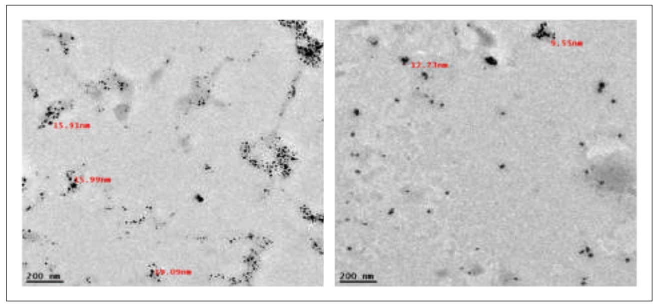


Fig. 17: Synthesis of silver and zinc nanoparticles using potato peel

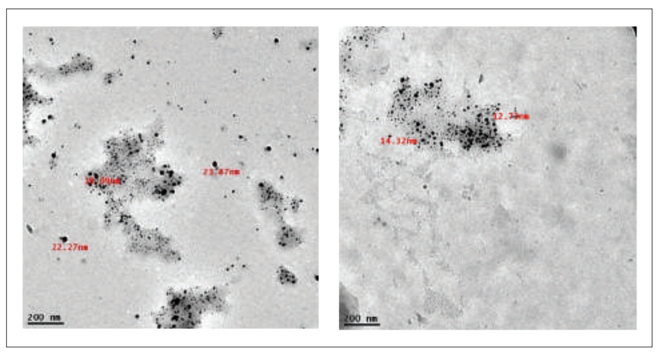


Fig. 18: Synthesis of silver and zinc nanoparticles using potato juice

Novel Value-Added Products from Potatoes

Potato Daliya and Semolina: The short shelf-life of potatoes due to its perishability is a big challenge for its preservation at the consumer level. Among the different preservation methods, drying is commercially accepted and economic for preserving the vegetables and reducing the bulk weight. In this direction ICAR-CPRI has standardized the pretreatment process for dehydration of fresh potato and further their utilization in the form of Porridge/Daliya and Semolina. Potato porridge can be cooked in milk or water and eaten with salt or sugar added as breakfast or whenever a light meal is required with added fruits or vegetables by the population of all ages. Moreover, potato porridge is a gluten-free alternative of wheat porridge for a population suffering from celiac disease or wheat allergy. Due to fasting friendly properties, its demand will be higher during festive seasons/Navratri, and other occasions where cereals and millets cannot be consumed. Shelf life of these products is 9 months if stored in a cool, dark and dry place (Fig. 19).

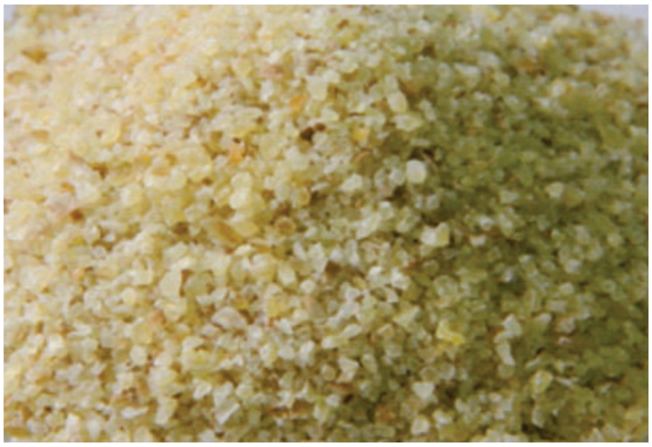


Fig. 19: Potato daliya (Up) and halwa premix (Down)

Potato Halwa premix: In India, potato processing sector is still in the infancy stage and has the potential to reduce post-harvest losses. Moreover, due to urbanization and modern lifestyle, the demand for ready-to-cook and ready to eat type processed food products is continuously increasing. ICAR-CPRI has developed ready-to-cook type potato halwa premix. Potato halwa premix is fat free, fasting friendly and gluten free product. This halwa premix can be cooked in water or milk with less than 5 minutes cooking. Shelf-life of the premix is 6 months. This halwa premix can be prepared from fresh as well as cold-stored potatoes of all varieties, size and storage period.

Lactose free potato burfi: In potatoes, the processing sector is still in the infancy stage and has the potential to tackle the frequently occurring glut situations and post-harvest losses in potatoes. In such circumstances ICAR-CPRI is continuously working on the development of novel processed products from potatoes and this year has developed the process for preparation of potato burfi using fresh potatoes (Fig. 20).

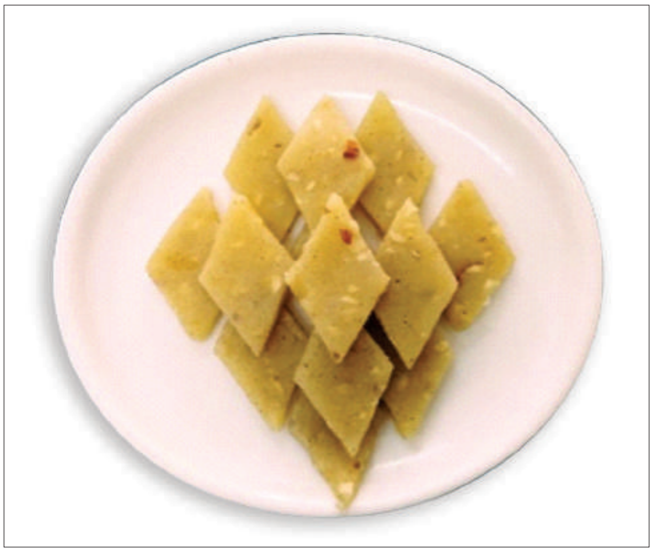


Fig. 20: Lactose free potato burfi

Potato burfi is also suitable for lactose intolerant population.

The shelf life of the burfi is 30 days. Both fresh, as well as cold-stored potatoes, can be utilized for the preparation of potato burfi. The potato burfi can be prepared from potato of any shape and size.

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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 high degree of health standard of the seed crop is maintained. Therefore, this program was started under Revolving Fund Scheme (RFS).

The nucleus and breeder seed production is being monitor by the scientists of the division at five different stations located in different regions of the country. The nucleus and breeder seed production and supply status of breeder seed for the plains in 2017-18 and hills 2018 are given below:

Seed Production

Plains (2017-18)

A total production of 29891.35 qtls nucleus and breeder seed was achieved from an area of 148.749 ha. Out of which, 24528.13 qtls production from 123.692 ha was through conventional and 5363.22 qtls from 25.057 ha through hi-tech seed production systems respectively. The percentage of nucleus and breeder seed from conventional system was 82.06 and 17.94 through hi-tech system.

Conventional Seed Production System: During 2017-18, total no. of 18834 indexed tubers of different commercial potato varieties were tested at regional stations in the plains (Table 1). Station/ stage wise area and production of different potato varieties is given in Table 2.

Stage-I: A total production of 145.29 qtls. was achieved from an area of 2.336 ha (Table-2) with average production of 75.83, 34.62, 67.49 & 66.04 qtls./ha at Modipuram, Jalandhar, Gwalior and Patna, respectively.

Stage-II: A total production of 983.27 qtls. was from an area of 6.656 ha (Table-2) with average production of 146.20, 169.13, 141.29 and 148.84 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively.

Stage-III: A total production of 4621.93 qtls. was from an area of 23.21 ha (Table-2) with average production of 240.31, 201.30, 142.45 and 145.71 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively.

Stage-IV: A total production of 18777.64 was from an area of 91.49 ha (Table-2) with average production of 264.72, 210.10, 136.37 and 156.10 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively.

Table 1. Tuber indexing and field ELISA (Stage-I) testing (Plains 2017-18)

Name of Station	Indexed Tubers		Field ELISA	
Plains (2017-18)	No of tubers tested	Healthy tubers No (%)	No of tubers/hills tested	Healthy tubers/ Hills No (%)
Modipuram	5428	5204 (95.87)	5194	5050 (97.23)
Jalandhar	3812	3336 (87.51)	3336	3204 (96.04)
Gwalior	7344	6232 (84.86)	6052	5252 (86.78)
Patna	1800	1724 (95.78)	2520	2208(87.62)

Table 2: Station & variety wise area (ha) and production (qtls) in Conventional system 2017-18 (Plains)

Variety	Stage-I		Stage-II		Stage-III		Stage-IV		TOTAL	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
I. Modipuram										
Kufri Anand	0.05	3.25	0.10	12.60	0.35	77.70	2.15	716.00	2.65	809.55
Kufri Bahar	0.36	31.20	1.40	234.00	5.00	1333.50	15.50	4256.40	22.26	5855.10
Kufri Chipsona-1	0.10	7.05	0.40	56.75	0.80	182.50	2.60	743.70	3.90	990.00
Kufri Chipsona-3	0.05	2.60	0.17	20.45	0.45	81.50	0.95	292.25	1.62	396.80
Kufri Chipsona-4	-	-	0.06	7.85	0.25	37.00	0.90	182.00	1.21	226.85
Kufri Frysona	0.03	2.40	0.09	11.0	0.40	75.50	2.55	594.00	3.07	682.90
Kufri Garima	0.05	3.25	0.15	20.55	0.62	167.50	2.40	553.25	3.22	744.55
Kufri Khyati	0.08	4.75	0.30	39.00	0.85	217.30	4.00	941.75	5.23	1202.80
Kufri Mohan	0.08	7.70	0.20	25.00	0.65	160.50	-	-	0.93	193.20
Kufri Pukhraj	0.06	3.25	0.18	23.00	0.65	124.50	2.40	663.70	3.29	814.45
Kufri Surya	0.04	2.80	0.15	17.50	0.38	75.60	1.25	340.00	1.82	435.9
Kufri Sadabahar	-	-	-	-	0.40	62.50	1.20	220.75	1.60	283.25
Total	0.90	68.25	3.20	467.70	10.80	2595.30	35.90	9503.60	50.80	12634.85
II. Jalandhar										
Kufri Badshah	0.01	0.47	-	-	0.14	31.78	0.65	138.40	0.8	170.65
Kufri Chandramukhi	0.01	-	0.03	-	0.25	57.85	1.4	314.00	1.69	371.85
Kufri Chipsona-1	0.01	0.52	-	-	-	-	-	-	0.01	0.52
Kufri Chipsona-3	-	-	-	-	-	-	0.20	42.20	0.20	42.20
Kufri Jyoti	0.48	15.27	0.86	149.40	2.75	498.50	11.5	2291.50	15.59	2954.67
Kufri Himalini	0.01	0.65	0.002	0.33	0.19	54.50	0.80	166.80	1.002	222.28
Kufri Khyati	0.02	1.15	0.006	1.5	0.23	41.50	1.70	383.80	1.956	427.95
Kufri Pukhraj	0.05	2.23	0.013	4.42	0.63	152.50	3.40	793.40	4.093	952.55
Kufri Surya	0.01	0.48	0.01	0.12	0.15	37.00	1.20	250.50	1.37	288.10
Total	0.6	20.77	0.921	155.77	4.34	873.63	20.85	4380.60	26.711	5430.77
III. Gwalior										
Kufri Chandramukhi	0.11	5.95	0.22	32.00	1.11	114.50	2.65	287.40	4.09	439.85
Kufri Jyoti	0.14	11.15	0.44	50.00	1.48	206.00	5.63	802.00	7.69	1069.15
Kufri Sindhuri	0.19	7.83	0.50	78.00	2.25	392.00	11.18	1296.50	14.12	1774.33
Kufri Lauvkar	0.09	6.40	0.22	25.40	0.38	47.00	1.83	251.50	2.52	330.3
Kufri Chipsona-I	0.05	6.52	0.39	56.00	0.92	176.50	3.63	730.62	4.99	969.64
Kufri Chipsona-3	0.07	3.27	0.36	56.00	0.88	64.00	1.92	292.25	3.23	415.52
Kufri Surya	0.08	8.15	0.19	30.40	-	-	-	-	0.27	38.55
Total	0.73	49.27	2.32	327.80	7.02	1000.00	26.84	3660.27	36.91	5037.34
IV Patna										
Kufri Arun	-	-	0.016	2.00	0.10	5.00	-	-	0.116	7.00

Variety	Stage-I		Stage-II		Stage-III		Stage-IV		TOTAL	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
Kufri Himalini	0.002	0.06	-	-	-	-	-	-	0.002	0.06
Kufri Jyoti	0.030	2.00	0.052	5.50	0.20	36.00	1.70	260.42	1.982	303.92
Kufri Khyati	0.027	2.32	0.064	11.00	0.40	64.00	2.10	375.63	2.591	452.95
Kufri Kesar	-	0.10	-	-	-	-	-	-	0	0.1
Kufri Kanchan	0.002	0.02	-	-	-	-	-	-	0.002	0.02
Kufri Lailt	0.016	1.00	0.017	2.00	0.05	2.50	1.40	218.80	1.483	224.3
Kufri Pukhraj	0.017	1.00	0.034	5.00	0.10	7.50	1.00	167.77	1.151	181.27
Kufri Sindhuri	0.012	0.50	0.032	6.50	0.20	38.00	1.70	210.55	1.944	255.55
Total	0.106	7.00	0.215	32.00	1.05	153.00	7.9	1233.17	9.271	1425.17
Plains' Total	2.336	145.29	6.656	983.27	23.21	4621.93	91.49	18777.64	123.692	24528.13

Table 3: Station & variety wise area (ha) and production (qtls.) in Hi-Tech system 2017-18 (Plains)

Variety	G1		G2		TOTAL	
	Area	Production	Area	Production	Area	Production
I. Modipuram						
Kufri Bahar	0.03	-	7.00	1856.00	7.03	1856.00
Kufri Chipsona-1	0.03	8.00	-	-	0.03	8.00
Kufri Chipsona-3	0.80	151.50	0.40	126.00	1.2	277.50
Kufri Chipsona-4	0.08	22.00	0.70	146.00	0.78	168.00
Kufri Frysona	0.09	22.00	0.05	12.00	0.14	34.00
Kufri Garima	0.02	6.50	-	-	0.02	6.50
Kufri Himalini	0.01	5.00			0.01	5.00
Kufri Khyati	1.22	215.00	3.00	646.00	4.22	861.00
Kufri Mohan	0.04	14.60	-	-	0.04	14.60
Kufri Pukhraj	0.27	23.30	0.50	132.50	0.77	155.80
Kufri Surya	0.55	99.70	1.95	511.05	2.5	610.75
Total	3.14	567.60	13.60	3426.55	16.74	3997.15
II Jalandhar						
Kufri Badshah	-	-	0.12	27.70	0.12	27.70
Chandramukhi	0.14	25.83	0.20	47.60	0.34	73.43

Variety	G1		G2		TOTAL	
	Area	Production	Area	Production	Area	Production
Kufri Chipsona-1	0.18	34.39	0.1	15.5	0.28	49.89
Kufri Chipsona-3	0.16	23.87	0.2	50.30	0.36	74.17
Kufri Jyoti	0.04	9.00	0.08	17.20	0.12	26.2
Kufri Gaurav	0.27	39.60	0.03	6.57	0.3	46.17
Kufri Himalini	0.13	26.50	0.1	22.50	0.23	49
Kufri Khyati	0.23	63.80	0.13	31.20	0.36	95
Kufri Pukhraj	0.11	30.00	0.73	153.50	0.84	183.5
Kufri Surya	0.14	23.00	0.20	43.50	0.34	66.5
Total	1.40	275.99	1.89	415.57	3.29	691.56
III Gwalior						
Kufri Chandramukhi	0.01	1.00	-	-	0.01	1.00
Kufri Lauvkar	0.11	11.00	0.59	62.00	0.7	73.00
Kufri Surya	-	-	0.54	72.50	0.54	72.50
Kufri Himalini	0.44	45.9	-	-	0.44	45.90
Total	**0.56**	**57.90**	**1.13**	**134.50**	**1.69**	**192.40**
IV Patna						
Kufri Arun	0.038	5.50	-		0.038	5.50
Kufri Ashoka	0.03	5.00	0.35		0.38	5.00
Kufri Chandramukhi	0.018	2.00	-		0.018	2.00
Kufri Chipsona-1	0.01	1.00	-		0.01	1.00
Kufri Chipsona-3	0.007	0.50	-		0.007	0.5.
Kufri Jyoti	0.003	1.00	-		0.003	1.00
Kufri Himalini	0.30	39.00	0.20	41.08	0.5	80.08
Kufri Kanchan	-	-	0.05	1.90	0.05	1.90
Kufri Khyati	0.09	18.50	0.50	110.00	0.59	128.5
Kufri Lauvkar	0.028	5.00	-	-	0.028	5.00
Kufri Pukhraj	0.074	16.00	0.40	70.00	0.474	86.00
Kufri Sindhuri	0.049	7.50	0.20	30.00	0.249	37.5
Kufri Surya	0.09	10.00	0.90	118.13	0.99	128.13
Total	**0.737**	**111.00**	**2.6**	**371.11**	**3.337**	**482.11**
Plains Total	5.837	1012.49	19.22	4347.73	25.057	5363.22

Hi-Tech Seed Production System: Station/ generation wise area and production of different potato varieties is given in table 3.

Generation-1: A total production of 1012.49 qtls. was achieved in G-I from an area of 5.837 ha with average production of 180.76, 197.14, 103.39 & 150.61 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively (Table-3).

Generation-2: A total production of 4347.73 qtls. was achieved in G-2 from an area of 19.22 ha with average production of 251.95, 219.88, 119.03 & 142.73 qtls/ha at Modipuram, Jalandhar, Gwalior and Patna, respectively (Table-3).

Total supply of breeder seed: During 2017-18, total 20893.36 qtls breeder seed was supplied to various government and private agencies, from plains Table-4 (A & 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 12, 252 culture tubes were multiplied and 1892 microtubers were produced. In aeroponics, a total of 62,014 minitubers of 20 varieties were harvested.

Stage-wise Area, Production & Supply at Kufri/ Fagu 2018-19: Although, the crop was raised but the production of Stage-IV and G2 was not considered as breeder seed because of the interception of Potato Cyst Nematodes reported by the monitoring team. Therefore, from the production of 808.64 q from an area of 5.0 ha (Table 5) total, 618.45 qtls of seed crop was sold/ disposed off locally and in the market.

Production and Supply of Quality Seed

Production of quality seed during spring 2017-18 (Ooty)

During spring season, two varieties *i.e.* of Kufri Swarna and Kufri Sahyadri was planted in an area of 0.10 ha each. Production obtained from Kufri Swarna was 1.15 t and Kufri Sahyadri was 1.32 t.

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.

Table 4 (A): Station and variety wise supply (qtls) during 2017-18

S. No.	Variety	Modipuram	Jalandhar	Gwalior	Patna	Total
1.	Kufri Anand	716.00	-	-	-	716.00
2.	Kufri Ashoka	-	-	-	33.53	33.53
3.	Kufri Arun	-	-	-	0.40	0.40
4.	Kufri Bahar	5143.90	-	-	-	5143.90
5.	Kufri Badshah	-	151.50	-	-	151.50
6.	Kufri Chipsona-1	739.70	15.50	730.62	-	1485.82
7.	Kufri Chipsona-3	480.75	92.48	291.25	-	864.48
8.	Kufri Chipsona-4	328.00	-	-	-	328.00
9.	Kufri Chandramukhi	-	336.36	287.40	-	623.76
10.	Kufri Frysona	633.50	-	-	-	633.50
11.	Kufri Gaurav	-	6.57	-	-	6.57
12.	Kufri Garima	490.50	-	-	-	490.50
13.	Kufri Himalini	-	164.34	-	40.90	205.24
14.	Kufri Jyoti	-	1784.63	711.30	189.30	2685.23
15.	Kufri Khyati	1431.25	312.96	-	483.80	2228.01
16.	Kufri Kanchan	-	-	-	1.75	1.75
17.	Kufri Lauvkar	-	-	264.70	-	264.70
18.	Kufri Lalit	-	-	-	242.65	242.65
19.	Kufri Pukhraj	720.20	913.72	-	234.20	1868.12
20.	Kufri Sadabahar	198.50	-	-	-	198.50
21.	Kufri Sindhuri	-	-	1228.50	239.45	1467.95
22.	Kufri Surya	851.05	211.00	72.50	118.70	1253.25
Total		11733.35	3989.06	3586.27	1584.68	20893.36

Table 4 (B): Variety/stage & agency wise breeder seed supply from plains (qtls) during 2017-18

S. No.	Variety	CG	HP	J&K	MP	GJ	PB	UP	WB	UK	RJ	NSC	NHRDF	NABARD	Uni./ KVK	ICAR/ FOC	Farmers/ Pvt.	Auction/ Market	Total
1.	Kufri Anand	-	-	-	-	-	-	375.00	-	-	-	-	-	-	-	-	181.00	160.00	716.00
2.	Kufri Arun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20	0.20	-	0.40
3.	Kufri Ashoka	-	-	-	-	-	-	4.38	2.00	-	-	-	15.00	-	1.50	7.45	3.20	-	33.53
4.	Kufri Badshah	32.10	-	20.10	-	-	25.50	40.30	-	-	-	-	-	-		17.20	16.30	-	151.50
5.	Kufri Bahar	-	-	-	-	-	64.00	4603.50	-	-	-	-	-	-	2.00	45.40	429.00	-	5143.90
6.	Kufri Chandramukhi	81.50	147.00	-	-	-	10.50	-	271.00	-	-	-	-	-	5.26	1.60	106.90	-	623.76
7.	Kufri Chipsona-1	-	-	-	-	0.02	-	981.50	5.00	-	-	-	-	-		0.70	443.60	55.00	1485.82
8.	Kufri Chipsona-3	200.00	-	-	20.00	-	32.00	-	-	-	-	-	-	-	8.50	23.75	504.23	76.00	864.48
9.	Kufri Chipsona-4	-	-	-	-	-	-	-	40.00	-	-	-	-	-	-	1.00	206.00	81.00	328
10.	Kufri Frysona	-	-	-	-	-	-	-	10.00	-	-	-	-	-	-	44.00	457.50	122.00	633.5
11.	Kufri Gaurav	-	-	1.00	-	-	1.00		2.00	-	-	-	-	-	-	0.20	2.37	-	6.57
12.	Kufri Garima	-	-	-	-	-	-	435.50	43.50	-	-	-	-	-	-	4.50	7.00	-	490.5
13.	Kufri Himalini	-	-	20.50	-	-	26.50	-	12.10	-	-	-	-	-	5.26	14.68	126.20	-	205.24
14.	Kufri Jyoti	63.00	267.50	-	-	-	128.5	-	205.00	92.00	5.00	53.50	150.50	3.00	122.76	77.70	1516.77	-	2685.23
15.	Kufri Khyati	15.00	-	30.00	-	-	59.5	1487.50	28.50	-	-	-	129.50	-	-	164.25	313.76	-	2228.01
16.	Kufri Kanchan	-	-	-	-	-	-	1.50	-	-	-	-	-	-	-	0.20	0.05	-	1.75
17.	Kufri Lauvkar	-	-	-	42.00	-	-	-	-	-	10.00	-	-	-	47.00	35.00	130.70	-	264.7
18.	Kufri Lalit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.70	241.95	-	242.65
19.	Kufri Pukhraj	146.50	-	-	-	-	144.0	244.50	361.00	-	-	-	73.50	-	53.50	134.8	710.27	-	1868.12
20.	Kufri Sadabahar	-	-	-	-	-	-	198.50	-	-	-	-	-	-	-	-	-	-	198.5
21.	Kufri Sindhuri	-	-	-	42.00	-	-	660.00	-	-	10.00	-	15.00	125.00	323.00	103.4	189.55	-	1467.95
22.	Kufri Surya	-	-	30.00	-	-	26.00	700.00	71.00	-	-	-	-	-	-	21.55	332.70	72.00	1253.25
	Total	538.10	414.50	101.60	104.00	0.02	517.5	9732.18	1051.10	92.00	25.00	53.50	383.50	128.00	568.78	698.3	5919.25	566.00	20893.36

Table 5: Area and production of seed at Kufri/fagu (2018-19)

Stages	Area (ha)	Production (qtls.)
I	0.10	16.89
II	0.30	58.99
III	0.80	164.81
IV	3.00	436.36
G-1	0.30	45.31
G-2	0.50	86.28
Total	**5.0**	**808.64**

Table 6. Quality seed production details of summer crop at ICAR-CPRS, Muthorai, Ooty

Summer crop- 2018-19			
Variety	**Area (ha)**	**Quantity harvested (t)**	**Average yield (t/ha)**
Kufri Swarna	0.96	6.04	6.29
Kufri Girdhari	1.98	8.12	4.10
Kufri Himalini	1.30	1.76	1.35
Kufri Jyoti	0.52	3.20	6.15
Kufri Sahyadri	0.24	0.72	3.00
Total	**5.00**	**19.84**	**4.18**

Table 7: Quality seed production and supply in Shillong

S. No.	Varieties	Conventional system	Hi-tech system	Total Yield (qtls)	Total Supply (t)
		Yield (qtls)	Yield (qtls)		
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.	Kufri Chipsona-3	**-**	**8.07**	**8.07**	**3.73**
8.	Kufri Himsona	**-**	**0.73**	**0.73**	**-**
9.	Kufri Pukhraj	**-**	**-**	**-**	**0.20**
Total		**183.42**	**134.74**	**318.16**	**133.8**

More PCN problem in Kufri Himalini, Kufri Girdhari and late blight problem due to heavy rain in Kufri Swarna resulted very poor yield. The details of quality seed production is given in Table 6.

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 ₹ 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.

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-7). Out of these 133.8 qtls of quality seed was supplied to the different states and a revenue of ₹ 3, 34, 500/- has been generated. A total of 38, 812 numbers of minitubers of four varieties were produced under aeroponics.

Supply of Aeroponic Minitubers

As per the MoU for breeder seed production, the healthy aeroponic minitubers of varities *viz.*, Kufri Himalini (13000 no.), Kufri Khyati (2500 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. 1, 55,000 was generated.

Supply of Microplants to Different Seed Agencies

A total 222 virus-free *in vitro* culture tubes of basic seed material of 19 varieties (Fig. 1) were supplied to 19 different seed producing organizations in India (Table-7) and a revenue of Rs. 11,10,000/- has been generated.

Revenue under RFS (2018-19)

A revenue of ₹ 8,69,21,987/- was generated under Revolving Fund Scheme (₹ 4,47,34,830/- at Modipuram; ₹ 2,10,12,081/- at Jalandhar; ₹ 1,43,62,780/- at Gwalior; ₹ 51,91,000/- at Patna; and ₹ 16,21,296/- at Kufri).

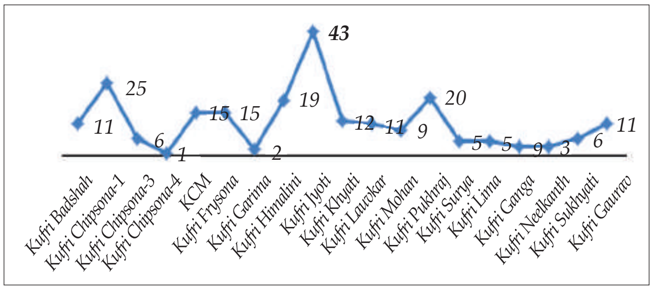

Fig. 1: Variety wise supply to different seed organizations

Table 7: Microplants supply to different seed producing organization

S. No	Firms	Varieties Supplied
1	M/s KF Biotech Pvt. Ltd., Theniyur Village, Sulibele Hobli, Hoskote Taluk, Bangalore Rural-562129, Karnataka	Kufri Chandramukhi, Kufri Lauvkar
2	M/s GMS Agritech, Kolakata	Kufri Chandramukhi, Kufri Jyoti, Kufri Pukhraj, Kufri Himalini, Kufri Sukhyati
3	M/s Shivam Agri. Biotech Pvt. Ltd., Itawa, UP	Kufri Mohan, Kufri Khyati
4	M/s Plant Biotechnology, Pallishree ltd, Arambagh, Hooghly	Kufri Pukhraj, Kufri Chandramukhi, Kufri Jyoti
5	M/s Sekhon Biotech, Jalandhar	Kufri Chandramukhi, Kufri Khyati, Kufri Frysona, Kufri Jyoti, Kufri Lauvkar, Kufri Pukhraj, Kufri Sukhyati, Kufri Frysona, Kufri Chipsona-1, Kufri Chipsona-3, Kufri Himalini, Kufri Badshah
6	M/s Shashnka Agritech, Jharkhand Ranchi	Kufri Gaurav, Kufri Chipsona-1
7	Assistant Director of Horticulture, Dept of Horticulture, PRS Horticulture Farm, Karnatka	Kufri Jyoti, Kufri Himalini
8	M/s Utkal Tubers India Pvt. Ltd., Garudacharapalya, Bangalore	Kufri Frysona
9	M/s Jain Irrigation Systems Ltd, Jalgaon, Maharashtra	Kufri Jyoti, Kufri Pukhraj, Kufri Khyati, Kufri Lauvkar, Kufri Badshah, Kufri Chipsona-1, Kufri Chipsona-3, Kufri Surya, Kufri Himalini, Kufri Frysona, Kufri Neelkanth, Kufri Mohan, Kufri Ganga, Kufri Lima, Kufri Chandramukhi
10	M/s TERI, Lodhi Road, New Delhi	Kufri Chipsona-1, Kufri Chipsona-3, Kufri Sukhyati, Kufri Pukhraj
11	M/s Sun Agritech, Kurukshetra, Haryana	Kufri Jyoti, Kufri Chipsona-1, Kufri Pukhraj, Kufri Sukhyati
12	M/s Sangha Agritech, Jalandhar Punjab	Kufri Himalini, Kufri Garima, Kufri Mohan

13	M/s Sagar Biotech, Palampur Distt-Kangra HP	Kufri Jyoti, Kufri Frysona, Kufri Pukhraj, Kufri Lauvkar, Kufri Himalini, Kufri Badshah, Kufri Chandramukhi
14	M/s West Bengal State Seed Co-operation Ltd., West Bengal	Kufri Chandramukhi, Kufri Jyoti, Kufri Khyati, Kufri Himalini
15	M/s JALPGO, Jalandhar, Punjab	Kufri Lauvkar
16	Dr Saurabh Gupta, Agri Genome labs pvt. Ltd., Hyderabad	Kufri Jyoti, Kufri Himalini, Kufri Frysona, Kufri Chipsona-4
17	M/s Deputy Director Horticulture, Potato Technology Center, Shamghah, Karnal	Kufri Jyoti, Kufri Chipsona-1, Kufri Pukhraj, Kufri Himalini, Kufri Frysona, Kufri Lima, Kufri Mohan
18	M/s Merino Industries Ltd, Hapur, UP	Kufri Chipsona-1
19	M/s Centre of Excellence for Potato, Dhogri, Distt-Jalandhar, Punjab	Kufri Jyoti, Kufri Chipsona-1, Kufri Pukhraj, Kufri Chandramukhi

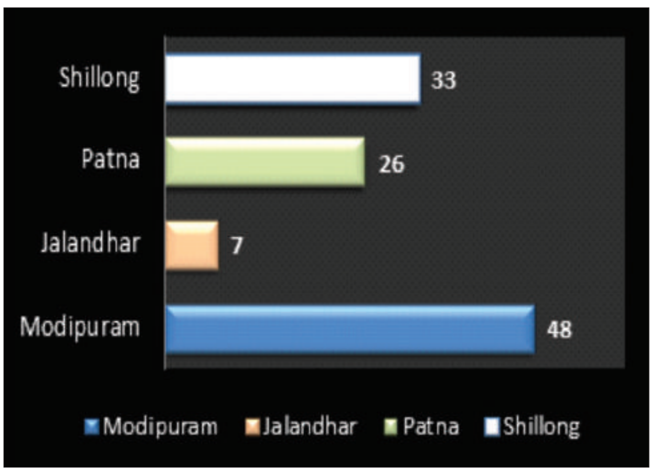

Fig 2. Station wise supply of virus-free cultures

A total of 186 culture tubes of 15 varieties were supplied to different seed production stations/ centers i.e. Modipuram, Jalandhar, Patna and Shillong (Fig.2).

Seed Research (Under Research Programme: Resource optimization in potato based cropping system)

Aeroponic minituber production through TPS: TPS as a source of plant material for minituber production through aeroponics was tried for the first time. 150 lines were evaluated and 100 minitubers/plant productions were recorded. It could serve the purpose of accelerated breeding to advance the generations (Fig. 1).

Effect of methods of hardening on aeroponic minituber production: The results revealed that the hardening of microplants by gradually acclimatizing the microplants to the natural climatic conditions (7-10 days) can harness the full potential of plants for minituber production under aeroponics (Fig. 2).

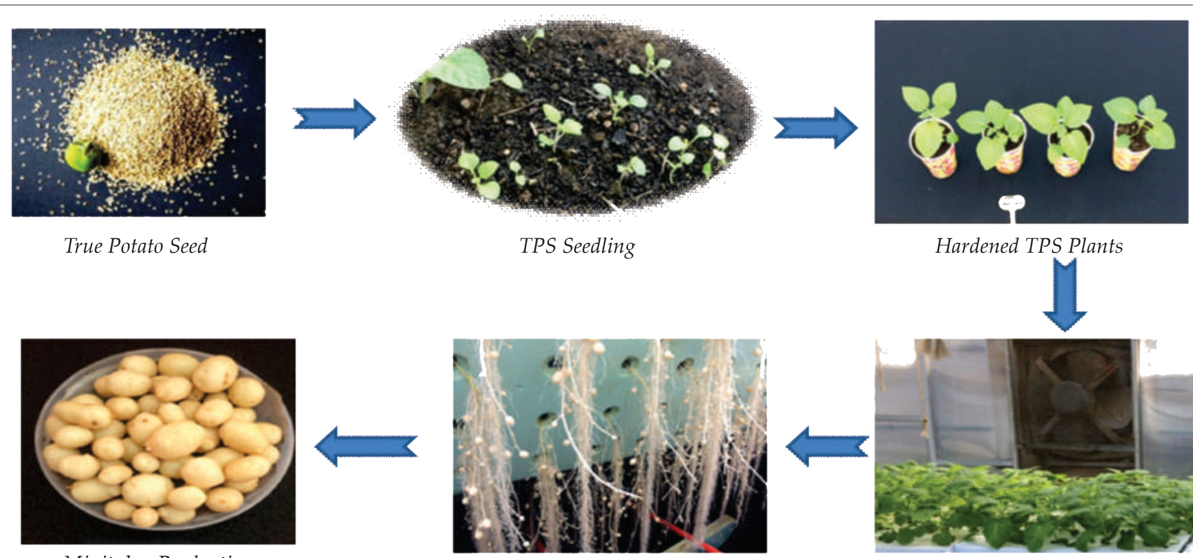

Fig. 2: Aeroponic minituber production through TPS.

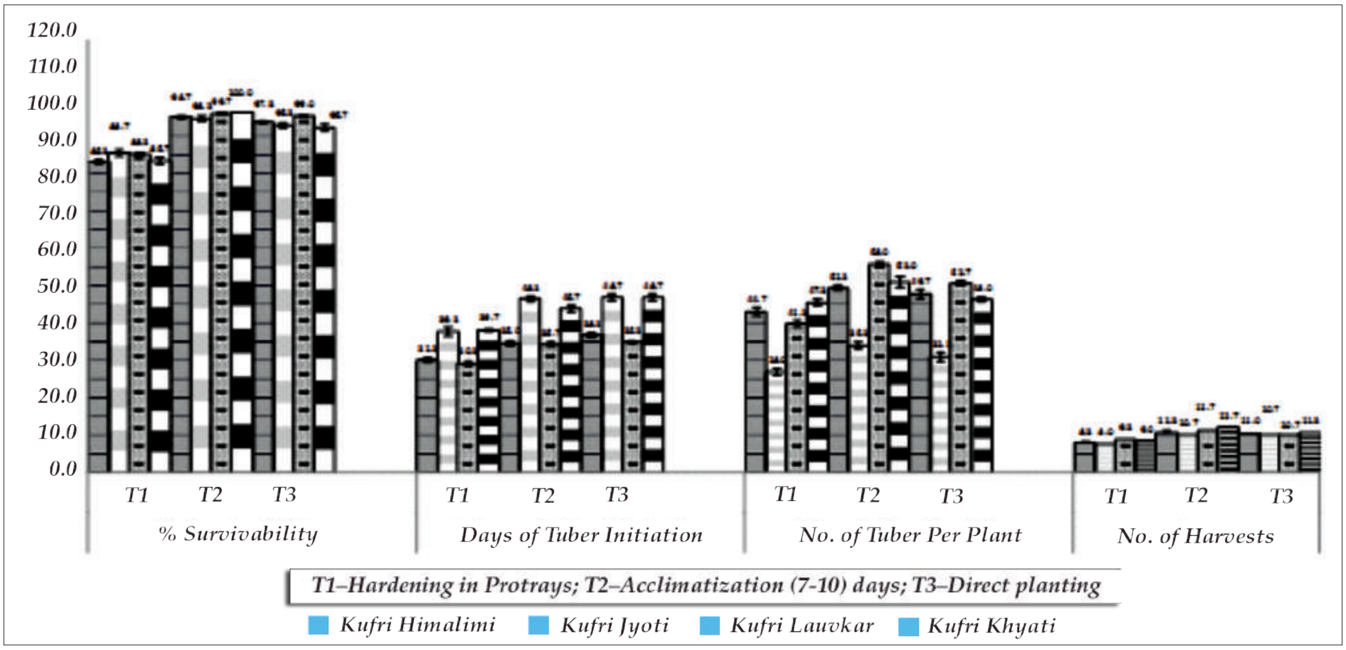

Fig. 2: Hardening methods effect on aeroponic minituber production

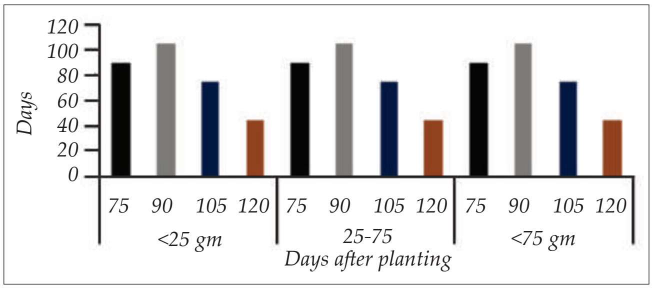

Fig. 3. Effect of different dates of haulm killing on dormancy period in Kufri Himalini

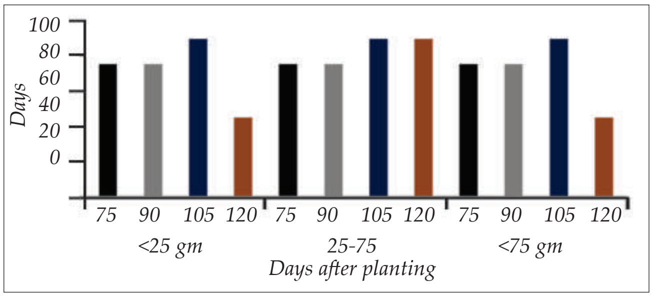

Fig. 4. Effect of different dates of haulm killing on dormancy period in Kufri Swarna

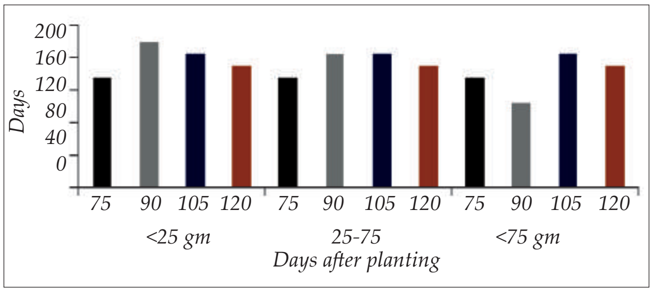

Fig. 5. Effect of different dates of haulm killing on dormancy period in Kufri Girdhari

Effect of different dates of haulm killing on seed quality parameters: Results shows that in the cultivars Kufri Himalini and Kufri Girdhari tubers harvested after 90 days of planting had maximum dormancy period of 105 and 180 days respectively whereas in Kufri Swarna tubers harvested after 105 days of planting had maximum dormancy period of 90 days. Cultivar Kufri Girdhari had minimum dormancy when the haulm killing was done 75 days after planting other cultivars it was 120 days after planting (Figs. 3-5).

Effect of media on micro-plant morphological characters: In the study on effect of media on different morphological characters of micro-plants of different potato cultivars (Table 1 & 2), the media had significant effect on number of leaves, root length and fresh weight. Among the media, B5 significantly increased the number of leaves, root length and fresh weight.

Post harvest handling of aeroponically produced minitubers: The study on post harvest handling of aeroponically produced minitubers was carried out for Kufri Girdhari in three different set of temperature/RH pattern [T1: 24°C/80-100% RH (0day)-16°C/40-60% RH (10days);T2:24°C/80-100% RH (10days); T3: 24°C/80-100% RH (10day)-16°C/40-60% RH (10days)] prior to final storage at 4°C. Post harvest handling of the minitubers for this variety has shown that reduced biomass loss due to shrinkage was observed T1, followed by T2 and T3. However, better sprout emergence was observed in T2 followed by T3 and T1.

Table 1: Effect of media on morphological characters of potato cultivars

Parameters / Cultivars	Micro-plant height (cm)			Shoot length (cm)			No. of leaves			No. of nodes		
	MS	B5	Mean	MS	B5	Mean	MS	B5	Mean	MS	B5	Mean
Kufri Swarna	12.6	12.6	12.6	9.4	8.9	9.1	8.2	9.3	8.7	5.1	5.0	5.0
Kufri Jyoti	10.5	12.2	11.4	7.5	7.6	7.5	6.6	8.5	7.6	3.4	4.1	3.8
Kufri Girdhari	11.9	13.4	12.6	9.0	10.2	9.6	7.1	8.0	7.6	4.5	4.4	4.4
Kufri Himalini	11.8	11.2	11.5	8.2	7.6	7.9	8.4	7.5	8.0	5.4	4.1	4.8
Kufri Sahyadri	9.8	10.4	10.1	6.8	7.5	7.1	8.0	9.0	8.5	4.2	4.4	4.3
Mean	11.3	12.0		8.2	8.3		7.7	8.5		4.5	4.4	
Factors	T	C	TC	T	C	TC	T	C	TC	T	C	TC
CD (0.05)	NS	0.84	NS	NS	0.59	NS	0.37	0.58	0.8	NS	0.32	0.5
SEd	0.26	0.41	0.6	0.18	0.29	0.4	0.18	0.29	0.4	0.1	16	0.2

MS- Murashige and Skoog medium; B5- Gamborg's B5 medium; T-Treatment; C-Cultivar; TC-Treatment × Cultivar

Table 2: Effect of media on morphological characters of potato cultivars

Parameters / Cultivars	Root length (cm)			No. of roots			Fresh weight (mg)			Dry matter (%)		
	MS	**B5**	**Mean**	**MS**	**B5**	**Mean**	**MS**	**B5**	**Mean**	**MS**	**B5**	**Mean**
Kufri Swarna	3.3	3.7	3.5	7.9	7.9	7.9	158	225	191	8.6	7.7	8.1
Kufri Jyoti	3.1	4.6	3.8	10.3	8.2	9.3	166	164	165	8.3	10.2	9.2
Kufri Girdhari	2.9	3.1	3.0	7.4	7.1	7.2	222	266	244	7.0	6.4	6.7
Kufri Himalini	3.7	3.6	3.6	8.5	8.7	8.6	143	178	161	8.2	8.0	8.1
Kufri Sahyadri	3.0	3.0	3.0	10.7	12.0	11.4	217	231	224	7.9	7.9	7.9
Mean	3.2	3.6		9.0	8.8		181	213		8.0	8.0	
Factors	T	C	TC	T	C	TC	T	C	TC	T	C	TC
CD (0.05)	0.16	0.25	0.4	NS	0.64	0.9	9.1	14.3	20.27	NS	0.6	0.8
SEd	0.08	0.12	0.2	0.2	0.32	0.5	4.5	7.1	10.0	0.2	0.3	0.4

MS- Murashige and Skoog medium; B5- Gamborg's B5 medium; T-Treatment; C-Cultivar; TC-Treatment × Cultivar.

Effect of different haulm killing dates on production of seed size tubers: In case of Kufri Pukhraj dehaulming at 90 DAP resulted in the maximum tuber yield 43.83 t/ha, whereas the yield of seed size tubers was found maximum at 70 DAP i.e. 14.57 t/ha. Total tubers was found maximum at 90 DAP *i.e.* 598 (000/ha), whereas seed size tubers number found maximum at 70 DAP i.e. 244 (000/ha) (Fig. 6).

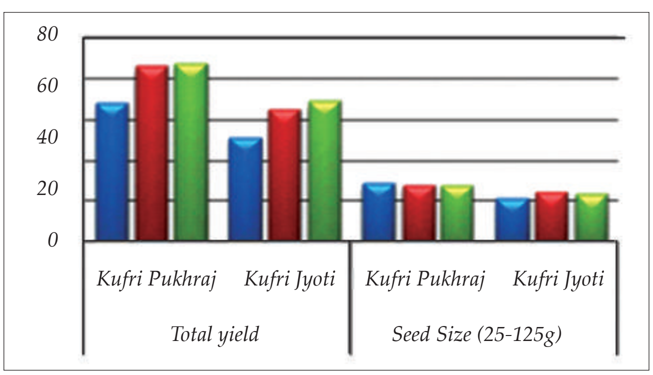

Fig. 6: Total tuber yield and seed size tuber yield (t/ha)

In case of Kufri Jyoti dehaulming at 90 DAP resulted in the maximum tuber yield 34.42 t/ha, apart this seed size tuber yield found maximum in 80 DAP i.e. 12.21 t/ha. 90 DAP dehaulming resulted in the maximum total tuber number i.e. 510 (000/ha), whereas 80 DAP resulted in the maximum seed size tuber numbers i.e. 190 (000/ha) (Fig. 7).

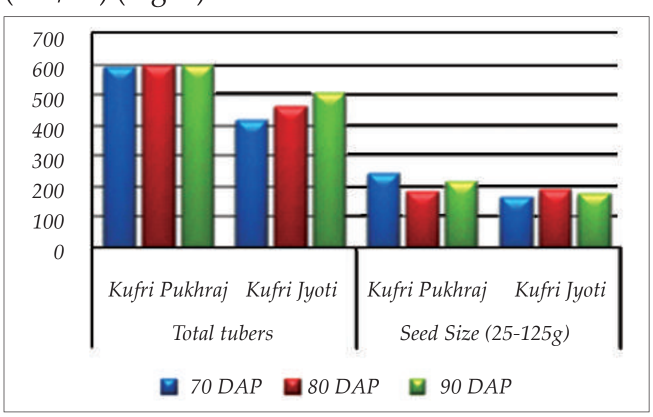

Fig. 7: Tuber number and seed size tuber numbrr (000/ha)

Effect of different planting dates on production of seed size tubers: 15 Oct. planting resulted in the maximum tuber yield in case of both the varieties Kufri Pukhraj and Kufri Jyoti *i.e.* 41.26 t/ha & 28.66 t/ha respectively, whereas maximum seed size tuber was found in 05 Nov. planting in Kufri Pukhraj & Kufri Jyoti *i.e.* 18.32 t/ha & 12.39 t/ha respectively (Fig. 8).

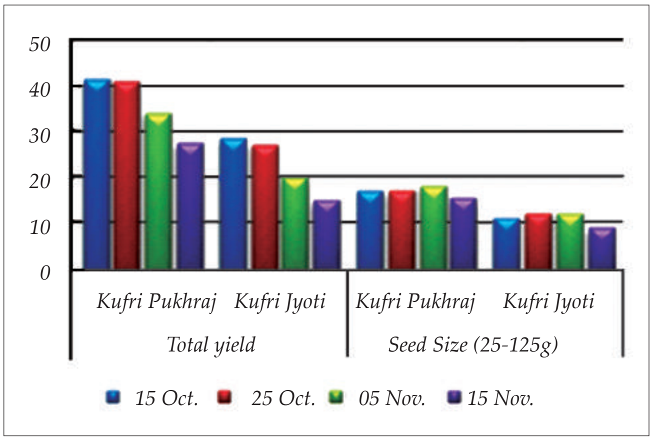

Fig. 8: Total tuber yield and seed size tuber yield (t/ha)

Total tuber numbers were found maximum in 15 Nov. planting date in Kufri Pukhraj & Kufri Jyoti i.e. 728 (000/ha) & 517 (000/ha) respectively, whereas seed size tubers was found maximum, 275 (000/ha) in 15 Nov. planting date in Kufri Pukhraj and in case of Kufri Jyoti, 212 (000/ha) found in 05 Nov. planting date (Fig. 9).

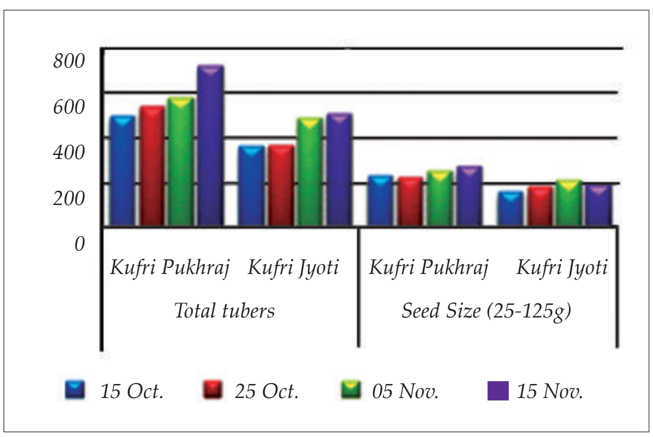

Fig. 9: Tuber number and seed size tuber numbrr (000/ha)

Optimization of inter and intra row spacing for production of seed size tubers: In case of Kufri Pukhraj paired row planting with dehaulming at 90 DAP resulted in the maximum tuber yield 48.70 t/ha, whereas seed size tuber yield (24.20 t/ha) was maximum in paired row planting with 90 DAP dehaulming. Total tuber number was found maximum, 760 (000/ha) in paired row planting with 8 DAP dehaulming, whereas seed size tuber number was maximum, 343 (000/ha) in paired row planting with 90 DAP dehaulming.

Evaluating two potato crop in net house: Six potato varieties (Kufri Khyati, Kufri Surya, Kufri Chandramukhi, Kufri Jyoti, Kufri Badshah and Kufri Himalini) with first (16/10/18, double crop early, DCE) and second (1/1/19, double crop late, DCL) planting dates for dual crop, and for single crop (16/10/18, SC) were planted in four replications. Varietal differences were also significant for these characters. In DCE/DCL, average tuber no. (299.2) were recorded with yield of 5.15 kg/m 2 as compared to 134.8 tubers and yield of 4.31 kg in SC. Planting of two crops under net-house has scope of higher productivity per unit area as compared to single crop.

Weight loss study in aeroponic minitubers: A study at Jalandhar in aeroponic minitubers of Kufri Himalini and Kufri Chandramukhi was carried out to find out weight loss at different stages after picking. Weight was recorded just after picking, after greening and then after keeping in cold store.

Indoor hardening of *in vitro* plants: In this method mortality during hardening was found around 1-2% as compared to 17.5% in traditional method. Mortality of plants hardened with new method in aeroponics was found 0.33% as compared to 9.5% with traditional method in which roots are removed while shifting to aeroponics. With this method it was possible to take two full crops of potato in aeroponic system.

Effect of water deficit regime on seed grade tuber yield in selected potato varieties: At Modipuram, an attempt was made to analyze the impact of less watering on seed grade tuber yield in six potato varieties for 90 days crop duration. Kufri Ganga had lowest yield reduction (8.5%) whereas Kufri Pukhraj (19.0%) and Kufri Mohan (19.2%) recorded highest yield reduction. Moderate seed grade yield reduction in purple skin potato cv. Kufri Neelkanth (13.5%) appears to be due to better antioxidants status as these are known to mitigate the adverse effect of abiotic stresses.

Soil solarization for aeroponic seed multiplication in stage G-1 under field condition: Field experiment was conducted at Gwalior with nine treatment combinations of two mulches (polythene and paddy straw) along with control and three varieties (Kufri Mohan, Kufri Chipsona-1 and Kufri Lauvkar) in three replication with factorial RBD. Experimental site was solarized/ mulched with polythene much or paddy straw along with control from April, 2018 till planting of crop. Emergence (%) was very good (92) in all mulch type, but varied among cultivars i.e. 93.9% in Kufri Mohan, 93.2% in Kufri Chipsona-1 and 88.4% in Kufri Lauvkar. Highest total tuber number (554000/ha) and yield (37.5 t/ha) was observed in paddy straw. Among varieties, highest tuber number (559000/ha) were in Kufri Chipsona-1 and yield (40.0 t/ha) was in Kufri Mohan.

Effect of planting dates on production of seed size tubers: At Gwalior, field study conducted with twelve treatment combinations of four planting dates (15 October, 25 October, 5 November & 15 November) and three varieties (Kufri Lauvkar, Kufri Jyoti and Kufri Gaurav) replicated thrice in factorial RBD resulted into highest seed size (290000/ha) and total tuber number (573000/ha) at 15 th November planting date. Maximum seed size (301000/ha) and total tuber number (637000/ha) were recorded in cv. Kufri Gaurav. Similar trend was reported for seed size (18.6 t/ha) and total tuber (28.5 t/ha) yield at 15 th November planting and among cultivars for cv. Kufri Gaurav with seed size (17.5 t/ha) and total tuber (29.6 t/ha) yield.

Performance of aeroponic minitubers under different irrigation systems: Emergence (%) was higher in raised bed (87.2), sprinkler irrigation (86.1) and in cv. Kufri Lauvkar (86.8) over their respective counterparts. Flat bed (1123000/ha) and raised bed (1115000/ha) system were at par for total tuber number. Furrow irrigation system (1204000/ha) recorded higher total tuber number than sprinkler irrigation (1034000/ha). Cv. Kufri Lauvkar (1191000/ha) had higher total tuber number as compared to Kufri Surya (1047000/ha). Raised bed (107.8 q/ha) attained higher total tuber yield over flat bed system (96.2 q/ha). Sprinkler irrigation system (105.1 q/ha) recorded higher tuber yield in comparison to furrow irrigation (98.2 q/ha).

Seed production agronomy for aeroponic minitubers under G-0 and field conditions: In net house, total tuber number (1756000/ha) was maximum in 45x10 cm spacing. In open field, total tuber number (1563000/ha) was highest in 30x10 cm. Fertilizer level of 120N:60P:100K kg/ha attained maximum total tuber number (1542000/ha) in net house, while in open field it was with 180N:60P:100K kg/ha. In net house, total tuber yield (21.7 t/ha) was highest in 45x10cm spacing and in open field, total tuber yield (19.7 t/ha) was maximum in 45x10cm spacing. Total tuber yield was highest in net house (17.2 t/ha) and open field (18.9 t/ha) with 150N:60P:100K kg/ha fertilizer level.

DIVISION OF SOCIAL SCIENCES

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

Economic Analysis of Potato Production in West Bengal

A survey for assessing of the cost and income of potato production was conducted in West Bengal by interviewing 100 farmers (Bardhaman=50, Hooghly=50).

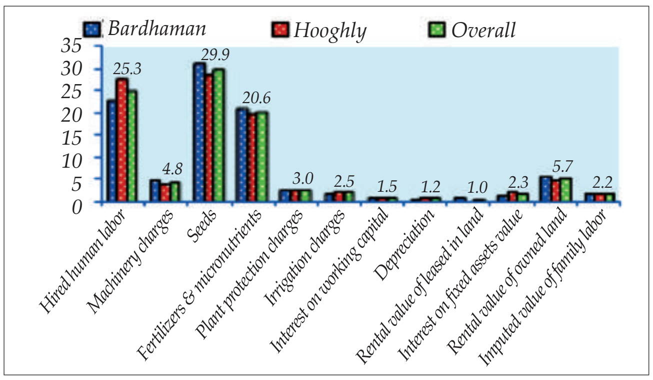

Fig. 1: Graphical representation of different cost components in West Bengal

It is evident from Figure 1 that overall; the highest cost contribution was that of seed (30%), followed by hired human labor (25.3%) and fertilizers, manure and micronutrients (20.6%) On an average, the total cost of potato cultivation (Cost C) was found to be ₹ 1,65,410/- per ha. Overall, the net income was ₹ 44,346.0/- per ha with the B: C ratio of 1:27 during 2017-18 crop season (Table 1).

Economic Impact Assessment of potato cv. Kufri Pukhraj

The Economic Surplus Method with closed economy was used to measure the benefits of and returns to research and development (R&D) of an early bulker and drought-tolerant potato cv. Kufri Pukhraj in India. A period of 40 years from 1978 (the year in which breeding of Kufri Pukhraj started) to 2018 was considered for developing the cost–benefit stream.

All these estimates of costs and benefits were expressed in real terms by adjusting to Wholesale Price Index with 2018 as the base year. The results of the model revealed that the total cost of R&D of Kufri Pukhraj was Rs. 12.1 crore. The Net Present Value (NPV) of the benefits of Kufri Pukhraj R&D was ₹ 10974.5 crore and 4215.5 crore at 5 and 8 per cent discount rate respectively and the internal rate of return (IRR) of the net benefit was 43 % (Table 2).

Table 1: Component wise break up of cost of potato cultivation and income in West Bengal

Components	Bardhaman	Hooghly	Overall
Cost A1 (in Rs/ha)	152199.8 (88.5)	142919.3 (89.3)	146923.8 (88.8)
Cost A2 (in Rs/ha)	154647.6 (89.9)	143678.6 (89.8)	148527.4 (89.8)
Cost B (in Rs/ha)	168287.0 (97.9)	156511.7 (97.8)	161763.6 (97.8)
Cost C (in Rs/ha)	171969.9 (100)	160033.4 (100)	165410.2 (100)
Yield (q/ha)	306.2	291.7	301.3
Price (Rs/q)	684.7	719.4	696.2
Gross Income (Rs/ha)	209665.0	209807.2	209756.2
Net Income (Rs/ha)	37695.1	49773.7	44346.0
B:C Ratio	1.22	1.31	1.27
Cost of production over Cos C (Rs/q)	561.61	548.72	549.04

Table 2: Impact of Kufri Pukhraj in India

Particulars	Discount Rate	
	5 %	8 %
NPV of ΔCS (in crore Rs.)	7854.9	3068.9
NPV of ΔPS (in crore Rs.)	2945.6	1150.9
NPV of ΔTS (in crore Rs.)	10800.5	4219.8
NPV of Net Benefit (in crore Rs.)	10794.5	4215.5
IRR (%)	43 %	

Note: ΔCS=Change in Consumer Surplus, ΔPS= Change in Producer Surplus, ΔTS= Change in Total Surplus

Assessment of Seed Replacement Rate of potatoes in West Bengal and Uttar Pradesh

Surveys were conducted by interviewing 85 farmers of Bulandshahr and Meerut districts of UP and 100 farmers of Bardhaman and Hooghly of West Bengal for 2017-18 crop season. Two approaches were used to study the seed replacement (SRR) of potato. The first approach is the conventional seed replacement approach which indicates the number of year in which the farmers replaced the potato seeds. For potato, it is generally recommended to replace seeds within 4 years. The second approach is by using Seed Replacement Rate model which compute 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 3 revealed that overall, about 99.0 percent and 88.2 percent farmers replaced seeds within 4 years in West Bengal and Uttar Pradesh, respectively. (Table 3).

Table 4 showed that on an average, the SRR for improved varieties was 100 percent and 91.8 percent in West Bengal and Uttar Pradesh, respectively and the SRR for certified seeds was 40.3 and 30.0 in West Bengal and Uttar Pradesh, respectively.

Table 3: Seed Replacement rate in year in West Bengal and Uttar Pradesh

Farm size categories	Seed Replacement Rate in year (% of farmers in West Bengal					Seed Replacement Rate in year (% of farmers) in Uttar Pradesh				
	1	2	3	4	≥ 5	1	2	3	4	≥ 5
Marginal	69.4	12.2	14.3	2.0	2.0	42.9	14.3	28.6	0.0	14.3
Small	68.6	22.9	5.7	2.9	0.0	31.3	18.8	37.5	0.0	12.5
Semi-Medium	61.5	23.1	7.7	7.7	0.0	32.0	12.0	36.0	8.0	12.0
Medium	100.0	0.0	0.0	0.0	0.0	33.3	12.5	37.5	8.3	8.3
Large	100.0	0.0	0.0	0.0	0.0	15.4	7.7	46.2	15.4	15.4
Overall	**69.0**	**17.0**	**10.0**	**3.0**	**1.0**	**30.6**	**12.9**	**37.7**	**7.1**	**11.8**

Table 4: Seed Replacement Rate of potato crop (percentage area) of West Bengal and Uttar Pradesh

Farm size categories	Seed of improved varieties		Certified seeds	
	WB	**UP**	**WB**	**UP**
Marginal	100	93.89	22.1	0
Small	100	79.45	36.9	12.69
Marginal	100	93.89	22.1	0
Small	100	79.45	36.9	12.69
Semi-Medium	100	81.82	47.1	8.13
Medium	100	87.89	19.1	21.89
Large	100	96.29	100.0	45.82
Overall	**100**	**91.78**	**40.3**	**29.88**

Assessment of Varietal Replacement Rate in Uttar Pradesh

The varietal replacement rate in Uttar Pradesh was estimated by interviewing 85 farmers of Bulandshahr and Meerut districts of Uttar Pradesh. The varietal replacement rate indicates the number of year in which an old variety is replaced by a new variety and was estimated using a varietal replacement index (VRI) developed by Brennan and Byerlee (1991). The varietal replacement index is a measure of the rate of varietal replacement that takes into consideration the age of the varieties and their relative sown area. The average age of improved varieties was found to be 23.85, which is very high, indicating that the varietal replacement rate in the study area is very high. It also indicates that the rate of adoption of new varieties by the farm communities in the study areas was very slow (Table 5).

Table 5: Varietal replacement rate in Uttar Pradesh

Varieties	Release year	Age	Area	Avg. Age
Kufri Bahar	1980	37	75.32	15.21
Kufri Pukhraj	1998	19	42.78	4.44
Kufri Khyati	2008	9	24.41	1.20
Kufri Chipsona-1	1998	19	16.71	1.73
Kufri Chipsona-3	2006	11	10.07	0.60
Kufri Garima	2012	5	4.86	0.13
Kufri Frysona	2009	8	4.05	0.18
Kufri Pushkar	2005	12	2.02	0.13
Kufri Surya	2006	11	1.34	0.08
Kufri Anand	1999	18	1.29	0.13
Kufri Sadabahar	2008	9	0.40	0.02
Total		**158**	**183.27**	**23.85**

Assessment of Varietal Adoption Pattern in West Bengal and Gujarat

The varietal adoption patterns was assessed by conducting surveys for 100 farmers of Bardhaman and Hooghly districts of West Bengal and 120 farmers of Banaskantha and Aravalli districts of Gujarat for the 2017-189 crop season. It is evident from Figure 2 that Kufri Jyoti (52 %) was the most popular variety in West Bengal, which was followed by Kufri Chandramukhi (18 %) and Kufri Pukhraj (16.2 %). In Gujarat (Fig. 3), the most popular varieties were Lady Rosetta (40.5 %) and Kufri Pukhraj (33.3 %).

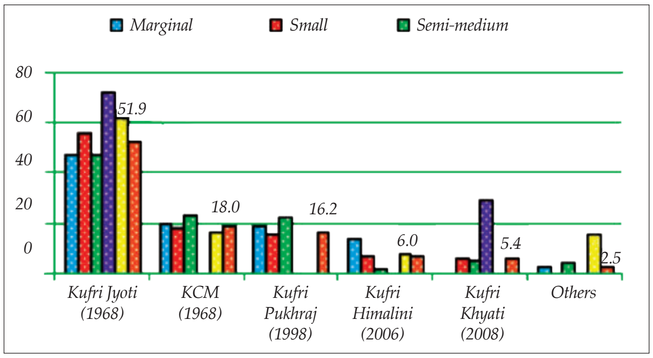

Fig. 2: Varietal adoption pattern in West Bengal

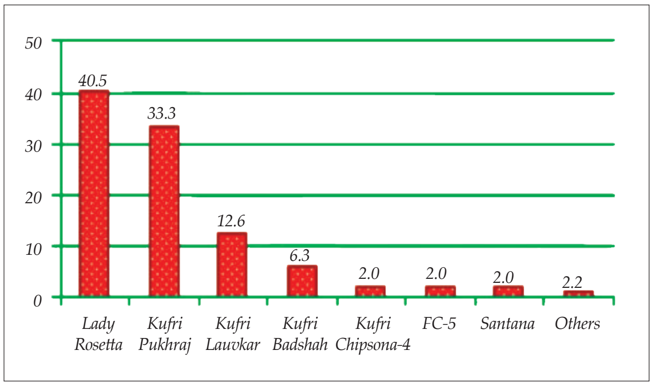

Fig. 3: Varietal adoption pattern in Gujarat

Estimation of Consumers' Preferences for Potatoes in Bihar and Punjab

A study was conducted to investigate consumers' preferences for potatoes by interviewing consumers of Patna and Vaishali districts of Bihar and 90 consumers of Jalndhar and Ludhiana districts of Punjab during 2018.

Based on weighted mean score (WMS) as ranked by consumers in Bihar, the ranks of attributes in order of importance were: skin color > tuber size > shape > skin smoothness > taste > cooking time > shelf life> flesh color = texture >eye's depth >aroma (Figure 4). In Punjab, the ranks of attributes in order of importance were: tuber size > cooking time=taste shape > aroma > skin color > shelf life > skin smoothness > texture > flesh color >eye's depth.

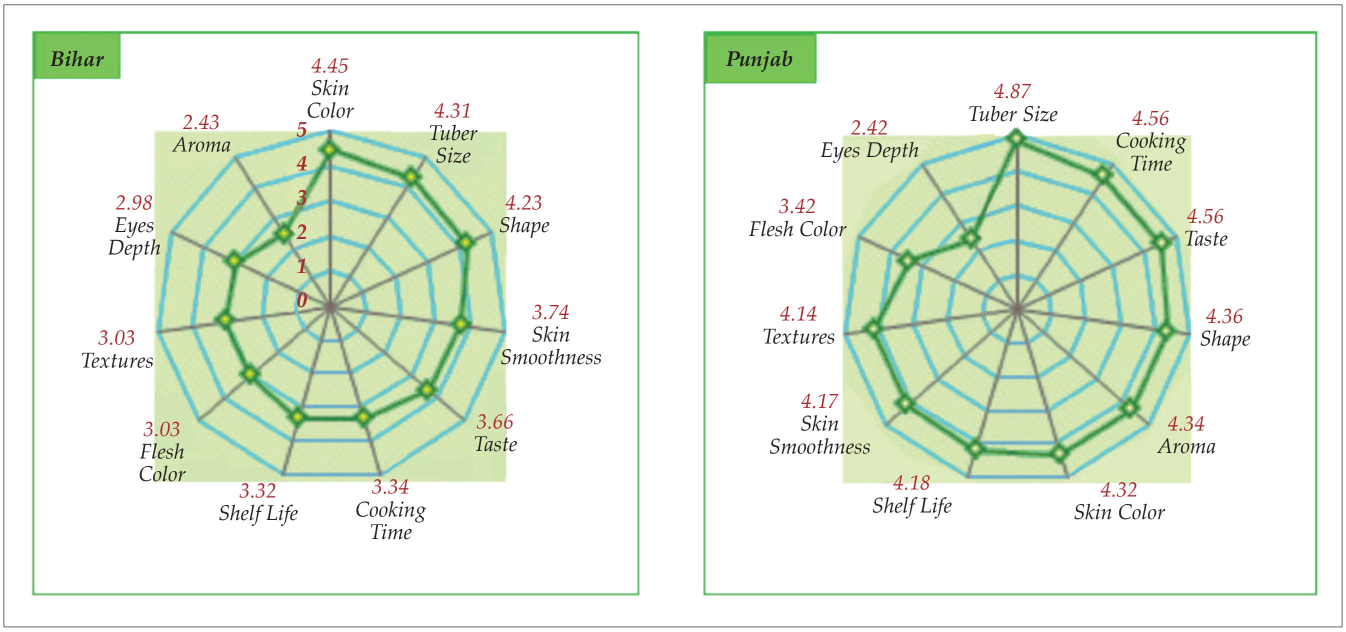

Fig. 4: Consumers' preferences for potato attributes in Bihar and Punjab

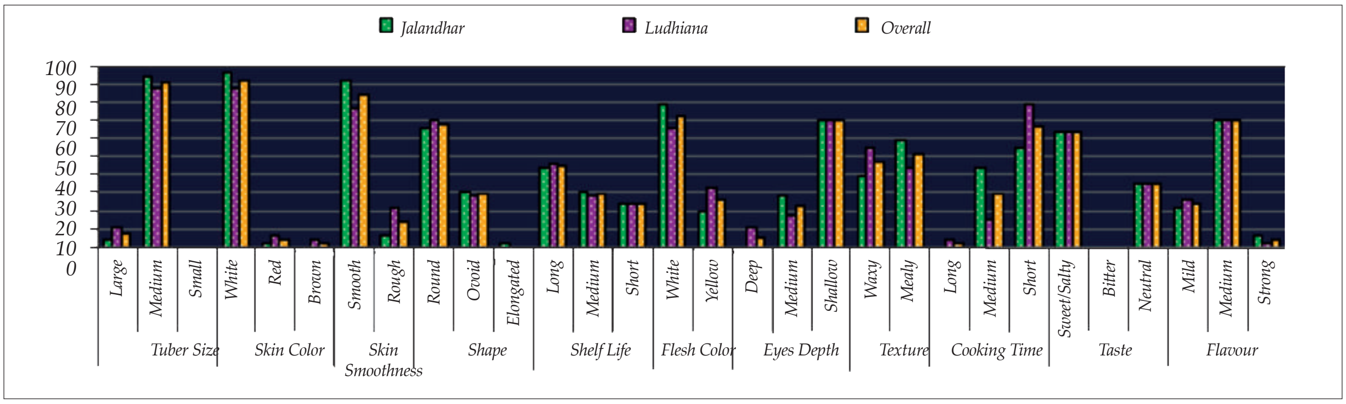

Fig. 5: Preferences for different levels of potato attributes in Bihar

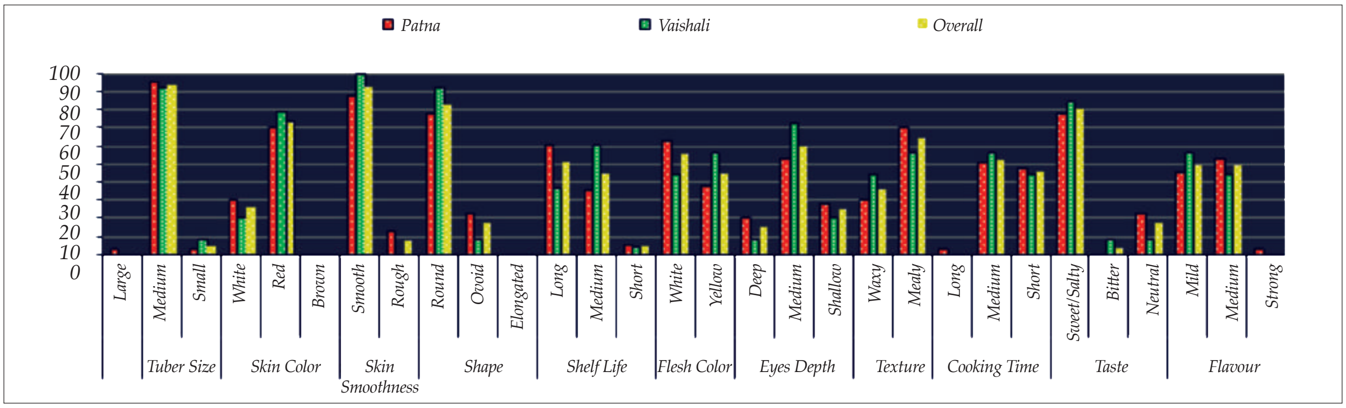

Fig. 6: Preferences for different levels of potato attributes in Punjab

Moreover, consumers' preferences for different levels of potato attributes were also studied.

The results (Fig. 5 & 6) revealed that in both states, consumers preferred potatoes with medium size, smooth skin, round shape, long shelf life, white flesh color, medium eye's depth, white flesh color, mealy texture, medium cooking time and medium aroma. While consumers of Bihar preferred red skinned potatoes, medium eye's depth and medium cooking time, Punjab consumers preferred white skinned, shallow eye's depth and short cooking time.

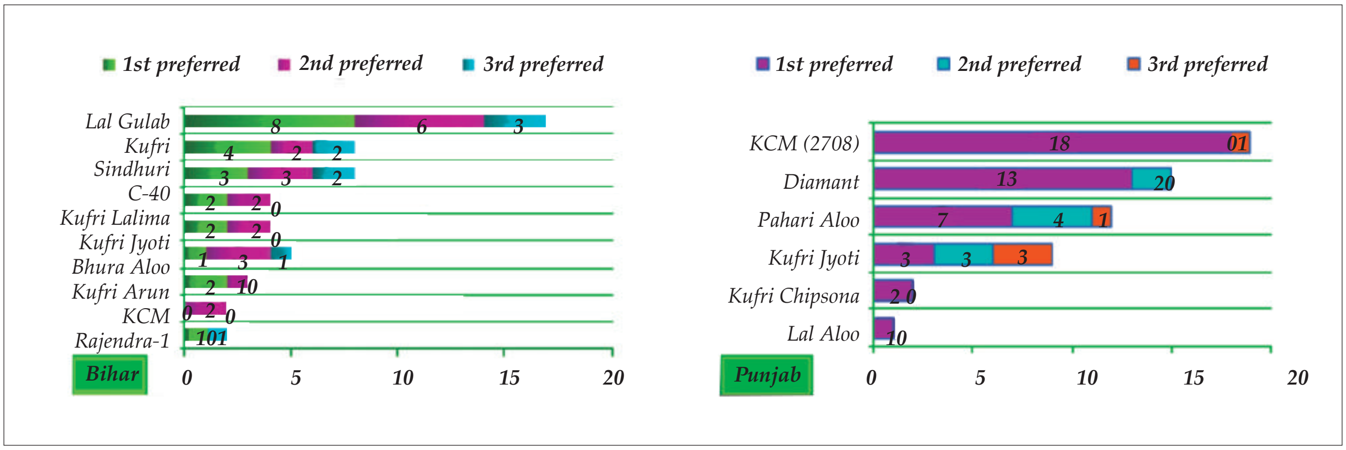

Fig. 7: Consumer's, varietal preferences in Bihar and Punjab

The consumers' awareness and preferences for potato varieties available in the market were also studied. The study revealed that in Bihar, out of 65 consumers interviewed, only 24 consumers (37 %) know the name of at least one variety available in the market whereas in Punjab, out of 90 respondents, only 43 (47.7 %) know the name of at least one variety available in the market.

Lal Gulab, Kufri Sindhuri and C-40 were the most preferred varieties in Bihar and Kufri Chandramukhi, Diamant pahari aloo and Kufri Jyoti were the most preferred varieties in Punjab.

Sources of Potato Seeds and Constraints to Adoption of Quality Seeds in WB

A survey was conducted by interviewing 100 farmers of Bardhaman and Hooghly of West Bengal for identifying the sources of potato seeds and constraints to adoption of quality/certified potato seeds. The findings revealed that overall; about 27.3 percent of the seed were obtained from local markets/ seed traders (Table 6). The second most important seed sources were Cooperatives societies and FPOs from which about 17.5 percent of seeds were procured by the farmers. Farmers also obtained seeds from state departments, SAUs and CPRI. About 31 percent of potato seeds were farm saved seeds and seeds obtained from friends or other farmers.

The analysis of constraints to adoption of quality/ certified potato seeds was done using Garrett's Ranking Technique. The study indicated that the first major constraint ranked by potato growers was high cost of quality/certified seed (with overall score of 64.7).

This was followed by non-availability of seeds of required varieties (score=52.3, Rank II), lack of information about improved varieties (score=50.2, Rank III), far from sources of quality seeds (Score=45.0, rank=IV) and lack of cold storages and high storage charges for keeping potato seeds (36.8, Rank V).

Table 6: Sources of potato seeds in WB

Seed Sources	Marginal	Small	Semi-Medium	Medium	Large	Overall
Local market/village seed traders	143.1(40.8)	180.5(35.6)	59.5 (11.4)	87.5 (41.7)	0.0 (0.0)	470.6 (27.3)
Co-op Society/FPOs/samitis	73.2 (20.9)	104.5(20.6)	124.2 (23.8)	0.0 (0.0)	0.0 (0.0)	301.9 (17.5)
State depts./SAUs/CPRI	5.3 (1.5)	7.8 (1.5)	133.0 (25.4)	0.0 (0.0)	135.0 (100.0)	281.0 (16.3)
Other farmers	37.1 (10.6)	89.5 (17.6)	113.2 (21.7)	35.0 (16.7)	0.0 (0.0)	274.8 (15.9)
Farm saved seeds	34.7 (9.9)	101.5 (20.0)	34.5 (6.6)	87.5 (41.7)	0.0 (0.0)	258.2 (15.0)
Private Companies	57.1 (16.3)	23.8 (4.7)	58.4 (11.2)	0.0 (0.0)	0.0 (0.0)	139.2 (8.1)
Total	**350.4 (100)**	**507.5 (100)**	**522.7 (100)**	**210.0 (100)**	**135.0 (100)**	**1725.7 (100)**

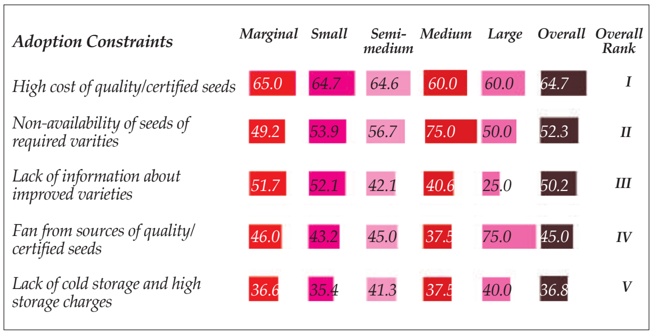

Fig. 8: Garrett's mean score and ranking of constraints to adoption of quality seeds

Frontline Demonstrations (FLDs) on Improved Potato Production Technologies during 2018-19

FLDs on new variety Kufri Mohan and Kufri Ganga in Uttar Pradesh

In view to popularize the new potato developed by the institute, 13 FLDs (10 FLDs for Kufri Mohan and 3 FLDs for Kufri Ganga) were laid out at farmer fields in Meerut, Hapur, Aligarh and Muzafarnagar districts of Uttar Pradesh. The yield of variety Kufri Mohan and Kufri Ganga was compared with the existing varieties, namely Kufri Bahar and Kufri Pukhraj (Table 7). Kufri Ganga (388.9 q/ha) was the highest yielder with about 36.5 % higher yield over Kufri Bahar and 13.5 % higher than Kufri Pukhraj. The overall yield of Kufri Mohan (363.4 q/ha) was about 27.6 % higher over Kufri Bahar 284.9 q/ha and only 6 % higher over Kufri Pukhraj (342.7 q/ha).

FLDs on Varietal Performance and Scientific Seed Production

Twelve FLDs were laid out at farmers' field for seed production of improved varieties, namely, Kufri Mohan, Kufri Ganga and Kufri Bahar at 5 villages in Pachperwa and Gainsari blocks of aspirational district Balrampur. Kufri Mohan was the highest yielder with about 25.0 % higher yield over the local red variety. Kufri Ganga was 21.5 % higher and Kufri Bahar was 18.5 % higher than the yield of local red variety. The average tuber yield of three improved varieties was 275 q/h and the yield of local red variety was 150 q/ha under farmers practices. Eleven FLDs were also laid out in Agra district of UP. Kufri Sindhuri was found to be 11.8 % higher yield than the existing local variety.

FLDs on scientific potato seed production under potato seed village scheme in East Champaran, Bihar

For establishment of seed village in East Champaran district of Bihar, 400 FLDs were laid out at farmers' fields which covered about 33 blocks of East Champaran, Bihar. The improved variey cv Kufri Sindhuri were utilized for demonstrations. The average yield of demonstrated variety Kufri Sindhuri (211.8 q/ha) was about 21.5 percent higher than the local variety cv. Lal Gulab (174.3 q/ha).

FLDs for potato seed production under Kisan Kalyan Abhiyan at Muzaffarpur, Bihar

20 FLDs were laid out in five villages of Motipur block of Muzaffarpur district for scientific seed production of improved variety cv. Kufri Jyoti. The average yield of Kufri Jyoti was found to be 26.7 percent higher than the popular local variety, Lal Gulab.

FLDs under Mera Gaon Mera Gaurav in Vaishali, Bihar

During 2018-19, five FLDs were laid out in adopted villages under MGMG Programme in Vaishali district for popularization of improved varieties, namely Kufri Ashoka, Kufri Pukhraj, Kufri Khyati and Kufri Sindhuri. Kufri Pukhraj (256.6 q/ha) was the highest yielder, which was followed by Kufri Khyati (248.5 q/ha), Kufri Sindhuri (232.3 q/ha) and Kufri Ashoka (217.3 q/ha).

FLDs for varietal performance in Guna, Madhya Pradesh

10 FLDs for showing the superiority of Kufri Sindhuri over local varieties were laid out at farmers' fields in Guna district of Madhya Pradesh. The yield of Kufri Sindhuri was 193.8 q/ha which was about 8.3 percent higher than the local variety (179.0 q/ha).

FLDs for varietal performance in Shimla district, Madhya Pradesh

In Himachal Pradesh, a total of 20 demonstrations, 10 each of potato varieties, cv. Kufri Himalini and Kufri Girdhari were laid out in different villages of Shimla district to assess their performance at farmers' fields. The average yield of demonstrated variety Kufri Himalini (242.5 q/ha) was about 15.9 percent higher than the control variety Kufri Jyoti (209.2 q/ha).

Table 7: Details of FLDs conducted at farmers' fields in several states of India (2018-19)

State	Districts	Demonstrations		Local Control		% increased yield over local check
UP	Meerut	Kufri Mohan (4 FLDs)	362.0	Kufri Bahar	281.1	28.8
	Meerut	Kufri Ganga (1 FLD)	437.5	Kufri Pukhraj	357.9	22.2
UP	Hapur	Kufri Mohan (3 FLDs)	389.5	Kufri Bahar	301.8	29.1
	Hapur	Kufri Ganga (1 FLD)	395.8	Kufri Pukhraj	327.5	20.9
	Aligarh	Kufri Mohan (2 FLDs)	320.8	Kufri Bahar	244.8	31.0
	Aligarh	Kufri Ganga (1 FLD)	333.3	Kufri Bahar	306.3	8.8
	Muzafarnagar	Kufri Mohan (1 FLD)	376.4	Kufri Bahar	308.0	22.2
	Overall	Kufri Mohan	363.4	Kufri Bahar	284.9	27.6
		Kufri Mohan	363.4	Kufri Pukhraj	342.7	6.0
		Kufri Ganga	388.9	Kufri Bahar	284.9	36.5
		Kufri Ganga	388.9	Kufri Pukhraj	342.7	13.5
	Agra	Kufri Sindhuri (11 FLDs)	190.0	Local	170.0	11.8
BR	East Champaran	Kufri Sindhuri (400 FLDs)	211.8	Lal Gulab	174.3	21.5
	Muzaffarpur	Kufri Jyoti (20 FLDs)	234.5	Lal Gulab	185.1	26.7
	Vaishali	Kufri Ashoka (1 FLD)	217.3	Bhoora Aloo	172.3	26.1
		Kufri Khyati (1 FLD)	248.5	Bhoora Aloo	172.3	44.2
		Kufri Pukhraj (1 FLD)	256.6	Bhoora Aloo	172.3	48.9
		Kufri Sindhuri (2 FLDs	232.3	Bhoora Aloo	172.3	24.8
MP	Guna	Kufri Sindhuri (10 FLDs)	193.8	Local	179.0	8.3
HP	Shimla	Kufri Himalini (10 FLDs)	242.5	Kufri Jyoti	209.2	15.9
		Kufri Girdhari (10 FLDs)	264.8	Kufri Jyoti	209.2	26.6
PB	Moga	Kufri Khyati (8 FLDs)	252.3	Diamant	218.0	15.7
ML	East Khasi Hills	Kufri Himalini (15 FLDs)	159.0	Kufri Jyoti	90.0	76.67
		Kufri Girdhari (15 FLDs)	181.2	Kufri Jyoti	90.0	101.3

Note: UP=Uttar Pradesh, BR=Bihar, MP=Madhya Pradesh, HP=Himachal Pradesh, PB=Punjab, ML=Meghalaya

The incidence of late blight disease was negligible (0.0-1.0 %) in Kufri Girdhari as compared to Kufri Jyoti (10-15 %). As a result, Kufri Girdhari (264.8 q/ha) gave higher yield *i.e.*, about 26.6 percent higher yield as compared to Kufri Jyoti.

FLDs in Inspirational District Moga, Punjab

For popularizing the improved variety cv. Kufri Khyati in aspirational district Moga, Punjab, eight FLDs were laid out in five villages. The average yield of Kufri Khyati (252.3 q/ha) was about 15.7 percent higher than the Diamant variety (218.0 q/ha).

FLDs on Improved Potato cultivation in Meghalaya

Thirty FLDs were laid out in East Khasi Hills district of Meghalaya on improved potato cultivation method "Ridge and furrow method of planting" was using improved potato varieties, Kufri Himalini and Kufri Girdhari. It was found that Kufri Girdhari under scientific cultivation was about 101 per cent higher than the local variety. Similarly, the yield of Kifri Himalini was 76.7 percent than that of the local variety.

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TRANSFER OF TECHNOLOGY

TECHNOLOGY TRANSFER ACTIVITIES ORGANIZED BY ICAR-CPRI, SHIMLA

As per its mandate, the Division of Social sciences organized a large number of technology transfer activities related to potato production at the headquarter and the regional stations. These extension activities include organization of training programmes for farmers, scientists and extension functionaries, laying out FLDs in farmers' fields, organization of and participation in exhibitions, live phone-in programmes on All India Radio as well as Doordarshan for farmers and other stakeholders. These kind of activities helped in creating awareness and improving knowledge of farmers as well as other stakeholders *viz.* scientists, teachers, processors, entrepreneurs in the field of potato research & development.

Organization of Trainings

During 2018-19, nine national and international training programmes for scientists, farmers, extension functionaries and other stakeholders were organized. Nearly all aspects of potato cultivation viz. seed preparation, planting, fertilizer application, intercultural operations, water management, disease/pest management, harvesting, processing, storage and marketing were covered during these trainings programmes (Table 1).

Table 1: Details of training programmes organized at CPRI, Shimla during 2018-19

Sl. No.	Title	Date (Duration)	No. of trainees	Sponsoring agency
1.	Seed Potato Production	April 4 -13, 2018 (10 days)	4 officers	Department of Agriculture, West Bengal
2.	Hi-tech potato seed production	June 18- 22, 2018 (4 days)	3 scientists	International Potato Center (CIP)
3.	Scientific potato seed production	June 7, 2018 (1 day)	25 farmers	ICAR-CPRI, Shimla
4.	Aloo utpadan evam rogon se bachav	July 16 -18, 2018 (3 days)	10 farmers	BADP, UttarKanshi (Uttarakhand)
5.	Quality Seed Potato Production Techniques	August 02 -04 2018 (3 days)	5 officers	Jain Irrigation systems Limited, Jalgaon
6.	Scientific potato seed production	October 5, 2018 (1 day)	30 farmers	CPRI, Shimla
7.	Aloo ki unnat kheti	January 07-09, 2019 (3 days)	20 farmers	Reliance Foundation, Uttarkanshi, Uttarakhand
8.	Aloo ki Unnat Kheti	February 12 -14, 2019 (3 days)	22 farmers	Dept. of Horticulure, Aravali, Gujarat
9.	Aloo ki Unnat Kheti	March 15 – 16 , 2019 (2 days)	3 students	ICAR-CPRI, Shimla
10.	Office procedure & etiquettes	March 25-27, 2019 (3 days)	30 SSS	ICAR-CPRI, Shimla

Table 2: Live phone-in programme on Doordarshan, Shimla during 2017-18

Sl No.	Date	Topic	Name of Experts
1.	June 2018	Storage and marketing of potato in central parts of Himachal Pradesh	Dr. NK Pandey Dr. Brajesh Singh
2.	July, 2018	Potato diseases and their management in higher hills of Himachal Pradesh.	Dr. Vinay Sagar Dr. Ravinder Kumar
3.	August, 2018	Weeding and harvesting of potato in higher hills of Himachal Pradesh.	Dr. Jagdev Sharma Dr. Tanuja Buckseth
4.	September 2018	Harvesting, storage and marketing of potato in higher hills of Himachal Pradesh.	Dr. Brajesh Singh Dr. Vinod Kumar
5.	December, 2018	Potato diseases and their management in lower hills of Himachal Pradesh	Dr. Ravinder Kumar Dr. Aarti Bairwa
6.	January, 2019	Potato varieties, planting and fertilizer management in the higher hills of HP	Dr. Tanuja Buckseth Dr. Vinod Kumar
7.	February, 2019	Potato cultivation, harvesting and storage in lower hills of Himachal Pradesh	Dr. Brajesh Singh Dr. Ashwani K. Sharma
8.	March, 2019	Management of potato diseases and pests for medium hills of Himachal Pradesh	Dr. Baswaraj Raigond Dr. Kailash Naga

Celebration of National Potato Day and Krishidham Expo-2019

ICAR-CPRI and Indian Potato Association organised National Potato Day and Krishidham Expo-2019 from February 15-17, 2019 at CPRI RS, Modipuram. Various events like agriculture exhibition, Potato dish making competition, Kufri Jyoti- Golden Jubilee celebration, session on "World without potato", Potato prize distribution and sugarcane convention were organized during this programme.

Seed Village Workshop in East Champaran, Bihar

ICAR-CPRI, Shimla organized a one-day workshop for establishment of potato seed villages on October 28, 2018 in Krishi Vigyan Kendra, Piprakothi, East Champaran, Bihar.

Live Webcast/Telecast of Inauguration of PM-KISAN at ICAR-CPRI, Shimla

On February 24, 2019, ICAR-CPRI organised a live telecast programme for farmers on the inauguration of "Pradhan Mantri Kisan Samman Nidhi Yojana" by the Prime minister of India. The programme was attended by 90 farmers of district Shimla.

Live phone-in Programme on Shimla Doordarshan

Expert scientists from different discipline of CPRI Shimla participated in live phone in programmes. A list of these programmes is given in Table 2.

Participation in Agricultural Fairs Exhibitions

ICAR-CPRI, Shimla participated in many exhibitions organized at different locations to showcase varieties and production technologies of potato. List of these exhibitions is given below.

- Participated and put up an exhibition stall during the International Day for Biological Diversity 2018 at ICAR-CPRI, Shimla.
- Participated and put up an exhibition stall in Mushroom mela at ICAR-DMR Solan on 10th September, 2018.
- Organized and put up exhibition stall during National Potato Day and Krishidham Expo -2019 during 15th - 17th February, 2019 at CPRI Shimla.

Demonstrations

In Himachal Pradesh, a total of 20 FLDs were laid out on performance of improved varieties at farmers' fields.

Activities of Agriculture Technology Information Centre (ATIC)

Sale and distribution of CPRI technical and extension bulletins: A total of 478 technical and extension bulletins were sold through ATIC. Moreover, nearly 3000 publications like CPRI profile, Crop Calendar and leaflets related to potato technologies were distributed free of cost to the institute visitors and during different exhibitions. One CD of PPM (Potato Pest Manager) were also sold through ATIC. Altogether revenue generated through sale of publications and CDs/Expert system was of value Rs. 21970/-.

Dissemination of knowledge to visitors: A total of 2305 persons visited in the institute during 2018-19. The visitors included 1336 School/B. Sc./M.Sc./Ph.D students from different states, 98 scientists/professors/teachers, 699 farmers and 172 extension workers/agri. or hort. officers. The visitors were made aware about various activities and technologies of the institute through films, lectures, discussions, visit to important laboratories and institute's museum and farmers' museum in which the technologies were displayed using posters, panels, live samples and models etc. Altogether revenue generated through visitors' fees was of value Rs. 12560/-.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, MODIPURAM

Training Programmes

Table 3: Details of training programme organized at ICAR-CPRI, RS, Modipuram

S. No.	Title of training	Duration	Nos. of trainees	Sponsored Agency
1.	Kisan Gosthi Evam Prasiksan on Krsihi ki Unnat Taknik	One day (19 May,2018)	200 Farmers of district Meerut	Gujrat State Fertilizers Chemicals Barodra (Gujrat)
2.	Improved Techniques of Potato Production	Five days 4-8 June, 2018	34 block levels agriculture officers	ATMA
3.	Beej Aaloo Utpadan Evam Vipran for Plains Areas	Five days (09-13 July, 2018)	30 district and block levels agriculture officers	State Agriculture Management Institute Lucknow (U.P.).
4.	Beej Aaloo Utpadan Evam Vipran for Plains Areas	Five days (27-31 August, 2018)	30 district and block levels agriculture officers	State Agriculture Management Institute
5.	आलू उत्पाद आधारित महिला उद्यमिता विकास कार्यक्रम	(03-04 January, 2019)	22 village level womens of district Hapur (U.P.)	NABARD
6.	Improved Techniques of Potato Production	(11-12 October, 2018)	25 field staff of Godrej Agrovet Limited.	M/s Godrej Agrovet Limited, Mumbai

Field days/Demonstrations

Table 4: Details of field days organized at ICAR-CPRI, RS, Modipuram

Sl No.	Title of training	Duration	No. of trainees
1.	Demonstration on quality potato seed production of under low cost net houses at village Amarpur district Meerut	13 December, 2018	71 farmers district Meerut (U.P.)
2.	Demonstration on quality potato seed production under low cost net houses	24 December, 2018	105 farmers of district Hapur
3.	Demonstration on quality potato seed production under low cost net houses	22 January, 2019	106 farmers of district Bulandsher
4.	किसान कल्याण अभियान के अन्तर्गत् आकांक्षात्मक (Aspirational) जिला बलरामपुर उत्तर प्रदेश में कृषक प्रक्षेत्र दिवस)	16 January, 2019	41 farmers of village Baggaur of block Pacpedwa
5.	Improved Techniques of Table and Potato Seed Production	One days (21 February 2019)	50 farmers of adopted village district Hapur (U.P.)
6.	Improved Techniques of Potato Production for U.P Hapur	One days (26 February 2019)	40 farmers of adopted village Mahmoodpur district Hapur
7.	Improved Techniques of Potato Production seed production	One days (8 March 2019)	32 Farmers of adopted villages nearby Meerapur district Muzafarnagar

Participation in Kisan Melas, Krishi Pardarshinis and Exhibitions

CPRI regional station, Modipuram participated in the following exhibitions to showcase potato technologies developed by the institute.

- Krishi Dham Expo Meerut organized by SVBP University of Agri. & Technology, Meerut during 12th -14th October, 2018.
- Krishi Pardarshini evam Kisan Mela Meerut on December 23rd, 2018 organized by Joint Director Agri. Meerut Mandal, Meerut.
- Krsihi Pardarshini evam Kisan Gosthi at village Godikhata district Haridwar (Uttrakhand) on February 23rd, 2019 organized by ICAR-IIFSR, Modipuram.
- Agriculture Science Congress Expo-2019 at Pusa, New Delhi during 20th – 23rd February, 2019.
- Pusa Krishi Vigyan Mela- 2019 at ICAR-IARI, Pusa, New Delhi from 5th -7th March, 2019.

Demonstrations

25 FLDs on varietal performance and scientific seed production were laid out in different districts of UP.

World Soil Day celebration

World Soil Day was celebrated on December 05th, 2018 at ICAR-CPRI, RS, Modipuram.

Phones attended at Kisan call centre

A total of 200 quarries of potato growers on various aspects from various districts of Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat, Punjab, Uttarakhand, Delhi and Haryana states answered through phone.

Visitors

Total of 465 visitors which include farmers, students, extension officers, etc. from various states visited the station.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, PATNA

Training Programmes

Table 5: Details of training programme organized at ICAR-CPRI, RS, Patna

S. No.	Title	Venue	Date	No. of Beneficiaries
1.	Scientific potato seed production for farmers	KVK, Piprakothi, Motihari	October 28, 2019	500
2.	Scientific potato cultivation to Samridhi Krishak of Mahuava, Motihari & Sitamarhi districts of Bihar	Mahuava, Motihari	December 28, 2018	35
3.	Scientific potato cultivation for DT/BT trainees	ICAR-CPRS, Patna	January 07, 2019	26
4.	Scientific potato cultivation to the Nalanda farmers	ICAR-CPRS, Patna	January 14, 2019	22
5.	Scientific potato cultivation to the Bhsari farmers of Begusarai district of Bihar	ICAR-CPRS, Patna	January 18, 2019	48
6.	Scientific potato cultivation to the students of JD Women's college, Patna	ICAR-CPRS, Patna	February 07, 2019	35

Kisan Melas/Exhibitions

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

- State Agriculture fair organized from April 13^{th} – 15^{th}, 2018 at Zila School Maidan, Motihari.
- Pashu Arogya Mela from December 23^{rd}-25^{th}, 2018 at KVK, Piprakothi, Motihari.
- Krishi Kumbh-2019 from February 9^{th} – 11^{th}, 2019 at Gandhi Maidan, Motihari.
- Bihar Kisan Mela-2019 from February 23^{rd}- 25^{th}, 2019 at BAU, Sabour, Bhagalpur.
- Purvanchal Kisan Mela from March 2^{nd} – 3^{rd}, 2019 at Mahayogi Gorakhnath KVK, Gorakhpur.

Demonstrations

425 FLDs for popularization of improved varieties and scientific potato seed production were laid out in various districts of Bihar.

Awaerness Programmes

Awareness programme on NHB's schemes and vegetable seed production specially potato seed and scope of processed vegetable products was organized on on February 23, 2019 at ICAR- CPRS, Patna.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, JALANDHAR

Training Programmes

S. No.	Title of the training	Venue	Date and duration	No. of beneficiaries
1.	Agri-business opportunities in potato seed production	ICAR-CPRS, Jalandhar	May 17, 2018	60
2.	Mini tuber production through Aeroponics	ICAR-CPRS, Jalandhar	Jun 25-26, 2018	6
3.	Aeroponics for seed potato production	ICAR-CPRS, Jalandhar	September 25, 2018	20
4.	Soil Sampling Techniques to Field Officers	ICAR-CPRS, Jalandhar	March 08, 2019	2
5.	Training on mobile App "Plant Village Nuru" to registered farmers	ICAR-CPRS, Jalandhar	December 23, 2018	10

Awareness Programmes

S. No.	Title of the awareness programmes	Date and duration	No. of beneficiaries
1.	Agri-business opportunities in potato seed production	May 17, 2018	60
2.	Mini tuber production through Aeroponics	Jun 25-26, 2018	6

Participations in Kisan Mela/ Exhibitions

- Exhibition/Technology showcase stall in Kisan Mela "Crop residue management" on February 22nd, 2019 at KVK, Nurmahal.
- Exhibition/Technology showcase stall in Kisan Mela organized by JPGA on September 5th -6th, 2019 at Jalandhar.
- Exhibition/Technology showcase stall in Indian Science Congress – 2019 from January 3rd -7th, 2019 at Lovely Professional University, Jalandhar.

Demonstrations

For popularizing the improved variety cv. Kufri Khyati in aspirational district Moga, Punjab, eight FLDs were laid out in five villages.

Visitors

A total of 550 visitors included students from different states, scientists/professors/teachers, farmers and extension workers etc. were made aware about various activities and technologies of the institute.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, GWALIOR

Trainings

Three day training for 50 farmers was organized at ICAR-CPRI, RS, Gwalior from February, 17^{th}-19^{th}, 2019.

Demonstrations

20 FLDs (10 each Guna district of Madhya Pradesh and Mathura district of UP) for showing the superiority of Kufri Sindhuri over local varieties were laid out at farmers' fields in.

Visitors

A total of 1395 farmers including the female farmers from various parts of the state visited the station. They were exposed to various new scientific methods to be used at station in potato cultivation and healthy seed production methods.

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, OOTY

Exhibitions

ICAR-CPRI, RS, Ooty participated in the following exhibition during the year 2018-19.

- Flower Show at Botanical Garden Ooty from May 18^{th} – 22^{nd}, 2018 organized by TamilNadu State Department of Horticulture.
- Kisan Samridhhi Mela on January 07th, 2019 organized by ICAR-SBI, Coimbatore (TN).
- 49^{th} State Varietal Research Committee meeting, Chennai on January 7^{th} , 2019.
- National Horticulture fair 2019 from January 23^{rd}–25^{th}, 2019 organised by ICAR-IIHR, Bengaluru, Karnataka.
- Radio Astronomy Centre, TIFR, Muthorai, Ooty on February 20^{th}, 2019.

MGMG activities

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.

Visitors

A total of 1100 visitors from various states of the country where acquainted with the various techniques and methods to be followed by the stations for healthy potato cultivation and answered to various questions and queries raised by the visitors.

EXTENSION ACTIVITIES AT ICAR-CPRS, RS, SHILLONG

Exhibitions

Participated in vegetable and indigenous fruit show on 4^{th} October, 2018 at All Saints Cathedral Hall, Shillong.

Trainings

One Day training on "Value addition in Potato" was conducted at Thangsning village, East Khasi Hills, Meghalaya on 29^{th} November, 2018.

Demonstrations

Thirty FLDs were laid out in East Khasi Hills district of Meghalaya on improved potato cultivation method "Ridge and furrow method of planting" was using improved potato varieties, Kufri Himalini and Kufri Girdhari.

Visitors

A total of 200 visitors visited the station during the period under report, which includes students, farmers, state Agriculture/Horticulture officers and foreign visitors (CIP).

EXTENSION ACTIVITIES AT ICAR-CPRI, RS, KUFRI

Visitors

1527 visitors which included 1423 students, 86 farmers and 18 officials visited the station in connection with the study tours of students, exposure visits of farmers and officials from the Agri./Hort. departments.

LIBRARY AND DOCUMENT SERVICES

Introduction

In accordance of one of the ICAR-CPRI mandate "To act as national repository of scientific information relevant to potato" ICAR-CPRI Library and Documentation Services unit was established in 1956 with a modest collection of 256 documents. Presently this library stacked more than 67 thousands documents and has attained the position of most sought-after library on potato R & D in India. Since its inception this library has acted as repository and clearinghouse of potato literature and information. It continually provided scientific and technical information supports and services towards attainment of research mission of the institute. Efforts were made for strengthening and developing the information resources and services through undertaking various activities given here below:

Resource Development

At the headquarter (Shimla), a total of 157 documents were purchased, procured and added to library resources. The total collection at Shimla stand at 39900 documents comprised of 16374 books, 15780 back volume of journals, 2746 serials, 2254 annual reports, 583 theses, 251 standards, 51 maps/atlases, 1663 reprints and 198 CD's. The libraries at six regional stations and one campus at Modipuram are having their own library collection of 27814 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 ICAR-CPRI & Regional Stations

Regional Stations		Books	Back vols. of Journals	Other Documents (AR/Rpr/Bull)	Total	Current Journals subscribed (Indian)
1	CPRIC, Modipuram	4651	5951	2557	13159	06
2	CPRS, Jalandhar	3315	1591	452	5358	03
3	CPRS, Patna*	2092	1280		3372	4
4	CPRS, Gwalior	1187	4	73	1264	-
5	CPRS, Ooty	1670	580	560	2810	09
6	CPRS, Shillong	1540	-	167	1707	-
7	CPRS, Kufri	144	-	-	144	
	TOTAL	14599	9406	3809	27814	22

Periodicals and Serials Management

Eleven serials title i.e. advances, annual reviews, reference annuals, yearbooks and statistical data publications etc. were purchased. A total of 126 current journals comprising of 21 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 25 on exchange or gratis. In all 855 issues of such journals were received, marked and kept in library for use. Besides, 22 titles of different journals were subscribed at CPRS libraries. 67 books were classified, catalogued, labeled, pasted and transcribed and entered in Library Automation Software for use. The library has the complete series of CABCD and ISA databases for retrospective and current scientific literature search and use of scientists.

Computerized & Net Based Services

The institute scientists were facilitated with full text access to 5 online databases, 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.

Readers and Reference Service

A total of 914 documents were circulated (borrowed and returned) for home studies and 7235 readers consulted 9821 documents within the library. Besides, 15 outside scientists and research scholars of various research organizations consulted the library resources. 3 new members were enrolled and 5 old members withdrew their library membership due to their transfer or retirement. At present 130 readers are active members of library including RAs/SRAs. Library received 10483 reference queries from the users of the library and responded to them satisfactorily. Besides, 219 job requests were received for 1,22,464 copies of photocopying and printing work of different scientific and administrative documents.

Documentation and Information Services

855 issues of journals (692 issues of national and 163 issues of international journals) were scanned for potato literature and 297 potato articles were found and recorded. Approximately, 157 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 3480 content pages of 870 potato books were scanned for integrating into institute OPAC and approximately 1,13,516 potato references searched, downloaded and supplied to scientists in response to their literature search requests.

Resource Generation and Utilization

The library has generated the revenue of ₹ 94,384.00 which includes the amount charged on account of rendering CDROM searching & photocopying (₹ 5,128.00), IGNOU computer practical (₹ 21,900.00) and library discount (₹ 67,356.00) in addition to normal 10% GOC discount saved on purchase of library books and journals through ICAR-CPRI Book store. A total of ₹ 10,63,014.00 was spent on purchase of library resources like books (₹ 4,19,201.00), and subscription of journals (₹ 6,43,813.00) at HQ library Shimla and ₹ 1,36,986.00 on ICAR-CPRI, RS, libraries.

CDS/ISIS Practical Training

As per MOU between ICAR-CPRI and IGNOU, New Delhi, 21 days computer, IT, and database creation and operation practical session was organized during 14th July-3rd August, 2018 for 4 MLIS and 12 BLIS students of IGNOU Study Center, Shimla.

PUBLICATIONS

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93. रविन्द्र कुमार, संजीव शर्मा, एस॰ के॰ चक्रबर्ती (2018) बीज आलू के अवनति (degeneration) के लिए उत्तरदायी प्रमुख विषाणु एवं उनसे बचाव के उपाय (प्रसार पुस्तिका). भा.कृ.अनु.प.–केन्द्रीय आलू अनुसंधान संस्थान, शिमला.

94. राजेश कुमार सिंह, एन के पाण्डेय, एस के चक्रबर्ती, जगेश तिवारी, तनुजा बक्सेठ, मु सदावर्ती (2018) बीज़ आलू ग्राम का विकासः संस्थान का एक प्रयास। प्रसार पुस्तिका सं 101. भा.कृ.अनु.प.–केन्द्रीय आलू अनुसंधान संस्थान, शिमला.

95. राजेश कुमार सिंह, तनुजा बक्सेठ, स्वरूप कुमार चक्रबर्ती (2018) जलवायु परिवर्तन के तहत पहाड़ी क्षेत्रों में आलू उत्पादन की आधुनिक तकनीके संगोष्ठी। बदलती जलवायु में उच्च तकनीकी पर्वतीय बागवानी के उभरते रुझान, राष्ट्रीय शीतोषण बागवानी संस्थान क्षेत्रीय केंद्र, मुक्तेश्वर नैनीताल उत्तराखंड, पृ सं 72–74।

96. विजय किशोर गुप्ता, बन्दना (2018) ग्रामीण परिवेश हेतु आलू आधारित कुटीर उद्योग। आलू की समस्याएँ और वैज्ञानिक समाधान। आकाशवाणी, नई दिल्ली द्वारा फोन–इन प्रोग्रामः आलू कृषि पाठ शाला के अंतग्रत प्रसारित प्रशनोतरी का संकलन. प्रसार पुस्तिका संख्या 110। पृष्ठ संख्या 91–95।

97. विजय किशोर गुप्ता, मेही लाल (2018) भोज्य एवं प्रसंकरण योग्य आलू उत्पादन की उन्नत विधिया, स्मसयाए और समाधान। आलू की समस्यायें और वैज्ञानिक समाधान। (आकाशवाणी, नई दिल्ली द्वारा फोन–इन–प्रोग्रामः आलू कृषि पाठशाला के अर्न्तगत प्रसारित प्रश्नोत्तरी का संकलन मनोज कुमार, कमलेश मलिक, विजय किशोर गुप्ता, एन के पाण्डेय एवं एस के चक्रवर्ती) आजाद ऑफसेट प्रिंटर चंडीगढ़, पृ सं 52–56।

98. संजय रावल, पूजा मानकर, विजय कुमार दुआ, शिव प्रताप सिंग, स्वरूप कुमार चक्रवर्ती (2018) आलू की फसल में खरपतवार नियंत्रण. प्रसार पुस्तिका. भा.कृ अनु.प.–केंद्रीय आलू अनुसंधान संस्थान, शिमला.

99. संजीव शर्मा, रविन्द्र कुमार, विनय सागर, कैलाश चन्द्र नागा, एस॰ के॰ चक्रबर्ती (2018) आलू में लगने वाले रोगों एवं कीटों की रोकथाम, प्रसार पुस्तिका. भा.कृअनु.प.–केंद्रीय आलू अनुसंधान संस्थान, शिमला.

100. सुगनी देवी, रत्ना प्रीती कौर, एके सिंह, आरके सिंह (2019) आलू बीज उत्पादन में उपयोगी नेट हाउस। फल–फूल, जनवरी–फरवरी 2019, प्र.सं. 14–16.

In addition, Abstracts published in seminar /symposia proceedings etc. and sequences submitted to NCBI are about 58.

INSTITUTE ACTIVITIES

Celebration of National Potato Day and Krishidham Expo-2019

In the direction of increasing farmers' income by the use of advanced farming techniques, ICAR-CPRI and Indian Potato Association celebrated National Potato Day and Krishidham Expo-2019 from 15-17 Feb. 2019 at CPRI RS Modipuram. Various events like Agriculture exhibition, Potato dish making competition, Kufri Jyoti- Golden Jubilee celebration, session on "World without potato", Potato pride prize distribution and sugarcane convention organized during this programme.

Dr. AK Singh, Deputy Director General (Hort. Sci.) was the Chief Guest of the opening ceremony. Dr. SM Paul Khurana and Dr. BP Singh, Former Directors of ICAR-CPRI, Shimla and Dr. S Mohanty, Regional Director, CIP, New Delhi were the Guest of Honour. Dr. SK Chakrabarti, Director, ICAR-CPRI, Shimla welcomed all the dignitaries and briefed them about the recent developments in the field of Potato. Dr. AK Singh, in his address, stressed upon beating China and making India No.1 World Potato Producing country and also improving the quality of potatoes and making it profitable crop for farmers. Winners of various events were also felicitated during this event.

Seed Village Workshop in East Champaran, Bihar

ICAR-CPRI, Shimla organized a one-day workshop for establishment of potato seed villages on 28th October 2018 in Krishi Vigyan Kendra, Piprakothi, East Champaran, Bihar.

Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers' Welfare was the Chief Guest of the function and launched the development of potato seed villages. About 550 farmers participated in the workshop. In his address, Shri Radha Mohan Singh gave special emphasis on how to double the farmers' income. Shri Pramod Kumar, Hon'ble Minister of Tourism, Government of Bihar was also present as a special guest and addressed the gathering. Dr. SK Chakraborty, Director, Central Potato Research Institute gave the welcome speech and discussed about the objectives of the workshop and how to establish seed villages in a phased manner. During the technical session, the detailed discussion on how to develop seed villages and role of farmers in it was coordinated by the multidisciplinary team of scientists of the institute.

ICAR-CPRI Celebrated its 70th Foundation Day

ICAR-CPRI Shimla Celebrated its 70th Foundation day on 5th October, 2018 and Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers' Welfare was the Chief Guest of this event. On this occasion, Hon'ble Agriculture minister of Himachal Pradesh, Dr. Ramlal Markande, Hon'ble Horticulture minister of Himachal Pradesh, Sh. Mahender Singh Thakur and Professor Ashok Kumar Sarial, Vice-Chancellor, CSK H.P. Agriculture University, Palampur were also present as the special guests.

During the event, awards were given to all categories of staffs of the institute and progressive farmers of Himachal Pradesh. The new logo of the institute was also launched along with some publications of the institute. Three newly released varieties, namely, Kufri Lima, Kufri Ganga and Kufri Neelkanth were devoted to the country. During the foundation day, institute organized an exhibition which was inaugurated by Hon'ble Agriculture and Farmers' Welfare minister. Other ICAR institutes like IARI's Regional Station (Shimla), IIWBR's Regional Station (Shimla) and NBPGR's Regional Station (Shimla) in Himachal Pradesh also exhibited their technologies during the event.

Live Webcast/Telecast of Inauguration of PM-KISAN at ICAR-CPRI, Shimla

On 24th February, 2019, ICAR-CPRI organised a live telecast programme for farmers on the inauguration of "Pradhan Mantri Kisan Samman Nidhi Yojana" by the Prime minister of India. The programme was telecasted live in the conference hall of the institute. The Deputy Mayor of Shimla MC, Sh. Rakesh Sharma was the chief guest of the function along with Smt. Brij Bala Sood, Councillor, Kanlog ward and Smt. Asha Kashyap, President Mahila Mandal also participated in the programme.

The programme was attended by 90 farmers of district Shimla. The acting director of CPRI Dr. VK Dua, Chief Administrative Officer, Sh. Ratnesh Kumar, Dr. NK Pandey, Head and Sh. P. Kharumnuid, Scientist, Division of Social Sciences presided over the programme.

International Training on Hi-tech Potato Seed Production

Five days training programme was organized by ICAR-CPRI Shimla in collaboration with International Potato Center (CIP) for scientists of Nepal during 18–22th June, 2018.

The objective of the training programme was to enhance the knowledge and skills of the trainees on different aspects of seed potato production with special reference to hi-tech system. Lecture-cum-discussion, video shows, demonstrations, practical exercises, field and lab visit, etc. were the modes for imparting training to the participants.

Stakeholders Meet for Identification of Potato Export Zones

Stakeholders meet on identification of potato export zones in Punjab, Madhya Pradesh and Gujarat for producing export quality potatoes was organised under the Chairmanship of Dr. AK Singh, Deputy Director General (HS) on April 21, 2018 at NASC Complex, New Delhi.

Many scientists and experts from ICAR headquarter, ICAR-CPRI, Shimla, ICAR-NBPGR, New Delhi, DPPQ&S, Faridabad, APEDA, New Delhi, AICRP(P), Deesa, Gujarat, Directorate of Horticulture of Gujarat, Punjab and Madhya Pradesh; representatives from seed and processing industries like Mahindra HZPC, Pepsico Holdings, ITC, Bhatti Agritech, SK International, Ahmedabad, Gujarat participated in the meet. The roadmap for identification of districts for producing export quality potatoes in the states of Punjab, Madhya Pradesh, Gujarat, Rajasthan and Uttar Pradesh was discussed. A megaproject would be prepared by ICAR-CPRI, Shimla for funding from APEDA involving Directorates of Horticulture and SAUs of above mentioned states. It was also decided that review meetings would be held after every two months.

ICAR- CPRI Celebrated Fourth International Yoga Day

The 4th International Yoga Day was celebrated on 21st June 2018 at ICAR- Central Potato Research Institute, Shimla. The Aasans, Pranayam and Dhyan of Yoga were demonstrated by learned and experienced Art of Living teachers Ms. Dhara Saraswati Ji and Shri Abhay Sharma Ji, and practiced by all staff member and research scholars of the institute. The aasans performed included Trikonasan, Salabhasan, Bhujangasan, Dhanurasan, Nokasan, Suryanamaskar, Natarajasan, Savasan, etc. The Pranayam performed included Anulom-vilom and Bhramari. Also, a session on Meditation (Dhyan) was conducted.

The yoga teachers also explained beneficial effects of all the demonstrated Aasans, Pranayam and Dhyan techniques. While sharing their experiences, all the participants told that after the yoga session they felt very happy and found their minds calm and at peace. The director thanked the teachers and the participants. Simultaneously, the yoga day was also celebrated at all the regional stations of ICAR-CPRI, Shimla.

One-day Workshop on "Aeroponics for Seed Potato Production" at ICAR-CPRI, RS, Jalandhar

Agri-business Incubator, ICAR-CPRI, RS, Jalandhar, Punjab organized one-day workshop on "Aeroponics for seed potato production" on September 25th 2018. The purpose of this workshop was to update the incubates/licensed holders about the recent up gradations in CPRI-Aeroponics Technology. Dr Satvir Singh, Deputy Director Horticulture, Jalandhar, Punjab was the chief guest and Dr Balwinder Singh, Project Officer, Centre of Excellence for citrus was guest of honour in the inaugural session. The Chief Guests applauded the constant efforts and contribution of the Central Potato Research Institute in developing technology for production of seed potato production through aeroponics.

About 20 representatives of license holding companies from Punjab and Haryana participated in this event and took advantage of the information exchanged by the subject experts regarding efficient use of CPRI-Aerponic Technology for production seed potato.

Visit of Shri Chhabilendra Roul, Special Secretary, DARE & Secretary, ICAR to ICAR-CPRI, Shimla

Shri Chhabilendra Roul, Special Secretary, DARE & Secretary, ICAR visited ICAR-CPRI, Shimla on 18-19th August, 2018. In the morning of 18th August, he visited the breeder seed production farm at Kufri/Fagu including the National Hybridization Facility & the Lister House, and interacted with the staff of the station.

During the interaction he suggested that for the benefit of farmers, there is need to develop short duration processing potato varieties which can compete with exotic processing varieties being imported by the multinationals.

In the afternoon, he chaired a meeting of Senior Officers of the institute and regional stations of other sister institutes of ICAR at Shimla wherein Dr. S. K. Chakrabarti, Director, ICAR-CPRI, Shimla made a brief presentation on 'Potato Research in India'.

Institute Research Council (IRC) Meeting

The Institute Research Council (IRC) Meeting of the year 2018 was held during 26-28th July, 2018 at ICAR–CPRI, Shimla.

This meeting was attended by 60 scientists from Headquarters and its regional stations.

A thorough discussion was held on the last year's recommendations and work done during the year. Work plan for next year i.e. 2018-19 were also finalized in this meeting.

25th Research Advisory Committee Meeting 2018

The twenty fifth meeting of the Research Advisory Committee (RAC) was held at the ICAR-Central Potato Research Institute, Shimla during 29-30 November, 2018 under the chairmanship of Dr. PL Gautam, Vice Chancellor, Career Point University, Hamirpur. RAC members Dr. SK Pandey, Ex. Director ICAR-CPRI, Dr. MS Palaniswami, Former Project Coordinator, AICRP on Tuber Crops, ICAR-CTCRI, Thiruvanthapuram, Dr. PK Mahapatra, Ex. Dean, Orissa University of Agriculture & Technology, Bhubaneshwar, Dr. C. Vishwanathan, Head, Plant Physiology, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi and Shri Rajesh Garg, non- official member attended the meeting.

Director, ICAR-Central Potato Research Institute, Shimla, Programme Leaders, Heads of Divisions and all the scientists from Headquarters also participated in the meeting. Chairman, Dr. PL

Gautam, showed satisfaction over the fact that Institute responded to 90-100% on the last year's meeting decisions. He also emphasized that every technology generated in the Institute should end up in the fields. The progress of ongoing 11 programmes was reviewed and work plan for the next year was also discussed.

Hindi Divas Celebration

ICAR-CPRI, Shimla celebrated Hindi Divas 2018 on 14th September, 2018 in the institute auditorium. Dr. Swarup Kumar Chakrabarti, Director of the institute grace the occasion as Chief Guest of the function.

The Chief Guest on his address congratulated the staffs and officers of the institute for their continued efforts to continuously making progress in Hindi usage and appeals them to not only sustain this progress but also take to a new height. He also appeals the staff members to participate with the great enthusiasm in the different Hindi competitions/events proposed to be organized in ensuing Hindi Divas celebrations during 14-28th September, 2018. The Chief Administrative Officer of the institute in his address mentioned that all sections of administrations are doing all noting/ drafting works in Hindi which is commendable step. He expressed his hope that institute will shortly achieve the target of Hindi usage set by the Department of Official Language, Ministry of Home Affairs, Govt. of India.

Cleanliness Drive under Mera Gaon Mera Gaurav

As a part of the Swachhata Pakhwada celebration of the institute, a one day cleanliness drive was organized under Mera Gaon Mera Gaurav Programme on December 28, 2018 in the selected villages of Cheog Panchayat, Shimla (Himachal Pradesh). During this event, school children of Government High School, Cheog, staffs of the institute, farmers and residents of the villages were actively involved in cleaning the school and the market surroundings.

Dr. NK Pandey, Principal scientist and Head of the Division of Social Sciences sensitized all participants about the objectives and importance of Swachhata Pakhwada and motivated them to take cleanliness activities as their daily routine.

Rashtriya Ekta Diwas Celebrated at ICAR-CPRI, Shimla and Regional Stations

On the eve of birthday of Indian Ironman Sh. Vallabh Bhai Patel, National Ekta Diwas was celebrated at ICAR-CPRI, Shimla and its regional stations on 31st October, 2018. In this occasion, Rashtriya Ekta Pledge ceremony was organized and all staff members took pledge to be united and to make all possible efforts towards National integration.

Vigilance Awareness Week Observed

Vigilance awareness week was observed at ICAR-CPRI, Shimla and its regional stations from 29th October to 3rd Nov. 2018. On the first day *i.e.* on 29th October, 2018, 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 was organized at ICAR-CPRI, Shimla and lectures on "My Vision– Corruption free India" were delivered to the staffs.

Celebration of World Soil Day

World soil day celebrated on 5th December, 2018 at ICAR-CPRI, RS, Modipuram. On this occasion, a farmers' forum (Kisan Goshti) on the topic "Importance of Soil health and advanced potato farming" was organized, in which 84 farmers participated. Prof. Gaya Prasad, Vice Chancellor, SVPUAT, Meerut graced this occasion as the chief guest of the function whereas Dr. NC Upadhayay, Formar Principal Scientist was the Guest of honour. During the programme, experts detailed about the importance of soil health and its conservation

Awareness Programme on New Value-added Potato Products at ICAR-CPRI, RS, Jalandhar

Agri-business Incubator of Central Potato Research Institute organized an awareness programme on new value-added products from potato developed by the institute at its one of the regional stations situated at Jalandhar on 12th March, 2019. The main emphasis of this program was to create an awareness about the significance and possible business opportunities in new value-added products from potato developed by the CPRI, which includes gluten-free potato cookies, fasting friendly cookies, low sodium cookies, fasting friendly potato Daliya, semolina, and low-fat halwa premix. These products may reduce the post-harvest loses and situation of glut in potatoes. Farmers, food processing entrepreneurs, bakery owners from different states of India and students participated in this programme.

Training Programme on "Office Procedure & Etiquettes" Organized at Gwalior

A three day training programme was arranged for 30 skilled supporting staffs of ICAR CPRS, Gwalior on topic "office procedure & etiquettes" The programme was inaugurated by Head ICAR CPRS, Gwalior on 25th March, 2019. Lectures were given by faculty members from CPRI and its regional stations on different aspects of office procedure *viz.* how to apply for leave, RTI rules, Personal Asset management, File management, Importance of cleanliness etc. On 27-03-2019, tour programme was arranged for 30 trainee staff at IISWC, Regional Station at Agra where SSS were made aware about different aspects of soil and water conservation. Certificates were distributed to the every Staff for their active participation in the programme.

Farmers' Day in Aspirational District Balrampur of Uttar Pradesh

Under the Kisan Kalyan campaign, the 'Farmers' Day' on improved technologies of potato production was organised in Bhaggaor village of the aspirational district Balrampur of Uttar Pradesh on 15th January, 2019. The latest varieties of potato developed by the institute were demonstrated on 6 farming fields in this village. On this occasion Dr. Manoj Kumar, Joint Director and Dr. Anuj Bhatnagar, Principal Scientist and

In-charge Krishi Vigyan Kendra, Balrampur and subject matter specialists were present. Fifty farmers took part in this event.

Scientists visited the potato and vegetables field of the farmers and discussed about various problems of the farmers and gave solutions on the spot.

Town Official Language Implementation Committee (TOLIC), Shimla

Town Official Language Implementation Committee (TOLIC), Shimla held its sixth monthly meeting in the institute auditorium on 13.2.2019. Thereafter three years Annual Official Language function for the year 2015-16, 2016-17 and 2017-18 celebrated and prize distribution thereof took place. ICAR-Central Potato Research Institute won 3rd prize among the Central Govt. big offices of North Zone for the year 2017-18 for best implementing and disposal of Official Language Policy and Rajbhasha works. Institute also won the 3rd prize for the year 2015-16; 2nd prize for the year 2016-17 and 1st prize for the year 2017-18 for the best implementation of Official language policy and disposal of Rajbhasha works from the Central Govt. offices of TOLIC, Shimla. TOLIC, Shimla honored the institute with Rajbhasha Samman Puruskar for winning 3rd prize among the Central Govt's big offices of North Zone for the year 2017-18.

International Women's Day Celebration at ICAR-CPRI, Shimla

The ICAR-Central Potato Research Institute, Shimla organised "International Women's Day" on 8th March, 2019.

The whole CPRI staff attended the live telecast speech of Hon'ble Prime Minister on the "International Women's Day" from Varanasi (UP). In his inaugural address, Dr. Swarup K. Chakrabarti, Director, ICAR-CPRI, Shimla briefed the staff about the history of International Women's Day and emphasised on women empowerment and necessity for development of the country. He asserted on the current year theme of International Women's Day: Think Equal, Build Smart, Innovate for Change.

Hon'ble Union Minister of Agriculture and Farmers' Welfare Visited Exhibition Stall of ICAR-CPRI

ICAR-CPRI, Regional Station, Patna participated and put up an exhibition stall during Purvanchal Kisan Mela at Mahayogi Gorakhnath KVK, Gorakhpur during 02 to 03 March, 2019. The function was inaugurated by Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers' Welfare. He and other VIPs visited the stall of institute and interacted with staffs of the institute about various technologies developed by the institute like potato varieties, processed products, True Potato Seeds (TPS), etc. A large number of farmers also visited the stall and they were made aware about various technologies for scientific potato cultivation.

TRAINING AND CAPACITY BUILDING

TRAINING AND CAPACITY BUILDING PROGRAMMES ATTENDED BY SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE STAFF OF ICAR-CPRI, SHIMLA DURING 2018-19

Sl. No.	Name of staffs	Name of Training Programme	Date and Venue
	A. Scientific Staffs		
1.	Dr. Manoj Kumar	MDP on leadership development	June 04-15, 2018 at ICAR-NAARM, Hyderabad
2.	Dr. Jagdev Sharma	Advances in micro irrigation for enhancing crop and water productivity in water scarce areas	Dec 03-12, 2018 at CSKHPKV, Palampur
3.	Dr. Jagesh Kumar Tiwari	Modern statistical techniques in genetics at IASRI, New Delhi	Feb 1-21, 2019 at ICAR-IASRI, New Delhi
4.	Dr. Baswaraj Raigond	Recent advances in diagnosis and management of emerging diseases of field crops, horticulture and medicinal plants	Dec 07-27, 2018 at COA, UAS, Dharwad
5.	Dr. Kailash Chandra Naga	Pest risk analysis	Dec 17-21, 2018 at NIPHM, Hyderabad
6.	Mr. Pynbianglang Kharumnuid	Recent trends in data analytics & knowledge management	Sep 6-26, 2018 at ICAR-IASRI, New Delhi
7.	Dr. (Mrs.) Pinky Raigond	Alternatives to experimental animal models to validate potential bioactives for sttudying diabtetes, obseity & cancer.	Feb 18-22, 2018 at CSIR-CFTRI, Mysore
8.	Dr. Mehi Lal	Recent trends in plant microbes interaction	Nov 27-Dec 17, 2018 at TNAU, Coimbatore
9.	Dr. (Mrs.) Bandana	Emerging post harvest engineering and technological intervention for enhancing farmers income	Sep 04-24, 2018 at ICAR-CIPHET, Ludhiana
10.	Dr. Ratna Preeti Kaur	Biotic and abiotic stress resistance breeding strategies in vegetable crops to enhance farmers income	Dec 03-12, 2018 at TNAU, Coimbatore
11.	Dr. Sugani Devi	Crop diversification for resilience in agriculture and doubling farmers' income.	Jan 25- Feb 3, 2019 at ICAR-IARI, New Delhi
12.	Dr. Clarissa Challam	Next- generation sequencing and its applications in plant sciences	Aug 28-Oct 18, 2018 at ICAR-NRCPB, New Delhi
13.	Dr. Shashi Rawat	Advances in web and mobile applications development	Dec 05-10, 2018 at ICAR-NAARM, Hyderabad
14.	Mr. Paresh Baldeorao Chaukhande	Geographical anaysis using QGIS and R.	Feb 01-06, 2019 at ICAR-NAARM, HyderabFad

Sl. No.	Name of staffs	Name of Training Programme	Date and Venue
	A. Scientific Staffs		
15.	Mr. Paresh Baldeorao Chaukhande	Assessment of vulnerability and adaptation to climate change in agriculture	28 Nov- 07 Dec, 2018 at ICAR-CRIDA, Hyderabad.
16.	Dr. Pooja Praful Mankar	Good agriculture practices for doubling farmers income and enhanced resource use efficiency	Dec 11-31, 2018 at ICAR-IARI, New Delhi
17.	Dr. Brajesh Singh	Priority setting, monitoring and evaluation of agriculture reseach projects	Dec 17-22, 2018 at ICAR-NAARM, Hyderabad
18.	Dr. Brajesh Singh	Training workshop of vigilance officers	Oct 31- Nov 1, 2018 at NAARM, Hyderabad
19.	Dr. Brajesh Singh	Managing technology value chains	Sep 3-7, 2018 at ASCI, Hyderabad
20.	Dr. NK Pandey	Stress management	Sep17-20, 2018 ICAR-NAARM, Hyderabad
21.	Dr. Janani, P	Positive selection for improving quality of farm-saved seed potato in Meghalaya	6 th December 2018 at MBDA Head Quarter, Nongrim Hills, Shillong
22.	Dr. Janani, P	District stakeholders workshop on Meghalaya livehoods access to markets (MLAMP)	28 th September 2018 at basin development unit, East Khasihills, Shillong
23.	Dr. Devendra Kumar	PRD (Partial Root Drying-zone) technology	PTC, Karnal, Haryana on October 8, 2018
24.	Sh. Milan Kumar Lal	Studies on understanding the starch metabolism, resistant starch and glycemic index in potato	ICAR- NRRI, Cuttack, 19th Nov 2018 to 17th Feb 2019
	B. Technical Staffs		
1.	Sh. Rakesh Mani Sharma	KOHA for library staffs of ICAR	Feb 21-26, 2019 at ICAR-NAARM, Hyderabad
2.	Sh. Rakesh Srivastava	MS-Excel (Advanced)	Mar 18-19, 2019 at ISTM, New Delhi
3.	Sh. Pushpendar Kumar	Seed health testing and molecular diagnostic techniques	Sep 24-28, 2018 at 2018 at NIPHM, Hyderabad
4.	Sh. Tilak Raj	Regional plant health system analysis	Nov 26-Dec 10, 2018 at NIPHM, Hyderabad
5.	Sh. Arun Kumar Singh	Identification of insect pests, pesticides application techniques, pesticide residue analysis	Nov 26-30, 2018 at NIPHM, Hyderabad
6.	Sh. Sushil Kumar	Good agricultural practices (GAP)	Oct 22-26, 2018 at NIPHM, Hyderabad
7.	Sh. Udaivir Singh	Identification of insect pests, pesticides application techniques, pesticide residue analysis	Feb 25–Mar 01, 2019 at NIPHM, Hyderabad
8.	Sh. Syed Danish Abbas Rizvi	Advances in integrated weed management	Nov 12-16, 2018 at NIPHM, Hyderabad

	B. Technical Staffs		
9.	Sh. Vinod Kumar	Post-harvest management and storage techniques-value addition	Jan 07-11, 2019 at NIPHM, Hyderabad
10.	Sh. Yogesh Kumar Gupta	Post-harvesting management and storage techniques, value addition	June 25-29 at NIPHM, Hyderabad
11.	Sh. Dharminder Kumar Gupta	New media for aagricultural extension	July 09-13, 2018 at MANAGE, Hyderabad
12.	Sh. Sanjay Kumar Sharma	Motivation, positive thinking and communication skills for technical officers	June 21-27, 2018 at ICAR-NAARM, Hyderabad
13.	Sh. Ajit Singh Bhatia	Motivation, positive thinking and communication skills	4-10 Oct, 2018 at ICAR-NAARM, Hyderabad
14.	Sh. Naresh Chand Sharma	Recent innovation in seed quality enhancement for production in quality seed production	Feb 28-Jan 1, 2019 at UAS, Raichur
15.	Sh. Ranjesh Bhardwaj	Pre and Post harvest management techniques for seed quality assurance	Feb 5-9, 2019 at NSRTC, Varanasi
16.	Sh. Krishan Pal Singh	Seed health testing and molecular diagnostic techniques	Sep 24-28, 2018 at NIPHM, Hyderabad
17.	Sh. Naresh Kumar Sharma	Farm Management	
18.	Smt. Kusum Singh	KOHA for library staffs of ICAR	Feb 21-26, 2019 at ICAR-NAARM, Hyderabad
19.	Sh. Nihal Singh	Auto mobile maintenance	Feb 19-25, 2019 at ICAR-CIAE, Bhopal
20.	Sh. Radha Kishan	Auto mobile maintenance	Feb 19-25, 2019 at ICAR-CIAE, Bhopal
21.	Shyam Kumar Gupta	Motivation, positive thinking and communication skills	
	C. Administrative Staffs		
1.	Smt. Babli Bhawani	Establishment and financial matters	July 5-10, 2018 at ICAR-NAARM, Hyderabad
2.	Ms. Prawartika Das	Refresher course on administration and finance management	Dec 10-14, 2018 at ICAR-NAARM, Hyderabad
3.	Smt. Shashi Bala Thakur	Enhancing efficiency and behavioural skills of stenographers grade - III, PSs and PPSs of ICAR HQs/ Institutes	Sep 24-29, 2018 at ICAR-NAARM, Hyderabad
4.	Sh. Amar Chand	Training on GST	Sep 26-26, 2018 at NIFM, Faridabad
5.	Sh. Sanjib Kumar	GEM & GFR 2017	Oct 22-23, 2018 at NIFM, Faridabad

	C. Administrative Staffs		
6.	Smt. Sandhya Kapila	Training on GEM and GFR	Sep 24-25, 2018 at ICAR-NAARM, Hyderabad
7.	Sh. Ramesh Kumar Gupta	GST	Oct 10-12, 2018 at NIFM, Faridabad
8.	Sh. Pradhuman Kr Sarswat	GEM & GFR 2017	Jan 7-8, 2019 at NIFM, Faridabad
	D. Skilled Supporting Staffs		
1.	Sh. Mohan Lal, Sh. Shiv Singh, Sh., Niranjan Singh, Sh. Kailash, Sh. Ram Babu, Sh. Ram Singh, Sh. Jagdish, Sh. Shyam Singh, Sh.Parkash Tomar, Sh. Virendra Singh,Sh. Ranbir Singh, Sh. Kallu, Sh. Ashok Kumar, Smt. Vimla Devi, Sh. Jaswant Singh, Sh. Kedar, Sh. Parasu Ram, Sh. Punjab Singh, Sh. Ram Parkash, Sh. Bharat Singh, Sh. Munnu Singh, Sh. Lala Ram, Sh. Kali Charan, Sh. Tilak Singh, Sh. Net Ram, Sh. Mangal, Sh. Jandel Singh, Sh. Bhagirath, Sh. Ramdin, Sh. Sikander Singh	Office procedure and etiquette for skilled supporting staffs of ICAR CPRI, Regional Station, Gwalior	March 25-27, 2019 at ICAR CPRI Regional Station, Gwalior

EDUCATION AWARDS AND HONOURS

CONFERENCE/SEMINAR/SYMPOSIUM/OTHERS ATTENDED BY ICAR-CPRI STAFFS

Sl. No.	Name and Designation	Conference/Seminar/Symposium etc Date & Venue
1.	Dr. SK Luthra	Project formulation meeting on 13.04.2018 at Haryana Bhawan, New Delhi; Hort. Haryana /CIP, New Delhi
2.	Dr. SK Luthra	Meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops on 5.11.2018, KrishiBhawan, New Delhi
3.	Drs. SK Luthra, Kamlesh Malik	National Seminar on Strategic Management of Production & Post Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers on 11.03.2019 to 12.03.2019, IARI, New Delhi, NHRDF, DVS, IARI, New Delhi.
4.	Drs. SK Luthra, Mehi Lal	Kisan Mela/Gosti (NADP), 06.09.2018, DR Resort, Behjoi, Horticulutre Deptt., Sambhal
5.	Dr. SK Luthra	मंडलीय रबी उत्पादकता गोष्टी, 13.10.2018, SVP Uni. Ag. Tec., Meerut, Ag. Dep, Gov. of Uttar Pradesh
6.	Drs. SK Luthra, Kamlesh Malik	Viraat Kisan Mela, 21.12.2018, Bagpat, Uttar Pradesh, Agriculture Dep. Bagpat
7.	Dr. Mehi Lal	National Symposium on Extension Plant Pathology: Technological Backstopping to Farmers/Other Stakeholders, during 25-26 Sep, 2018 at Indira Gandhi KrishiVishwavidyalaya, Raipur, Chhattisgarh, India
8.	Dr. Mehi Lal	National seminar on New Paradigms of Plant Health Management: Sustaining Food Security Under Climate Change Scenario, during 17-19 Nov, 2018 at Bihar Agricultural University, Sabour Bhagalpur, Bihar
9.	Dr. Devendra Kumar	Workshop on PRD (Partial Root Drying-zone) technology at Potato Technology Center, Shamgargh Karnal Haryana on October 8, 2018. (Organizers: CIP-SWCA and Haryana Potato Project under RKVY)
10.	Dr. Devendra Kumar	National workshop on "Horti-produce transport in India - Present status and issues for reduction in post-harvest losses", 8/1/19 at NASC complex, ICAR New Delhi
11.	Dr. Brajesh Nare	Workshop on e-Crop an IoT Solution in Agriculture during 5-7 September, 2018 organised by ICAR-CTCRI, Thiruvananthapuram
12.	Dr. Pooja Mankar	First International conference on "Entrepreneurship in Agriculture and renewable Energy Sector" held at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra on March 15-16, 2019
13.	Dr. Pooja Mankar	First Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019) at Agriculture University, Jodhpur, Rajasthan from 1-3 February, 2019
14.	Er. Sukhwinder Singh	National Agri-Business entrepreneurship conclave, 9-11 Feb, 2019, ICAR Research Complex, Umiam, Meghalya. on Agri-Business opportunities in hand operated farm tools

Sl. No.	Name and Designation	Conference/Seminar/Symposium etc Date & Venue
15	Mr. Paresh Chaukhande	DUS Testing Workshop on Potato" organized by Protection of Plant Varieties and Farmers Rights Authority (PPVFRA, New Delhi) at ICAR-Central Potato Research Institute, Shimla from June 11 to 12th 2018
16	Mr. Paresh Chaukhande	Hindi workshop on "Hindi Rajbhasha kadainan din karya main mahatva" at ICAR- ICAR-Central Potato Research Institute, Shimla on 19 September 2018
17	Mr. Bapi Das	National Seminar on "Vegetables for livelihood and nutritional security under changing climate scenario" at BCKV, West Bengal during 6th to 7th December, 2018
18	Drs. Sanjay Rawal, SP Singh, MJ Sadawarti	Three day AICRP on potato workshop on "Potato" from 9-11 September, 2018 at SD Agriculture University, Sardar Krushinagar
19	Dr. SP Singh	Two-day National Conference "Sustainable management of rainfed agriculture: Threats and Remedies" organized on 16-17 September, 2018 organized by School of Agriculture, ITM University, Gwalior, MP
20	Dr. SP Singh	National conference on Intensification and diversification in Agriculture for livelihood and rural development" from 28-31 May, 2018 at DRPCAU PUSA(Samastipur) Bihar
21	Dr. SP Singh	4 days XIV agriculture Science congress on "Innovations for agriculture Transformation" being organised by Agriculture Science Congress from 20-23 February, 2019 at NAAS COMPLEX New Delhi.
22	Dr. SP Singh	Two days international Conference on "Technology, innovation and management for sustainable development from 29th -30th March, 2019
23	Dr. RK Singh	ISMPP 39th Annual Conference and National Symposium on "Plant and Soil Health Management: New Challenges and Opportunities" during Nov. 16-18th 2018
24	Dr. Baswaraj Raigond	International Conference on Virology (INTERVIROCON2018) with theme "Global Viral Epidemics: A Challenging Threat" held at Postgraduate Institute of Medical Education and Research, Chandigarh, between 12-14th November 2018
25	Dr. Sanjeev Sharma	APS-IPS Joint Workshop on 'Decision Support System in Crop Disease Management' organized by Indian Phytopathological Society, New Delhi at BHU, Varanasi on 26-28.02.2019
26	Dr. Sanjeev Sharma	National Symposium on 'Alternative Approaches in Plant Health Management for Enhancing Farmers Income' organized by Indian Phytopathological Society, New Delhi and Himalayan Phytopathological Society, Solan at UHF, Solan on 02-03.11.2018
27	Dr. Kamelesh Malik	National Conference on Arid Horticulture for Enhancing Productivity & Economic Empowerment, ICAR-Central Institute for Arid Horticulture, Bikaner, 27-29 October 2018
28	Dr. Anuj Bhatnagar	National Seminar on strengthening of seed system in the North-Eastern and unreached regions-problems, prospects and policies from 3-5, Feb.,2019 held at ICAR-Campus, Imphal, Manipur
29	Dr. Anuj Bhatnagar	National Seminar on Entomology 2018:Advances and challenges, 11-12, December, 2018 at PJTSAU, Hyderabad
30	Dr. Bandana	National Conference on Women empowerment Through Agro-Entrepreneurship for Livelihood Security. 07-08th Februray, 2019, at SKAUST, Jammu

Sl. No.	Name and Designation	Conference/Seminar/Symposium etc Date & Venue
31	Dr. Manoj Kumar	2nd International conference on Advances in agricultural, Biological and Applied Sciences for Sustainable Future (ABAS-2018). Sardar Patel Auditorium, Swami Vivekanad Subharti University, Meerut, U.P. India. 22-22nd October, 2018
32	Dr. Pinky Raigond	International Conference on Recent Advances in Food Processing Technology held at Indian Institute of Food Processing Technology, Thanjavur from 17-19 August 2018.
33	Drs. Brajesh Singh, RK Singh	4th International Plant Physiology Congress held at CSIR-National Botanical Research Institute, Lucknow from 2-5 December 2018
34	Drs. SK Chakrabarti, Brajesh Singh, RK Singh, JK Tiwari	8th Indian Horticulture Congress 2019 at IGKVV, Raipur during 17-21 January 2019. Organised by The Horticultural Society of India, New Delhi
35	Dr. Brajesh Singh	National Collaboration Building Conference of NHB-ICAR Horticulture Institutions during 5-6 February 2019. Organised by NHB, Gurgaon at New Delhi.
36	Dr. Tanuja Buckseth	2nd international conference on food security, nutrition and sustainable agriculture- emerging technology (ICFNSA-2019 on 14-16 February at BFGI, Bathinda, Punjab
37	Dr. Tanuja Buckseth and Dr RK Singh	National workshop on vertical farming held at NASC Complex, ICAR New Delhi 18 October, 2018
38	Dr. Tanuja Buckseth and Dr G. Vanishree	Workshop on International OECD Seed Certification on 11th & 12th September, 2018 at Uttrakhand State Seed & Organic production Certification Agency, Dehradun, Uttarakhand.
39	Dr. RK Singh	National conference on Strategies and challenges in doubling farmer's income through horticultural technologies in subtropics, 21-22 June, at ICAR-CISH, Lucknow
40	Mr. Pynbianglang Kharumnuid	International Conference on "Rural Livelihood Improvement by Enhancing Farmers' Income through Sustainable Innovative Agri and Allied Enterprises (RLSIAAe)" at Birla Institute of Technology, Patna during 30th October to 01st November, 2018

ICAR-CPRI BEST WORKER AWARD FOR THE YEAR 2018-19

Sl. No.	Category	Awardee Name
1	Scientific	Dr Jagesh Kumar Tiwari (1st)
		Dr Shambhu Kumar (2nd)
2	Technical	Sh. Dharmender K. Gupta (1st)
		Smt. Vineet Sharma and Sh. RK Samadhiya (2nd, joint)
3	Administrative	Smt. Meena Verma (1st)
		Sh. Kamal C Verma and Sh. Suresh Kumar (2nd, joint)
4	Supporting	Sh. Nand Lal (1st)
		Sh. Tejbir Singh (2nd)

1. ICAR-CPRI bagged Rajbhasha Award for North Zone in Big Offices Category for 2017-18.
2. ICAR-CPRI bagged Rajbhasha Samman Puraskar for getting Kshetriya Samman Puaraskar for 2017-18 from NARAKAS, Shimla, HP State.
3. Dr. Brajesh Singh was conferred Dr. JC Anand gold medal for PHT (2018) conferred by Hort. Society of India.
4. Dr. Sanjeev Sharma was awarded Fellow (2018) of Indian Potato Association, Shimla.
5. Dr. SK Luthra was awarded Fellow (2018) of the Horticulture Society of India, New Delhi.
6. Dr BP Singh et al., was awarded IPA-Kaushalya Sikka Memorial Award 2013-17 for research on "Decision Support Tools for Potato Research & Development" by Indian Potato Association, Shimla.
7. Dr. RK Singh was awarded Yashasvi samman (2018) from Royal Association for Science- led Socio-Cultural Advancement, New Delhi.
8. Dr. Jagesh Kumar Tiwari was awarded NAAS Assciateship-2018.
9. Best oral presentation award, Buckseth T, Singh RK and Chakrabarti SK (2019) Response of potato varieties grown in a novel aeroponic system for minituber production. In: 2nd international conference on food security, nutrition and sustainable agriculture- emerging technology (ICFNSA-2019) on 14-16 February at BFGI, Bathinda, Punjab.
10. Best poster award, Sundaresha S, Sharma S, Salaria N, Thakur K, Sharma N, Bhardwaj V and Chakrabarti SK (2018) dsRNA formulation (fungicide): as an alternate and novel protection strategy for potato late blight in the 'National Symposium on alternate approaches in plant health management for enhancing farmers' income', held at Dr. YSPUHF, Solan, Nov. 2-3, 2018 by Indian Phytopathological Society& Himalayan Pathological Society.
11. Best Paper Award for Development of competitive indirect enzyme linked immunosorbent assay for detection of cephalexin residues in milk during 47th Dairy Industry Conference held between 7-9 Feb. 2019 at Patna.
12. Best poster Presentation award, Mhatre, PH. et al (2018). The First Report of Steinernema cholashanense (Rhabditida: Steinernematidae) from India and its biocontrol potential against potato pests. In: International Conference on Biological Control, Approaches and Applications, held at Bengaluru, Karnataka on 27th -29th September 2018, pp: 38.
13. Best Oral Presentation award, Berliner S, Mhatre PH, Kalai PV and Khan MR (2019) Nematode trophic group diversity at

different cropping sequence in Nilgiris. In: 28th national conference "Farmers friendly Soil and Water Conservation Technologies for mitigating Climate Change Impact organized by Soil Conservation Society of India, New Delhi and ICAR-IISWC, RC, Ooty from 31st -2nd February 2019

14. Best Oral Presentation award, Patil J, Gowda MT, Mhatre PH and Vijaykumar R (2018) Compatibility and efficacy of entomopathogenic nematode-insecticide combinations against Holotrichia consanguinea Blanch. (Coleoptera: Scarabaeidae). In: International Conference on Biological Control, Approaches and Applications, held at Bengaluru, Karnataka on 27th -29th September 2018, pp: 117.

15. Best paper award: Mankar P, Rawal S, Dua VK and Chakrabarti SK (2019) "Good Agricultural practices for Quality Sustainable Food production" for oral presentation at First International Conference on "Entrepreneurship in Agriculture and renewable Energy Sector" held at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during March 15-16, 2019.

16. Best paper award Thakur K, Sundaresha S, Salaria N, Sagar V, Gautam U, Sharma N, Sharma S, Bhardwaj V and Chakrabarti SK (2018) Alternative Approaches for Management of Ralstonia solanacearum in Potato by Silencing Host Susceptible Gene" in Prof MJ Narsimha Academic Award Contest during National Seminar on 'Alternative Approaches in Plant Health Management for Enhancing Farmers' Income' organized by Indian Phytopathological Society at UHF, Nauni, Solan (HP) during 2-3 November, 2018.

17. Dr. BP Singh et al., awarded Nanaji Deshmukh ICAR Award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences 2015-16 for research on "Forecasting for Management of Late Blight of Potato".

18. Dr. Salej Sood was conferred NAAS Associateship-2019.

19. Dr. Salej Sood was awarded Australian Endeavour Post-Doctoral Research Fellowship 2018.

Patent:

1. Filed a patent application entitled "SPADE" by inventors Sukhwinder Singh and Brajesh Nare on 30-October 2018 (Application No. 305966).
2. Filed a patent application entitled "WEEDER" by inventors Sukhwinder Singh and BrajeshNare on 30-October 2018 (Application No. 305965).
3. Filed a patent application entitled "Weeder-1" (T-hoe) Proposed Locarno Class: 08-05 (Class 08-Tools and hardware and Sub class 05- other tools and implements) by inventors Sukhwinder Singh and BrajeshNare on 17- December 2018 (Ref. DD031671IN-SC).
4. Filed a patent application entitled "Weeder-2" (L-hoe) Proposed Locarno Class: 08-05 (Class 08-Tools and hardware and Sub class 05- other tools and implements) by inventors Sukhwinder Singh and BrajeshNare on 17- December 2018 (Ref. DD031672IN-SC).
5. Filed a patent application entitled "Aerponic nutrient solution, and applications thereof" by inventors Tiwari JK, Buckseth T, Singh RK, Dua VK and Chakrabarti SK on 22nd March, 2019 (Application no. 201911011277).

STAFF POSITION

NAME OF STAFF AT ICAR-CPRI, SHIMLA & ITS REGIONAL STATIONS AS ON 31.03.2019

ICAR-CPRI, SHIMLA

SCIENTIFIC

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, PS & Head
13. Dr. Jagdev Sharma, Pr. Scientist
14. Dr. (Ms.) Pooja Praful Mankar, Scientist
15. Sh. Paresh Baldeorao, Scientist
16. Ms. Preeti Singh, Scientist

Division of Social Sciences

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

Division of Plant Protection

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

Division of Crop Physiology & PHT

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

ARIS Cell

35. Dr. Shashi Rawat, Pr. Scientist

ICAR-CPRI, RS, Modipuram

36. Dr. Manoj Kumar, Pr. Scientist & Joint Director
37. Dr. Devendra Kumar, Pr. Scientist
38. Dr. (Mrs.) Kamlesh Malik, 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. Vijai Kishore Gupta, Pr. Scientist
46. Dr. Babita Chaudhary, Pr. Scientist
47. Dr. Mehi Lal, Scientist
48. Dr. (Mrs) Bandna, Scientist
49. Dr. Raghavendra KV, Scientist

ICAR-CPRI, RS, Jalandhar

50. Dr. Raj Kumar, Pr. Scientist & Officiating Head
51. Er. Sukhwinder Singh, Scientist (SG)
52. Er. Sunil Gulati, Scientist (SG)
53. Dr. (Mrs) 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, RS, Gwalior

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

ICAR-CPRI, RS, 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, RS, Muthorai

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

ICAR-CPRI, RS, Kufri

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

ICAR-CPRI, RS, 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

TECHNICAL

ICAR-CPRI, Shimla

1. Dr. Rakesh Mani Sharma, CTO
2. Dr. Sushil Kumar, ACTO
3. Smt. Tarvinder Kochhar, ACTO
4. Sh. Dharminder Verma, ACTO
5. Smt. Shelly Chopra, ACTO
6. Sh. Pravesh Jassal, ACTO
7. Sh. Kameshwar Sen, ACTO
8. Sh. Avnish Kumar Atrey, ACTO
9. Sh. Chander Mohan Singh Bist, ACTO
10. Sh. Yogesh, ACTO
11. Sh. Rajdeep Bux, STO
12. Dr. Sumita Sharma, STO
13. Sh. Harvinder Singh, STO
14. Sh. Vinod Kumar, STO
15. Smt. Shruti Gupta, STO
16. Sh. Tilak Raj, STO
17. Sh. DP Gautam, TO
18. Sh. Kana Singh Chauhan, TO
19. Sh. Sheesh Ram, TO
20. Sh. Naresh Kumar Sharma, TO
21. Sh. Rajinder Kumar, TO
22. Sh. Rakesh Kumar Patyal, TO
23. Sh. Sushil Singh, STA
24. Sh. Naresh Chand Sharma, STA
25. Smt. Manjeet Syal, STA
26. Smt. Madhu Bala, STA
27. Smt. Asha Thakur, STA
28. Sh. Hari Kishore, STA
29. Sh. Ram Singh, STA
30. Sh. Dharminder Kumar Gupta, STA
31. Sh. Naresh Kumar, STA
32. Sh. Ranjesh Bhardwaj, STA
33. Sh. Roop Lal, STA
34. Sh. Ashok Kumar, STA
35. Sh. Ravinder Kumar, TA
36. Sh. Deep Ram, TA
37. Sh. Rakesh Kumar, TA

38. Smt Jitender Kaur Arora, TA
39. Sh. Jagdish Chand, TA (Welder)
40. Ms. Nisha Verma, TA
41. Sh. Sanjay Kumar, TA
42. Sh. Jagdish Chand, Sr. Technician (Balksmith-cum-Carpenter)
43. Sh. Dev Raj, Sr. Technician
44. Sh. Ram Dayal, Sr. Technician
45. Sh. Parmesh Dutt, Sr. Technician
46. Sh. Anil Kumar Dubey, Sr. Technician
47. Sh. Neem Chand, Sr. Technician
48. Sh. Laiq Ram, Sr. Technician
49. Sh. Surinder Pal, Sr. Technician
50. Sh. Mansha Ram, Technician
51. Sh. Arjun Dass, Technician
52. Sh. Vivek Kumar, Technical Trainee
53. Sh. Rahul, Technical Trainee
54. Sh. Rohit Verma, Technical Trainee
55. Sh. Rakesh Kumar, Technical Trainee
56. Ms. Sonam, Technical Trainee
57. Ms. Vandana Parmar, Technical Trainee
58. Ms. Vineeta Sharma, Technical Trainee
59. Sh. Sanjay Kumar, Technical Trainee

ICAR-CPRI, RS, Kufri

60. Sh. Kapil Kumar Sharma, ACTO
61. Sh. Kedar Singh, TO
62. Sh. Ajit Singh, TA
63. Sh. Ramjivan, TA
64. Sh. Mohan Lal, Sr. Technician
65. Sh. Rajat, Technical Trainee

ICAR-CPRI, RS, Modipuram

66. Sh. Ram Kumar Verma, CTO
67. Sh. Mahesh Kumar, CTO
68. Dr. Ashok Kumar, CTO
69. Sh. Harvir Singh, CTO
70. Sh. Mahipal Singh Bharti, ACTO
71. Sh. Krishan Pal Singh, ACTO
72. Sh. Om Pal, ACTO
73. Mrs. Kusum Singh, ACTO
74. Sh. Jasvir Singh, ACTO
75. Sh. Santosh Kumar, ACTO
76. Sh. Murari Lal, ACTO
77. Sh. Harvir Singh, STO
78. Sh. Omvir Singh, STO
79. Sh. Subhash Chand, STO
80. Dr. Vineet Sharma, STO
81. Sh. Avinash Chaudhary, STO
82. Sh. Dinesh Singh, STO
83. Sh. Pushpender Kumar, STO
84. Dr. Sanat Kumar, STO
85. Sh. Udaivir Singh, STO
86. Sh. Vijay Kumar Yadav, STO
87. Sh. Ved Singh, TO
88. Sh. Pawan Kumar Malik, STA
89. Sh. Krishan Pal Singh ,TA
90. Sh. Syed Danish Abbas Rizvi, TA
91. Sh. Mahesh Pal, Sr. Technician (T-1-3)
92. Sh. UP Paudel, T-I-3
93. Sh. Satpal Singh, Sr. Technician
94. Sh. Vipin Kumar, Sr. Technician
95. Sh. Rambir Singh, Sr. Technician
96. Sh. Madan Pal, Sr. Technician
97. Sh. Kamal Singh, Sr. Technician
98. Sh. Siddharth Saroha, Technical Trainee

ICAR-CPRI, RS, Jalandhar

99. Sh. Munna Lal, ACTO
100. Sh. Jaswinder Singh, STO
101. Sh. Yogesh Kumar Gupta, STO
102. Sh. Akhilesh Kumar Singh, STO
103. Sh. Vijay Kumar, STA
104. Sh. Som Dutt, STA
105. Sh. Narinder Mayer, STA
106. Sh. Kulwinder Singh, STA
107. Sh. Praveen Kumar, TA
108. Sh. Anil Kumar Chandel, TA
109. Sh. Pradeep Kumar Upadhaya, TA
110. Sh. Pawan Kumar, Sr. Technician
111. Sh. Virender Singh, Tech. Trainee

ICAR-CPRI, RS, Gwalior

112. Dr. Yogendra Pal Singh STO
113. Sh. Sanjay Kr. Sharma, STO
114. Sh. Shyam Kumar Gupta STO
115. Sh. Rajinder Kumar Samadhiya, STO
116. Sh. Surendar Singh, STO
117. Sh. Radha Kishan, TA
118. Sh. Nihal Singh, TA
119. Sh. Bijendra Singh, Sr. Technician
120. Sh. Tara Chand, Sr. Technician
121. Sh. Chet Ram, Technician
122. Sh. Dhanvantri Meena, Tech. Trainee

ICAR-CPRI, RS, Patna

123. Sh. Arun Kumar Singh, CTO
124. Sh. Arjun Kumar Sharma, STO
125. Sh. Rakesh Srivastava, STA
126. Sh. Anil Kumar, STA
127. Sh. Alekh Narain, STA
128. Sh. Narinder Kumar, Sr. Technician
129. Sh. Lal Babu Dass, Sr. Technician
130. Sh. Sunil Kr. Singh, Sr. Technician
131. Sh. Parvesh Kumar Yadav, Sr. Technician
132. Sh. Sanjeev Kumar Meena, Tech. Trainee
133. Sh. Pratish Kumar Patel, Tech. Trainee
134. Sh. Rishav Kumar, Tech. Trainee
135. Sh. Ajaya Kumar, Tech. Trainee

ICAR-CPRI, RS, Shillong

136. Sh. PR Khongbuh, TA
137. Sh. Ram Dass Rai, TA
138. Sh. S.Nongrum, Sr. Technician
139. Sh. Sumit Kumar, Tech. Trainee

ICAR-CPRI, RS, Muthorai

140. Sh. V Rajendran, TO
141. Sh. R Lakshmanan, TA
142. Sh. B Suresh, Sr. Technician

ADMINISTRATIVE

ICAR-CPRI, Shimla

1. Sh. Ratnesh Kumar, CAO
2. Sh. Zakir Hussain Khilji, Sr. FAO
3. Sh. Sandeep Singh Dudi, AO
3. Sh. Joginder Singh Thakur, AAO
4. Smt. Sunita Thakur, Asstt.
5. Sh. Om Parkash, Asstt.
6. Smt. Poonam Sood, AAO
7. Smt. Urmila Verma, Asstt.
8. Sh. Jai Ram Thakur, AAO
9. Sh. Amar Chand, Asstt.
10. Ms. Reeta Walia, Asstt.
11. Sh. Ashwani Gupta, UDC
12. Sh. Tej Singh, UDC
13. Sh. Raghubir Singh, UDC
14. Sh. Mohit Oberoi, Steno Grade-III
15. Sh. Chander Prakash, AF&AO
16. Sh. Girish Thakur, Steno Grade-III
17. Sh. Jagdish Chand, Asstt.
18. Sh. Ashish Kalyan, LDC
19. Smt. Shyam Lata Beakta, Asstt.
20. Sh. Sandeep Verma, Asstt.
21. Sh. Kamal Chand Verma, UDC
22. Smt. Geeta Devi, UDC
23. Smt. Sonia Chauhan, UDC
24. Smt. Meena Verma, AAO
25. Sh. Narender Paul, UDC
26. Smt. Punam Jyoti, UDC
27. Sh. Pawan Kumar, UDC
28. Sh. Chanda Ram, AAO
29. Sh. Krishan Lal, Asstt.
30. Sh. Hans Raj, UDC
31. Sh. Kundan Lal, LDC
32. Sh. Mohinder Singh, UDC
33. Sh. Gokal Ram, UDC
34. Sh. Deep Ram, Asstt.
35. Sh. Sachin Kanwar, UDC
36. Sh. Rakesh Negi, LDC

37. Sh. Shashi Thakur, Pvt. Secretary
38. Smt. Nirmala Chauhan, UDC
39. Smt. Kanta Rani, Asstt.
40. Sh. Gurjeet Singh, Pvt. Secy.
41. Sh. Ram Chand, Pvt. Secy.
42. Sh. Suresh Kumar, PA
43. Sh. Rajesh Chauhan, LDC
44. Sh. Nand Lal, LDC

ICAR-CPRI, RS, Kufri

45. Smt. Babli Bhawani, AAO
46. Smt. Chandni Bhagta, Asstt.

ICAR-CPRI, RS, Modipuram

47. Shri Jaspal Singh, AO
48. Sh. Jagbir Singh, AAO
49. Sh. Sandeep, AAO
50. Sh. Santosh Kumar, Asstt.
51. Smt. Sneh Lata, UDC
52. Smt. Seema Verma, UDC
53. Sh. Ashok Kumar, UDC
54. Sh. Ashish Kalyan, LDC
55. Sh. Rajesh Kumar, Pvt. Secy.
56. Sh. Sunil Kumar, LDC
57. Sh. Suraj Singh, LDC

ICAR-CPRI, RS, Jalandhar

58. Miss. Prawartika Das, AAO
59. Sh. Suresh Kumar Verma, PA
60. Sh. Sukhpal Sharma, Asstt.
61. Smt. Sandhya Kapila, Asstt.
62. Sh. Rakesh,Asstt.
63. Smt. Bimla Salhotra, UDC
64. Smt. DaisheyTuli, UDC
65. Sh. Naresh Kumar, LDC
66. Sh. Daljeet Singh, UDC

ICAR-CPRI, RS, Gwalior

67. Sh. Surender Singh, Asstt.
68. Sh. Pradhuman Kumar Saraswat, UDC
69. Sh. Shri Krishan, LDC

ICAR-CPRI, RS, Muthorai

70. Smt. IC Dharmapaul, AAO
71. Smt. M. Rani, Asstt.

ICAR-CPRI, RS, Patna

72. Sh. Sanjib Kumar, Asstt.
73. Sh. Ramesh Kumar Gupta, UDC
74. Sh. Pawan Kumar, Steno Grade-III

ICAR-CPRI, RS, Shillong

- NIL-

SKILLED SUPPORT STAFF

ICAR-CPRI, Shimla

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

ICAR-CPRI, RS, Kufri

22. Sh. Hira Singh , SSS (SS Gr. III)
23. Sh. Saran, SSS (SS Gr. III)
24. Smt. Muni Devi, SSS (SS Gr. II)
25. Sh. Madan Lal, SSS (SS Gr. I)

26. Sh. Roop Singh, SSS (SS Gr. I)
27. Sh. Jia Lal, SSS (SS Gr. I)
28. Smt. Sodha Devi, SSS

ICAR-CPRI, RS, Modipuram

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

ICAR-CPRI, RS, Jalandhar

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

ICAR-CPRI, RS, Patna

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

ICAR-CPRI, RS, Gwalior

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

ICAR-CPRI, RS, Shillong

92. Smt.Theibet Thawmuit, SSS(SS Gr. III)
93. Mrs. Tellinora, SSS(SS Gr. III)

ICAR-CPRI, RS, Muthorai

94. Sh. K. Ramasamy, SSS(SS Gr. I)
95. Smt.S Pankajam, SSS(SS Gr. I)
96. Smt. M, Anagamma, SSS

SANCTIONED , FILLED AND VACANT POSITIONS AT ICAR-CPRI, SHIMLA & ITS REGIONAL STATIONS AS ON 31.3.2019

SCIENTIST

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

Sl. No.	Discipline	Scientist (including Sr. Sci.&PS promoted Through CAS)			Senior Scientist (DR)			Principal Scientist (DR)			Total		
		S	F	V	S	F	V	S	F	V	S	F	V
1.	AGRICULTURAL BIOTECHNOLOGY	4	3	1	-	-	-	-	-	-	4	3	1
2.	AGRONOMY	4	4	-	-	-	-	1	1	-	5	5	-
3.	AG. ENTOMOLOGY	6	5	1	1	2	(-)1	-	-	-	7	7	-
4.	AG. ECONOMICS	3	-	3	-	-	-	-	1	(-)1	3	1	2
5.	AG METROLOGY	1	1	-	-	-	-	-	-	-	1	1	-
6.	AGRICULTURAL MICROBIOLOGY	3	1	2	-	-	-	-	-	-	3	1	2
7.	AG. STATASTICS	1	-	1	-	-	-	-	-	-	1	-	1
8.	COM. APPLN.	1	1	-	-	-	-	-	-	-	1	1	-
9.	AG. EXTENSION	3	1	2	-	-	-	1	-	1	4	1	3
10.	AGRI. PROCESS ENGINEERING	1	-	1	-	-	-	-	-	-	1	-	1
11.	AG. ENGG.(FM&P)	3	3	-	-	-	-	-	-	-	3	3	-
12.	AG. ENGG (ASPEE)	-	-	-	-	-	-	-	-	-	-	-	
13.	AG. CHEMISTRY	-	-	-	-	-	-	-	-	-	-	-	-
14.	PL.BIOCHEMISTRY	2	2	-	1	1	-	-	-	-	3	3	-
15.	FOOD TECHNOLOGY	2	1	1	-	-	-	-	-	-	2	1	1
16.	FRUIT SCIENCE	-	-	-	-	-	-	-	-	-	-	-	-
17.	GEN. & CYTOGEN	-	-	-	-	-	-	-	-	-	-	-	-
18.	VEG. SCIENCE	14	14	-	2	-	2	4	1	3	20	15	5
19.	NEMATOLOGY	2	2	-	-	-	-	1	-	1	3	2	1
20.	GENETICS AND PLANT BREEDING	9	8	1	4	2	2	1	-	1	14	10	4
21.	PL. PATHOLOGY	10	7	3	2	2	-	1	-	1	13	9	4
22.	PL. PHYSIOLOGY	4	4	-	1	-	1	-	1	(-)1	5	5	-
23.	SOIL SCIENCE SOIL CHEM./ FERT. MICRO	5	2	3	-	-	-	-			5	2	3
24.	SOIL PHY. & SOIL WATER CONSERV.	-	-	-	-	-	-	-	-	-	-	-	-
25.	SEED SCIENCE AND TECHNOLOGY	5	3	2	-	1	(-)1	1	-	1	6	4	2
26.	FLEXI DISCIPLINES	-	-	-	2	-	2	-	-	-	2	-	2
27.	JOINT DIRECTOR	-	-	-	-	-	-	1	1	-	1	1	-
	TOTAL	83	62	21	13	8	5	11	05	06	107	75	32

S-Cadre Strength F-In position V-Vacancy

TECHNICAL

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	34	5	3	8	7	13	12	4	5	12	10	4	3	8	5	**83**	**79**	**04**
Cat. II Sr. Tech. Asstt. (T-4) Tech. Asstt. (T-3)	9	8	–	–	4	3	13	10	2	2	3	2	–	–	–	01	**31**	**26**	**05**
Cat. III Farm Supdt. T-6	–	–	–	–	1	–	1	2	–	–	–	–	–	–	–	–	**2**	**2**	**0**
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	2	–	–	1	1	1	–	–	–	–	–	–	–	–	–	**3**	**3**	**0**
Asstt. Librarian (T-5)	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**	**1***	**0**
Documentalist, T-3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**	**–**	**1**
Tech. Asstt. (Stat.) (T-3)	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**	**–**	**1**
Photography																			
Cat. I Photographer /	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**	**–**	**1**
Press & Editorial Staff Cat. II																			
Hindi Translator, T-3	1	1	–	–	–	–	1	1	–	–	–	–	–	–	–	–	2	2	0
Workshop & Engg. Staff																			
Cat. I Blacksmith-cum- Carpenter	1	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**

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
Workshop & Engg. Staff																			
Operator Electrical	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	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**
Total	**61**	**59**	**08**	**04**	**22**	**13**	**42**	**33**	**13**	**11**	**19**	**13**	**05**	**03**	**08**	**06**	**178**	**142**	**36**

Sl. No.	Category	Sanctioned	Filled	vacant
1.	Category- I	125	101	24
2.	Category-II	49	39	10
3.	Category-III	04	02	02
	Total	178	142	36

SKILLED SUPPORT STAFF

Grade	Sanctioned	Filled	Vacant
SS Grade-I	85 + 3*	53	35
SS Grade-II	65	30	35
SS Grade-III	39	13	26
SS Grade-IV	18	-	18
Sub Total	210	96	114

STATION-WISE/GRADE-WISE LIST OF THE SKILLED SUPPORTING STAFF 31.03.2019

Station	Sanctioned Strength	Grade-IV	Grade-III	Grade-II	Grade-I	Total
Shimla	75+3*=78	-	7	03	11	21
Kufri	12	--	02	01	04	07
Modipuram	42	--	00	03	12	15
Jalandhar	26	--	01	07	04	12
Patna	20	-	01	03	02	06
Gwalior	12	-	-	13	17	30
Shillong	12	-	02	-	-	02
Muthorai	08	-	-	-	03	03
Total	210	-	13	30	53	96

* 3 posts of Skilled Support Staff are returned back by the Ranchi Regional Centre of the ICAR research Complex for Eastern Region.

ADMINISTRATIVE

Group	Shimla			Shillong			Jalandhar			Modipuram			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	Sanctioned	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	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
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	5	0	0	0	0	1	1	0	2	2	0	1	0	1	1	0	1	0	1	-1	0	1	-1	10	10	0
AF&AO	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1
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	1	6	0	0	0	1	1	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	10	2	8
Steno Gr-III	0	2	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	0	0	0	0	0	0	0	3	-3
Asstt.	20	11	9	2	0	2	1	3	-2	3	1	2	1	1	0	1	1	0	1	1	0	1	1	0	30	19	11
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	5	9	1	0	1	2	1	1	3	2	1	1	1	0	2	0	2	1	0	1	0	0	0	24	9	15
	61	45	16	4	0	4	8	9	-1	12	10	2	5	3	2	7	3	4	3	2	1	2	2	0	102	74	28

SCIENTIST

New Joining

1. Dr. Raghavendra K.V., Scientist (Ag. Ento.), ICAR-CPRI, RS, Modipuram joined on 08.10.2018.
2. Sh. Rahul Kumar Tiwari, Scientist (Pl. Path.), ICAR-CPRI, Shimla joined on 08.10.2018.
3. Dr. Kumar NishantChourasia, Scientist (Gen. & Pl. Breeding), ICAR-CPRI, Shimla joined on 08.10.2018.
4. Sh. Dharmendra Kumar, Scientist, ICAR-CPRI (Ag. Microbiology), Shimla joined on 09.10.2018.
5. Sh. Milan Kumar Lal, Scientist (Pl. Physiology), ICAR-CPRI, Shimla joined on 09.10.2018.
6. Ms. Preeti Singh, Scientist (Soil Science), ICAR-CPRI, Shimla joined on 09.10.2018.
7. Sh. Subhash S., Scientist (Ag. Entomology), ICAR-CPRI, Shimla joined on 09.10.2018.

Promotion

1. Dr. (Mrs.) Sarla Yadav, Scientist placed in Level-11 (Pre-revised PB 15600-39100 + RGP 7,000/- pre-revised) *w.e.f.* 15.12.2015 vide ICAR office order 2-7/2017-Per.1 (CAS) dated 28.09.2018.
2. Dr. Som Dutt, Sr. Scientist placed in Level-14 (Pre-revised PB 37400-67000 + RGP 10,000/-pre-revised) *w.e.f.* 31.05.2017 vide ICAR office order 2-5/2017 - AU dated 15.02.2019.

Joining on Inter – Instt. transfer

1. Sh. Raj Kumar, Scientist (Horticulture/ Floriculture) relieved from ICAR-NRC for Orchids, Pakyong, Sikkim w.e.f. 30.06.2018 (AN) and joined at ICAR-CPRI, Shimla on 04.07.2018 (AN).
2. Dr. Ngursangzuala Sailo, Scientist (Plant Physiology) relieved from ICAR-NRC for Orchids, Pakyong, Sikkim *w.e.f.* 06.07.2018 (AN) and joined at ICAR-CPRI, RS, Shillong on 09.07.2018 (FN).
3. Dr. (Mrs.) P. Janani, Scientist (Spices, Plantation, Medicinal and Aromatic Plants) relieved from ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada district, Karnataka State, India *w.e.f.* 30.06.2018 (AN) and joined at ICAR-CPRI, RS, Shillong on 02.07.2018 (FN).

Transfers

1. Dr. Satyajit Roy, Principal Scientist & Head, ICAR-CPRI, RS, Gwalior relieved to join at ICAR-Directorate of Medicinal and Aromatic Plants Research, Boriavi, Anand (Gujarat) – 387310 from 31.08.2018 (AN).

TECHNICAL

New Appointments

1. Sh. Sanjay Kumar, Technical Asstt. (T-3), ICAR-CPRI, Shimla, joined on 22.12.2018 (FN).
2. Kumari Nisha Verma, Hindi Translator, ICAR-CPRI, Shimla, joined on 24.12.2018 (AN).
3. Sh. Vivek Kumar, Technical Trainee, ICAR-CPRI, Shimla, joined on 24.12.2018 (FN).
4. Sh. Rohit Verma, Technical Trainee, ICAR-CPRI, Shimla, joined on 19.12.2018 (FN).
5. Sh. Rahul, Technical Trainee, ICAR-CPRI, Shimla, joined on 19.12.2018 (FN).
6. Sh. Sanjay Kumar, Technical Trainee, ICAR-CPRI, Shimla, joined on 21.12.2018 (FN).
7. Kumari Sonam, Technical Trainee, ICAR-CPRI, Shimla, joined on 08.01.2019 (FN).
8. Sh. Rakesh Kumar, Technical Trainee, ICAR-CPRI, Shimla, joined on 28.12.2018 (FN).
9. Sh. Rajat, Technical Trainee, ICAR-CPRI, RS, Kufri, joined on 18.12.2018 (FN).
10. Sh. Rishav Kumar, Technical Trainee, ICAR-CPRI, RS, Patna, joined on 26.12.2018 (FN).
11. Sh. Siddharth Saroha, Technical Trainee, ICAR-CPRI, RS, Modipuram, joined on 29.12.2018 (FN).
12. Sh. Sumit Kumar, Technical Trainee, ICAR-CPRI, RS, Shillong, joined on 29.12.2018 (FN)
13. Sh. Virender Kumar, Technical Trainee, ICAR-CPRI, RS, Jalandhar, on 28.12.2018 (FN).
14. Kumari Vandana Parmar, Technical Trainee, ICAR-CPRI, Shimla, joined on 29.01.2019(FN).
15. Sh. Dhanvantri Meena, Technical Trainee, ICAR-CPRI, RS, Gwalior, joined on 31.12.2018 (FN).
16. Sh. Sanjeev Kumar Meena, technical Trainee, ICAR-CPRI, RS, Patna, joined on 18.12.2018 (FN).
17. Sh. Pratish Kumar Patel, Technical Trainee, ICAR-CPRI, RS, Kufri, joined on 01.02.2019 (FN).

18. Kumari Vineeta Sharma, Technical Trainee, ICAR-CPRI, Shimla, joined on 22.02.2019 (FN).
19. Sh. Ajay Kumar, Technical Trainee, ICAR-CPRI, RS, Patna, joined on 06.02.2019 (FN).

Promotion

1. Sh. Tilak Raj, Tech. Officer (T-5) , ICAR-CPRI, Shimla promoted to Sr. Tech. Officer (T-6) from 24.09.2017.
2. Smt. Shruti Gupta, Tech. Officer (T-5), ICAR-CPRI, Shimla promoted to Sr. Tech. Officer (T-6) from 22.02.2018.
3. Sh. Vijay Kumar Yadav, Tech. Officer (T-5), ICAR-CPRI, RS, Modipuram promoted to Sr. Tech. Officer (T-6) from 19.10.2017.
4. Sh. R Lakshmanan, Tech. Asstt. (T-3), ICAR-CPRI, RS, Muthorai promoted to Sr. Tech. Asstt. (T-4) from 13.04.2018.
5. Sh. Vijay Kumar, Tech. Asstt. (T-3), ICAR-CPRI, RS, Jalandhar promoted to Sr. Tech. Asstt. (T-4) from 17.11.2017.
6. Sh. B Suresh , Technician, (T-1) ICAR-CPRI, RS, Muthorai promoted to Sr. Technician (T-2) from 21.06.2018.
7. Sh. Surinder Pal, Technician, (T-1) ICAR-CPRI, Shimla promoted to Sr. Technician (T-2) from 16.11.2017.
8. Sh. Ashok Kumar, Tech. Asstt. (T-3), ICAR-CPRI, Shimla promoted to Sr. Tech. Asstt. (T-4) from 01.03.2018.
9. Sh. Vipin Kumar, Sr. Technician (T-2), ICAR-CPRI, RS, Modipuram promoted to Tech. Asstt. (T-3) from 31.03.2017.
10. Sh. Roop Lal, Tech. Asstt. (T-3), ICAR-CPRI, Shimla promoted to Sr. Tech. Asstt. (T-4) from 17.11.2018.
11. Sh. Lal Babu Dass, Tech. Asstt. (T-3) ICAR-CPRI, RS, Patna promoted to Sr. Tech. Asstt. (T-4) from 07.11.2018.
12. Sh.Ram Kumar Verma, Chief Tech. Officer,(T-9) ICAR-CPRI, RS, Modipuram granted one advance increment from 02.12.2014.
13. Sh. Mahipal Singh Bharti, Asstt. Chief Tech. Office,(T-7-8) ICAR-CPRI, RS, Modipuram promoted to Chief Tech. Officer(T-9) from 01.07.2017.
14. Sh. Murari Lal, Sr. Tech. Officer, (T-6) ICAR-CPRI, RS, Modipuram promoted to Asstt. Chief Tech. Officer (T-7-8) from 16.01.2017.
15. Sh. Satender Kumar, Ex. Sr. Tech. Officer(T-6) ICAR-CPRI, RS, Modipuram promoted to Asstt.Chief Tech. Officer(T-7-8) from 03.02.2017.
16. Sh. Omvir Singh, TO,(T-5) ICAR-CPRI, RS, Modipuram promoted to Sr. Tech. Officer(T-6) from 09.01.2017.
17. Sh. Pravesh Jassal, Sr. Tech. Officer (T-6), ICAR-CPRI, Shimla promoted to Asstt. Chief Tech. Officer (T-7-8) from 29.01.2017.
18. Sh. Yogesh, Sr. Tech. Officer (T-6), ICAR-CPRI, Shimla promoted to Asstt. Chief Tech. Officer (T-7-8) from 01.02.2012.
19. Sh. Chander Mohan Singh Bist, Sr. Tech. Officer(T-6), ICAR-CPRI, Shimla promoted to Asstt. Chief Tech. Officer(T-7-8) from 24.12.2017.
20. Sh. Jagdish Chand, Sr. Technician (T-2), ICAR-CPRI, Shimla Promoted to T-I-3 (Tech. Assistant) from 29.06.2006.
21. Sh. DP Gautam, Technical Officer (T-5), ICAR-CPRI, Shimla promoted to Technical officer (T-5), from 21.02.2005 (review case)
22. Sh. Harvir Singh, Asstt. Chief Tech. Officer (T-7-8), ICAR-CPRI, RS, Modipuram promoted to Chief Tech Officer (T-9) from 30.03.2018.
23. Sh. Avnish Kumar Atry, Sr. Tech. Officer (T-6), ICAR-CPRI, Shimla promoted to Asstt. Chief Tech. Officer (T-7-8) from 30.01.2018.
24. Sh. Jasvir Singh, Sr. Tech. Officer (T-6), ICAR-CPRI, RS, Modipuram promoted to Asstt. Chief Tech. Officer(T-7-8)from 16.02.2018.
25. Sh. Mahesh Kumar, Asstt. Chief Tech. Officer (T-7-8), ICAR-CPRI, RS, Modipuram promoted to Chief Tech. Officer (T-9) from 19.02.2018.
26. Dr. Ashok Kumar, Asstt. Chief Tech. Officer (T-7-8), ICAR-CPRI, RS, Modipuram promoted to Chief Tech. Officer (T-9) from 08.05.2018.
27. Sh. Arun Kumar, Asstt. Chief Tech. Officer(T-7-8), ICAR-CPRI, RS, Patna promoted to Chief Tech. Officer(T-9) from 16.07.2017.

Transfer

1. Sh. Pratish Kumar Patel, Technical Trainee, relieved from ICAR-CPRI, RS, Kufri on 02.03.2019 to join at ICAR-CPRI, RS, Patna.

2. Sh. SDA Rizvi, Tech. Asstt. transferred from ICAR-CPRI, RS, Patna to ICAR-CPRI, RS, Modipuram and joined on dated 05.09.2018.

Retirements/ Death

1. Sh. Yash Pal, Tech. Officer, ICAR-CPRI, Shimla, retired on 30.04.2018.
2. Sh. Ramesh Chand, ACTO, ICAR-CPRI, RS, Modipuram, retired on 30.04.2018.
3. Sh. Hesting Zyrwa, Sr. Tech. Asstt.,(Driver) ICAR-CPRI, RS, Shillong, retired on 30.04.2018.
4. Sh. Narayan Singh, Tech. Asstt. (Driver) ICAR-CPRI, RS, Modipuram, retired on 31.12.2018.
5. Sh. Islam Ahmed, CTO, ICAR-CPRI, RS, Modipuram, retired on 31.01.2019.
6. Sh. Prithi Singh, TA, ICAR-CPRI, Shimla, died on 16.05.2018.
7. Sh. Sita Ram, Sr. Tech, ICAR-CPRI, Shimla, died on 10.02.2019.

ADMINISTRATIVE

Appointment/New Joining

1. Sh. Zakir Hussain Khilji, SF&AO, ICAR-CPRI, Shimla joined on 01.09.2018 (FN).
2. Sh. Nand Lal, LDC joined on 23.06.2018.
3. Sh. Mohit Oberoi, Steno Grade-III, Division of Social Sciences, ICAR-CPRI, Shimla – 22.03.2019(FN).
4. Sh. Pawan Kumar, Steno Grade-III, ICAR-CPRS, Patna – 23.03.2019 (FN).
5. Sh. Rajesh Chauhan, LDC, Admn. Block, ICAR-CPRI, Shimla – 24.12.2018.
6. Sh. Suraj Singh, LDC, ICAR-CPRI, RS, Modipuram – 17.12.2018.
7. Sh. Sunil Singh, LDC, ICAR-CPRI, RS, Modipuram – 07.12.2018.

Promotion

1. Miss Prawartika Das, Asstt. promoted to Asstt. Admn. Officer – 03.04.2018 (FN).
2. Sh. Santosh Kumar, UDC promoted to Assistant – 28.11.2017 (AN).

Retirement

1. Sh. Jagdish Chand, Asstt., Audit Section, ICAR-CPRI, Shimla – 31.03.2019.

Transfers on selection basis

1. Sh. GC Prasad, Sr. Finance & Accounts Officer relieved *w.e.f.* 18.06.2018 to join as Comptroller at BASU, Bihar.
2. Sh. Ashish Dhangar, Asstt. Finance & Accounts Officer relieved *w.e.f.* 28.02.2019 to join as Asstt. Comptroller at BASU, Bihar.

Transfer within Institute

1. Sh. Ashish Kalyan, LDC, ICAR-CPRI, RS, Modipuram transferred to CPRI, Shimla and joined on29.09.2018.

Granted financial up-gradation under MACP Scheme

1. Smt. IC Dharmapal, Asstt. Admn. Officer, ICAR-CPRI, RS, Muthorai, granted 2nd MACP *w.e.f.* 14.10.2017 in Pay Matrix Level 8.
2. Smt. Seema Verma, UDC, ICAR-CPRI, RS, Modipuram, granted 2nd MACP w.e.f. 09.10.2018 in Pay Matrix Level 5.
3. Smt. Geeta Devi, UDC, ICAR-CPRI, Shimla, granted 2nd MACP *w.e.f.* 18.08.2018 in Pay Matrix Level 5.
4. Smt. Bimla Salhotra, UDC, ICAR-CPRI, RS, Jalandhar, granted 2nd MACP *w.e.f.* 26.02.2018 in Pay Matrix Level.

Clearance of Probation Period

1. Smt. Sandhya Srivastava, Assistant, ICAR-CPRI, RS, Jalandhar, probation cleared *w.e.f.* 14.01.2018.
2. Smt. Shyam Lata Bekta, Assistant, ICAR-CPRI, Shimla, probation cleared *w.e.f.* 13.01.2018.
3. Smt. Chandni Bhagta, Assistant, ICAR-CPRI, RS, Kufri probation cleared *w.e.f.* 08.06.2018.
4. Sh. Suresh Kumar Verma, Personal Assistant, ICAR-CPRI, RS, Jalandhar, probation cleared *w.e.f.* 21.07.2016.

SKILLED SUPPORT STAFF

Grant of MACP benefit

1. Sh. Sukhwinder, SSS, ICAR-CPRI, RS, Jalandhar granted , 2nd MACP w.e.f. 30.6.2018

2. Sh. Jagai Ram, SSS, ICAR-CPRI, RS, Jalandhar granted, 2nd MACP *w.e.f.* 30.6.2018
3. Sh. Paramjit Singh, SSS, CPRS, Jalandhar, 2nd MACP *w.e.f.* 30.6.2018
4. Sh. Shiv Singh, SSS, ICAR-CPRI, RS, Gwalior, granted , 2nd MACP *w.e.f.* 4.7.2018
5. Sh. Niranjan Singh, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
6. Sh. Kailash, SSS, ICAR-CPRI, RS, Gwalior, granted , 2nd MACP *w.e.f.* 4.7.2018
7. Sh. Ram Singh, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018,
8. Sh. Jagdish, SSS, ICAR-CPRI, RS, Gwalior, granted , 2nd MACP *w.e.f.* 4.7.2018
9. Sh. Shyam Singh, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
10. Sh. Prakash Tomar, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
11. Sh. Virendra Singh, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
12. Sh. Ranbir Singh, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
13. Sh. Kallu, ICAR-CPRI, RS, SSS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
14. Sh. Ashok Kumar, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
15. Sh. Jaswant Singh, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
16. Sh. Kedar, SSS, ICAR-CPRI, RS, Gwalior, granted, 2nd MACP *w.e.f.* 4.7.2018
17. Sh. Sompal, SSS, ICAR-CPRI, RS, Modipuram , granted , 2nd MACP *w.e.f.* 25.6.2018
18. Sh. Krishan Pal, SSS, ICAR-CPRI, RS, Modipuram, granted, 2nd MACP *w.e.f.* 25.6.2018

Clearance of Probation period

1. Smt. Sodha Devi, Skilled Support Staff, ICAR-CPRI, RS, Kufri, *w.e.f.* 10.3.2018.
2. Sh. Rajinder Singh, Skilled Support Staff, ICAR-CPRI, Shimla, *w.e.f.*10.3.2018.
3. Smt. M. Angamma, Skilled Support Staff, ICAR-CPRI, RS, Muthorai,*w.e.f.* 15.3.2018.
4. Sh. Ramdin, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 17.3.2018.
5. Sh, Net Ram, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 17.3.2018.
6. Sh. Mangal, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 17.3.2018.
7. Sh. Lala Ram, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 17.3.2018.
8. Sh. Tilak Singh, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 17.3.2018.
9. Sh. Sikander Singh, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 17.3.2018.
10. Sh. Kali Charan, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 18.3.2018.
11. Sh. Bhagirath, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 18.3.2018.
12. Sh. Jandel Singh, Skilled Support Staff, ICAR-CPRI, RS, Gwalior, *w.e.f.* 18.3.2018.

Promotion

1. Sh. Nand Lal, Wash Boy, ICAR-CPRI, Shimla promoted as LDC *w.e.f.* 23.6.2018.

Retirements

1. Sh. Gian Singh, SSS, ICAR-CPRI, RS, Jalandhar, retired on 30.04.2018.
2. Sh. Bir Bahadur ,SSS, ICAR-CPRI, Shimla, retired on 31.05.2018.
3. Sh. Ram Balak Rai, SSS, ICAR-CPRI, RS, Patna, retired on 30.06.2018.
4. Smt Tara Devi, SSS, ICAR-CPRI, RS, Patna, retired on 31.07.2018 .
5. Sh. J. Bhojan, SSS, ICAR-CPRI, RS, Muthorai, retired on 31.07.2018.
6. Sh. Sonpal, SSS, ICAR-CPRI, RS, Gwalior, retired on 31.08.2018.
7. Kr. Thapa, SSS, ICAR-CPRI, RS, Shillong, retired on 30.11.2018.
8. Sh. Satya Pal Singh , SSS, ICAR-CPRI, RS, Modipuram, retired on 31.12.2018.
9. Sh. Sita Ram, SSS, ICAR-CPRI, RS, Kufri, retired, on 31.12.2018.
10. Sh. Maharaj Singh, SSS, ICAR-CPRI, Shimla, retired on 31.01.2019 .
11. Sh. Indira Devi, SSS, ICAR-CPRI, RS, Kufri, Retired on 31.03.2019.

INSTITUTE BUDGET (FOR THE YEAR 2018-19)

Amount in Rs.

S. No.	Head	Allocation Govt. Grant	Allocation Internal Res + Council's share	Total Allocation	Expenditure (Govt.Grant)				Expenditure (Revenue Generation)	Total Expenditure
1	2	3	4	5 (3 + 4)	6				7	8 (6 + 7)
					NEH	TSP	SCSP	Other than NEH , TSP & SCSP		
1	**Works**									
	A. Land									
	B. Building									
	i. Office building	5100700	0	5100700	0	0	0	5100655	0	5100655
	ii. Residential building	0	0	0	0	0	0	0	0	0
	iii. Minor Works	0	0	0	0	0	0	0	0	0
2	**Equipments**	**4529300**	**0**	**4529300**	**0**	**0**	**0**	**4547879**	**0**	**4547879**
3	**Information Technology**	**1800000**	**0**	**1800000**	**0**	**0**	**0**	**1816083**	**0**	**1816083**
4	**Library Books and Journals**	**1200000**	**0**	**1200000**	**0**	**0**	**0**	**1174915**	**0**	**1174915**
5	**Vehicles & Vessels**	**1300000**	**0**	**1300000**	**0**	**0**	**0**	**1278092**	**0**	**1278092**
6	**Livestock**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
7	**Furniture & fixtures**	**1770000**	**0**	**1770000**	**0**	**0**	**0**	**1782376**	**0**	**1782376**
8	**Others**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Total – CAPITAL (Grants for creation of Capital Assets)	**15700000**	**0**	**15700000**	**0**	**0**	**0**	**15700000**	**0**	**15700000**
1	**Establishment Expenses(Salaries)**									
	i. Establishment Charges	377000000	0	377000000	0	0	0	377000501	0	377000501
	ii. Wages	600000	0	600000	0	0	0	598812	0	598812
	iii. Overtime Allowance	0	0	0	0	0	0	0	0	
	Total – Establishment Expenses (Grant in Aid - Salaries)	**377600000**	**0**	**377600000**	**0**	**0**	**0**	**377599313**	**0**	**377599313**
1	**Pension & Other Retirement Benefits**	**240000000**		**240000000**	**0**	**0**	**0**	**239999978**	**0**	**239999978**
2	**T.A.**									
	A. Domestic TA / Transfer TA	5200000	0	5200000	0	0	0	5199999	0	5199999
	B. Foreign TA	0	0	0	0	0	0	0	0	0
	Total – Travelling Allow ance	5200000	0	5200000	0	0	0	5199999	0	5199999

3	**Research & Operational Expenses**									
	A. Research Expenses	29200000	0	29200000	117602	0	0	25149934	0	25267536
	B. Operational Expenses	16943000	0	16943000	182500	0	0	20692027	0	20874527
	Total - Research & Operational Expenses	46143000	0	46143000	300102	0	0	45841961	0	46142063
4	**Administrative Expenses**									
	A. Infrastructure	16000000	0	16000000	0	0	0	14834685	0	14834685
	B. Communication	857000	0	857000	0	0	0	764890	0	764890
	C. Repair & Maintenance		0							
	i. Equipments, Vehicles & Others	2850000	0	2850000	0	0	0	3726889	0	3726889
	ii. Office building	2500000	0	2500000	0	0	0	3657287	0	3657287
	iii. Residential building	2500000	0	2500000	0	0	0	2388179	0	2388179
	iv. Minor Works	1000000	0	1000000	0	0	0	889735	0	889735
	D. Others (excluding TA)	12300000	0	12300000	0	0	0	11746096	0	11746096
	Total - Administrative Expenses	38007000	0	38007000	0	0	0	38007761	0	38007761
5	**Miscellaneous Expenses**									
	A. HRD	850000	0	850000	0	0	0	880403	0	880403
	B. Other Items (Fellowships, Scholarships etc.)	0	0	0	0	0	0	0	0	0
	C. Publicity & Exhibitions	0	0	0	0	0	0	0	0	0
	D. Guest House – Maintenance	750000	0	750000	0	0	0	719139	0	719139
	E. Other Miscellaneous	0	0	0	0	0	0	0	0	0
	Total - Miscellaneous Expenses	**1600000**	**0**	**1600000**	**0**	**0**	**0**	**1599542**	**0**	**1599542**
	Total --Grants in Aid - General	**330950000**	**0**	**330950000**	**300102**	**0**	**0**	**330649241**	**0**	**330949343**
	Grand Total (Capital + Establishment +General)	**724250000**	**0**	**724250000**	**300102**	**0**	**0**	**723948554**	**0**	**724248656**
6	**Loans and Advances**	**0**	**500000**	**500000**	**0**	**0**	**0**	**0**	**136000**	**136000**
7	**Swachh Bharat Mission**									**4000000**